

Monetary Policy Transmission in Economies with Informal Labor Markets *

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Abstract

Labor informality is a widespread phenomenon affecting over 61% of the world's workforce; however, its macroeconomic impact is not well understood. This paper investigates how labor informality influences the transmission mechanisms of monetary policy. Using panel data from Peru's National Household Survey (ENAHO) spanning 2012 to 2022, the paper examines the consumption, income, and employment patterns of both formal and informal workers. The findings indicate that informal workers have a higher marginal propensity to consume and that their incomes are more sensitive to economic fluctuations. Based on these findings, the paper constructs a Two-Agent New Keynesian model with informal labor markets. The model shows that informal labor markets amplify the transmission of monetary policy on output and inflation. Finally, the paper proposes some policy analyses that underscore the importance of accounting for informal labor markets when designing effective monetary policies.

Key words: Monetary Policy, Labor Informality, Marginal Propensity to Consume, Labor Market Flexibility

JEL: E52, E24, O17, O54, E21.

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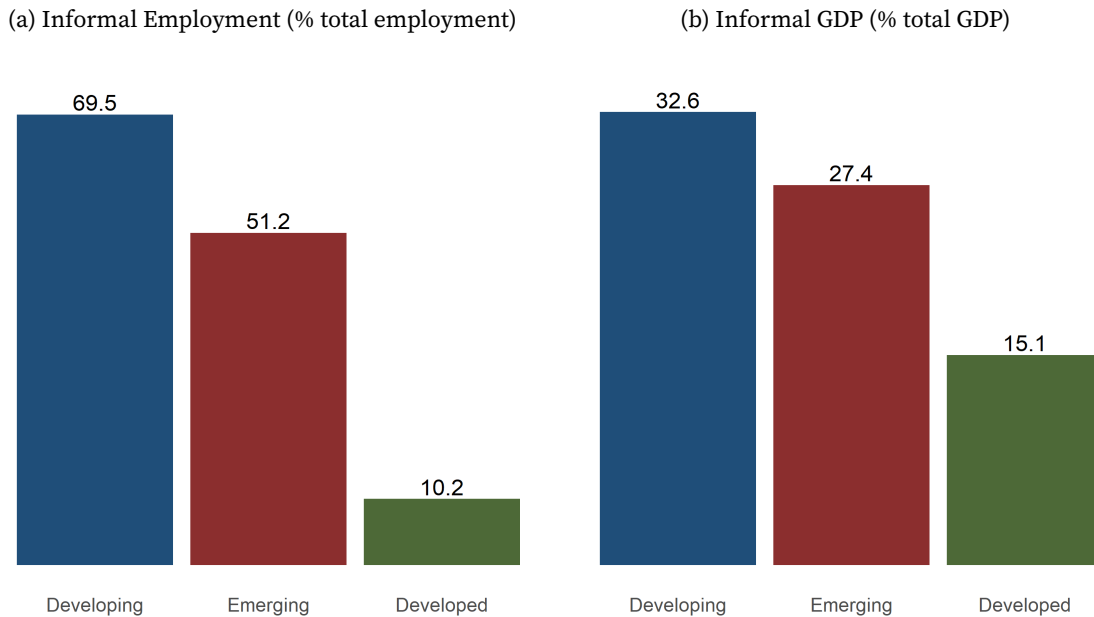
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1. Introduction

Labor informality is not merely a side note in the economy; it is a widespread phenomenon that affects billions of people around the world. According to the International Labour Organization (ILO), over 61% of the world’s employed population work informally¹, although this share varies widely between developed, emerging, and developing countries (see figure 1). Despite the substantial size of the informal sector and the growing attention it has received in other fields, the macroeconomic literature, especially regarding monetary policy, has largely overlooked it.

As a result, we do not understand how monetary policy interacts with labor informality, largely due to two major gaps: the lack of reliable data and the absence of models that adequately account for the informal sector. The difficulty in collecting reliable data arises because informal activities are often unrecorded and not reflected in official statistics. Additionally, most macroeconomic models do not account for the informal sector and instead implicitly assume that monetary policy affects all workers identically. This neglects the unique characteristics of informal workers, which display a combination of higher vulnerability to economic fluctuations and distinct consumption patterns.

Figure 1: Informality around the world



Note: Panel (a) shows the unweighted average of informal employment rates across countries (2012–2022) using data from the International Labour Organization (ILO). Panel (b) presents the unweighted average of the informal economy as a percentage of GDP (2012–2017), based on data from Medina and Schneider (2019). Countries are grouped into developed, emerging, and developing categories according to International Monetary Fund (IMF) classifications. However, since the IMF does not distinguish between emerging and developing economies, we use the MSCI definition for emerging markets. Four countries—Czech Republic, Greece, Korea, and Taiwan—are excluded from the MSCI list as they are classified as developed by the IMF, with the remaining countries classified as developing.

¹If the agriculture sector is excluded, informal employment falls to 50.5% (ILO, 2018).

This paper addresses these two gaps by offering improved micro-level data and using a more refined macroeconomic model. Specifically, we ask: How does the presence of informal employment alter the effectiveness of monetary policy? To answer this question, we focus on two critical aspects: income sensitivity to economic fluctuations and the marginal propensity to consume (MPC). Regarding income sensitivity, we postulate that informal workers' incomes are more sensitive during business cycles. In other words, during recessions, their income drops more, and during booms, their income increases more than that of formal workers. This hypothesis relies on the simple idea that informal employment allows firms to adjust their workforce more rapidly and at minimal cost in response to economic fluctuations because informal workers lack formal contracts. As a result, there are no firing costs since these employment arrangements fall outside government labor protections. However, this flexibility is a double-edged sword for the economy: it enables efficient labor cost management for firms during business cycles, but often leads to a lack of job security and protections for workers due to the absence of formal contracts. We summarize this concept by assuming that informal labor markets are more flexible than formal labor markets. In terms of MPC, we postulate that workers engaged in informal employment in developing economies typically have limited access to financial services, making their consumption highly sensitive to changes in disposable income. In other words, informal workers exhibit a higher MPC than formal workers.

Thus, in this paper, we postulate that the combination of high labor flexibility in informal labor markets and the high marginal propensity to consume (MPC) of informal workers can amplify the impact of monetary policy on aggregate output and inflation. To empirically investigate our hypothesis, we focus on Peru—a developing economy where informal labor is widespread and high-quality microeconomic data on informality are available. Utilizing detailed household-level data from Peru's National Household Survey (ENAH) spanning 2012 to 2022, we analyze the consumption behavior and income of informal and formal workers. The ENAH survey provides comprehensive information on income, expenditure, employment status, and access to financial services. It includes both cross-sectional data covering approximately 30,000 households annually and a valuable longitudinal panel component. The panel data tracks about 10,000 households, each followed for at least two years, with some tracked for up to five years, across nine waves of longitudinal data. Using this cross-sectional and panel data, we construct empirical facts, estimate MPCs, and track the income of informal workers during recessions. In order to align our data with the hypothesis, we divide households into two categories: Ricardian and hand-to-mouth (HtM) households. HtM households are defined as those that consume all their current income and are unable to save or borrow. In developing economies like Peru, this group is often represented by informal workers who, due to limited access to financial services, are restricted in their ability to save and borrow. We use the lack of a bank account as a proxy for identifying HtM individuals, acknowledging that this operational definition may underestimate their numbers, as some individuals with bank accounts may still lack access to loans and therefore remain financially constrained. Conversely, Ricardian households are those that plan their consumption based on both current and future

income, smoothing consumption over time. Typically, these households work in the formal sector and have access to financial services. We use holding a bank account as a proxy for identifying these households.

Our analysis highlights several key findings. First, there is a strong correlation between informal jobs and HtM individuals. Cross-country analysis using national surveys and data from the ILO-SDG database (2014–2022) shows a 90% correlation between the lack of bank accounts—used as a proxy for HtM households—and informal employment. At the household level, our analysis of ENAHO survey data further supports this relationship, revealing a strong empirical link between HtM status and labor informality. Over 80% of HtM households, including those in the top income quintile, are engaged in informal jobs. This demonstrates that informality and HtM status are not purely correlated with income. In contrast, Ricardian households are more evenly split between formality and informality, although differences exist at income extremes. Formal Ricardian households are concentrated in the top 20% of the income distribution, while informal Ricardian households are largely found in the bottom 20%. Collectively, these findings demonstrate how informality and HtM status often coincide, intensifying the difficulties informal workers face in smoothing consumption and accessing credit, particularly during economic downturns.

Secondly, we find a higher MPC among informal workers. We estimate the MPC in Peru using panel data from the ENAHO survey and apply a structural estimation method to analyze how income changes affect consumption, particularly for informal workers. Under this approach, we first extract the unpredictable component of consumption and income (controlling for observable variables), and then use a structural model to disentangle permanent and transitory income shocks. By calculating partial insurance parameters and utilizing covariance restrictions, we estimate the annual MPC for transitory income. The results show that the MPC for informal workers is statistically higher than that for formal workers.

Thirdly, informal workers are particularly vulnerable during economic downturns, as demonstrated by the 2019–2020 recession in Peru. Our analysis shows that informal workers experienced sharper income declines during recessions but quicker recoveries during expansions than formal workers, highlighting their sensitivity to business cycles. This difference in income sensitivity remains robust even after accounting for sectoral employment, with informal workers in most sectors experiencing steeper losses than their formal counterparts. Additionally, the difference in income sensitivity is even more evident when comparing informal HtM workers with formal Ricardian workers².

On the other hand, to quantify the impact of labor informality on monetary policy transmission and understand the channel of transmission in a general equilibrium setup, we construct a Two-Agent New Keynesian (TANK) model with labor informality, calibrated using the earlier empirical findings. The TANK model includes five key agents: the central bank, which sets monetary policy; two types of households—Ricardian households, which optimize intertemporally, and HtM households, which consume their entire labor income and hold no assets; and two types of firms—wholesale firms and retail firms. Additionally, we assume the existence

²In this paper, we focus on the intensive margin, although it can be generalized to the extensive margin as well.

of five markets: the bond market, the final goods market, the intermediate goods market, and two labor markets—formal and informal.

Importantly, from the firm’s perspective, we assume that formal and informal hours are perfect substitutes in the production function³. Since labor markets are assumed to be competitive, firms cannot set wages. Therefore, their only way to minimize labor costs is by adjusting the number of hours worked. Thus, the key distinction between formal and informal jobs lies in the nature of their contracts: formal contracts impose penalties on firms for adjusting hours beyond the equilibrium, while informal contracts do not. As a result, it is easier for firms to adjust the hours of informal workers than formal workers.

In this sense, formal contracts are analogous to hiring and firing decisions, implying that it is more challenging for firms to hire and fire workers under formal contracts than under informal ones. The TANK model incorporates these ideas by introducing a quadratic adjustment cost for changes in formal working hours, creating an asymmetry where firms are more incentivized to disproportionately reduce labor demand for informal workers. As a result, during periods of contraction, informal workers experience a greater reduction in labor demand, leading to larger drops in income compared to formal workers. In other words, informal workers’ income are more sensitive to changes in the business cycle.

The impact of this income asymmetry on the aggregate economy becomes more significant when considering both Ricardian and HtM households simultaneously. For Ricardian households, income fluctuations are less problematic, as they can access bond markets to smooth their consumption. In contrast, HtM households face limited options: they can either increase their labor supply or reduce their consumption. Although an increase in labor supply could help mitigate negative economic effects, the reduction in consumption by HtM households negatively impacts aggregate demand, creating a broader economic effect—often referred to as a general equilibrium effect. Therefore, the interaction between labor informality and HtM households can amplify the effects of monetary policy.

The underlying mechanism through which monetary policy impacts the economy operates through both direct and indirect channels. The direct effect, referred to as the *partial equilibrium effect*, works through the intertemporal substitution channel. When the central bank raises interest rates, Ricardian households, who can smooth their consumption over time, are incentivized to save more, thereby reducing their current consumption. This decline in consumption decreases aggregate demand, prompting firms to adjust their production and labor demand. However, due to the adjustment cost on formal jobs, the reduction in labor demand disproportionately affects informal workers. At this point, the indirect or *general equilibrium effect* becomes relevant. As informal workers experience rapid income declines due to reduced informal employment, their consumption also falls, further exacerbating the reduction in aggregate demand and deepening the contraction in output. Of course, this indirect effect would be less significant if informal workers had access to bond markets. However, as the data show,

³Furthermore, we assume that both labor markets are competitive, meaning that, in equilibrium (or steady state), wages in both markets are the same. The purpose of this assumption is to eliminate unnecessary complexity. The focus of this paper is not on explaining wage gaps between formal and informal jobs but rather on the consequences of deviations from this steady state. Therefore, wage differences are considered irrelevant for the purposes of our analysis.

these workers are more likely to belong to HtM households, which implies they have a high MPC. Therefore, it is the combination of informal workers and HtM households that amplifies the power of monetary policy. This new channel is particularly relevant for economies with large informal labor markets.

Finally, after calibrating the TANK model using data from the ENAHO survey, we examine the effects of a 1-percentage-point increase in interest rates on the Peruvian economy. The results indicate that such a rate hike leads to a 0.34 percentage point reduction in output and a 0.13 percentage point decrease in inflation. These findings are consistent with earlier empirical studies on the Peruvian economy. Next, we explore four scenarios. For example, if households become more HtM, how does this change the central bank's transmission mechanism? What would happen if the informality rate changes? To analyze these scenarios, we use a standard Representative Agent New Keynesian (RANK) model as a baseline⁴. The TANK model predicts that the inclusion of HtM households increases the power of monetary policy by approximately 4 percentage points. Additionally, the power increases by another 4 percentage points if labor informality is included. However, the model also suggests that if most HtM households become formal, the power of monetary policy will be reduced by up to 6 percentage points compared to the TANK model with informality.

Related Literature . This paper is related to four main strands of literature:

Informal Labor Markets and Heterogeneous Agents There has been a growing literature on introducing informality in a heterogeneous agents setup. Many of these papers have emphasized the role of entrepreneurship as an important feature of informality (Ulyssea, 2018, 2019; Lopez-Martin, 2019; Granda-Carvajal and Hamann, 2015, 2020; Granda-Carvajal et al., 2019; Maya and Pereira, 2021, 2022; Erosa et al., 2023). In this framework, these studies focus on income distribution, labor policies, and other real frictions. Our contribution to this literature lies in analyzing informality in a heterogeneous agents setup while introducing nominal rigidity to examine the effects of monetary policy. However, rather than focusing solely on a quantitative model, we first see the necessity of introducing a tractable heterogeneous model to better understand the mechanisms that link labor informality and monetary policy.

Monetary Policy and Informal Labor Markets This paper contributes to the literature on monetary policy and informal labor markets⁵. The first known study in this area was conducted by Batini et al. (2011), who used a Representative Agent New Keynesian (RANK) model to analyze the effects of certain monetary policy rules in economies with informal labor markets. Later, Castillo and Montoro (2012), along with Alberola and Urrutia (2020), incorporated

⁴During the exercise, we define "power" in terms of the central bank's ability to change output.

⁵Previous research has integrated informality into Real Business Cycle (RBC) models for both closed economies (Conesa et al., 2002; Granda-Carvajal, 2012, 2015; Restrepo-Echavarría, 2014) and open economies (Fiess et al., 2010; Fernández and Meza, 2015; Horvath, 2018; Coskun, 2022; Alba and McKnight, 2022). Other studies have incorporated search frictions to understand informal labor market dynamics in flexible price settings (Cook and Nosaka, 2005; Charlot et al., 2011; Shapiro, 2014, 2015; Colombo et al., 2019; Lama et al., 2022; Bosch and Esteban-Pretel, 2012).

search-matching frictions into a RANK model, finding that informality helps reduce inflationary pressures after demand shocks. Their intuition is that informal labor lowers costs, thereby acting as a buffer for wages⁶. In this regard, our model offers two key contributions to the literature: it extensively uses microdata to better understand the behavior of informal labor markets, and from a theoretical perspective, it introduces, to the best of our knowledge, the first model of monetary policy with heterogeneous agents and informal labor markets.

Financial Access and Monetary Policy The literature on Heterogenous New Keynesian models highlights the importance of HtM households in the transmission of monetary policy (Galí et al., 2004, 2007; Bilbiie, 2008; Kaplan et al., 2018; Bilbiie, 2024)⁷. These models demonstrate that the influence of monetary policy on the economy is closely linked to the proportion of HtM households, with indirect effects of monetary shocks being more pronounced when the share of HtM households increases⁸. In this context, this paper is closely related to two studies: Mehrotra and Yetman (2014), who examine the impact of financial inclusion on optimal monetary policy⁹, and Cantore et al. (2023), who focus on the interactions between labor supply and monetary policy in the U.S. At a theoretical level, we extend these studies by focusing on a developing economy. We also explore formal and informal labor markets and their interaction with monetary policy, while also highlighting the crucial role of financial inclusion in shaping these dynamics.

Marginal Propensity to Consume in Emerging Economies In recent decades, there has been a significant expansion in the literature on the marginal propensity to consume (MPC), reflecting growing recognition of micro-level heterogeneity in aggregate consumption patterns. Researchers have employed a variety of methodologies to estimate MPCs, with some of them relying on structural approaches, natural or quasi-experiments, or elicitation surveys (Crawley and Theloudis, 2024). Despite this wide range of approaches, one limitation of the existing literature is that most MPC estimations are concentrated on developed countries. Moreover, the limited research that does exist for developing nations tends to focus on specific regions or targeted populations¹⁰. In contrast to this narrow focus, we identify three studies that estimate MPCs in developing countries, particularly in Peru (Hong, 2023; Guntin et al., 2023; Céspedes and Talledo, 2024). Unlike these studies, which focus on aggregate or quintile MPC, this paper emphasizes the differences in MPC between formal and informal workers in a developing economy, especially in relation to financial inclusion.

⁶We note two other papers related to monetary policy in a RANK setup: Ospina (2023), who examines optimal monetary policy in an economy with an informal sector, and Bandaogo (2018), who explores informality using a small open RANK model with informal goods and informal labor employment.

⁷For a discussion of the fiscal multiplier in the context of TANK models, see Cantore and Freund (2021).

⁸However, this also introduces a stability problem: as the number of HtM households increases, it becomes more difficult to achieve stability under conventional monetary policy parameters (Mehrotra and Yetman, 2014).

⁹Several studies have examined the role of financial inclusion in relation to monetary policy. Some examples include Yetman (2017), Usman Arshad et al. (2021), Jungo et al. (2022), and Ozili (2023).

¹⁰For example, Paxson (1992) studies the consumption responses of rice farmers in rural Thailand, while Haushofer and Shapiro (2016) and Egger et al. (2022) analyze the consumption behaviors of poor households in rural Kenya.

Roadmap. The rest of the paper is structured as follows: Section 2 presents the empirical analysis, detailing the data sources, methodology, and key findings regarding the consumption of formal and informal workers in Peru, including an examination of cross-country data, the relationship between informality and financial inclusion, and the estimation of the MPC among different household types; Section 3 introduces the theoretical framework based on the TANK model and explains how labor informality is incorporated, covering both the simple multiplier model and the more complex TANK model to illustrate the mechanisms at play; Section 4 discusses the calibration of the model using Peruvian data and presents simulation results, demonstrating the amplification effects of monetary policy in the presence of labor informality; and finally, Section 5 concludes with a discussion of the policy implications.

2. Data and Empirical Analysis

2.1. Cross country data

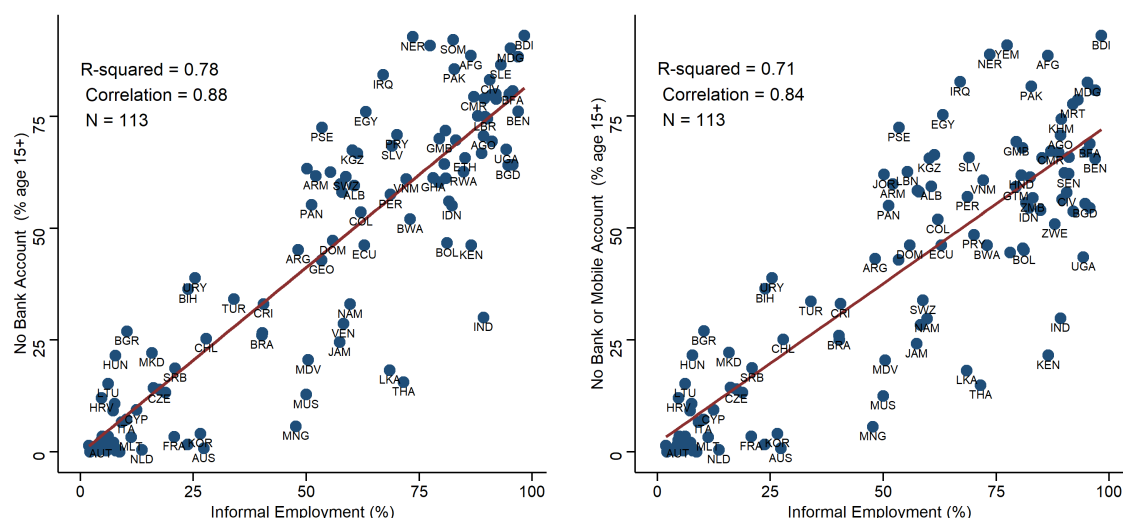
What can we learn from cross-country data regarding informality? As shown in Figure 2, our findings indicate a striking 88% correlation between the lack of bank accounts and informal employment across countries. In other words, countries that have a higher informality rate are also countries that show low degrees of financial inclusion.

In this paper, we do not aim to explain the reasons behind this correlation but rather explore its consequences¹¹. First, we propose that the lack of access to bank accounts serves as a useful proxy for identifying HtM households. While studies like [Kaplan et al. \(2014\)](#) have estimated the prevalence of HtM households in some developed countries, the available data are insufficient to establish meaningful cross-country correlations. This limitation exists because accurately estimating HtM households requires comprehensive surveys capturing both income and financial wealth—data that are especially scarce in developing economies. Given this constraint, we use the lack of access to financial products as a proxy for identifying HtM households. We assume that individuals without bank accounts are likely to face difficulties in accessing loans, as banks lack prior financial information about them. As a result, these individuals struggle to obtain credit during economic downturns, severely constraining their ability to smooth consumption.

Therefore, a more refined interpretation of Figure N2 is that informality is positively correlated with the HtM condition. However, the problem with this graph is that it only shows a correlation. To be more certain about this relationship, we need to find a more reliable dataset. In the next subsection, we will use micro-level data to confirm this correlation.

¹¹One possible explanation is that informal labor, by its nature, operates outside the law and therefore must minimize records. Using a bank account might increase the likelihood of detection by the government, making the use of cash essential. This reliance on cash could explain why informal workers often lack access to bank accounts. Another reason could be that informal labor does not generate income records, which severely limits the likelihood of obtaining financial services.

Figure 2: Cross-country data: Financial Inclusion & Informal Employment (2014-2022)



Notes: Values represent an unweighted average for 2014–2022. Informal unemployment data is sourced from the International Labor Organization (ILO-SDG database), and financial inclusion data comes from the World Bank’s Global Financial Inclusion Database. The first panel variable is the ‘no bank account’ variable, which captures the percentage of individuals over 15 years old who report not holding any type of account with banks or other financial institutions. The second panel combines access to bank accounts with access to ‘mobile accounts.’ Like the first measure, this variable applies to individuals over 15 years old.

2.2. Microdata-household level data

To study the role of informality, it is important to have reliable data on employment, income, and expenditure while ensuring enough detail to distinguish between formal and informal workers. After reviewing various countries, we found that Peru’s microdata provides a good basis for this analysis. The microdata originates from the National Household Survey (ENAH), covering the years 2012 to 2022. This dataset is particularly useful because it includes both cross-sectional and panel data. The panel data tracks around 10,000 households, each followed for at least two years, with some tracked for up to five years across nine waves. In contrast, the cross-sectional data covers roughly 30,000 households each year over the entire period from 2012 to 2022. The ENAH employs a stratified sampling technique that ensures a balance between urban and rural areas, thereby making the data nationally representative. The dataset includes a wide range of variables, including those related to income, consumption, and labor markets. To assess consumption accurately, we measured aggregate consumption for each household, adjusting for the number of household members. Additionally, all variables are converted to real terms and expressed in Peruvian soles¹².

*Definition of informality*¹³. We define informal workers as individuals who declare employment and have one of the following three characteristics: (1) *they are employers or self-employed in the informal sector*, (2) *they are white- or blue-collar workers who do not contribute to social health*

¹²For a more detailed discussion of the ENAH modules used in this paper, refer to Annex B.1.

¹³This is the same definition used by the National Institute of Statistics (INEI) when working with the ENAH.

insurance, or (3) they are unpaid family workers. This definition allows us to clearly distinguish between the sector and the type of employment—whether formal or informal. Crucially, the formality or informality of a job is independent of the formality or informality of the firm. For example, a worker may be employed by a formal firm but still hold an informal job. Conversely, if an individual is self-employed and the firm is formal, the job is also considered formal. This method of measuring formal and informal employment relies on two factors: the formality of the firm and the formality of the job¹⁴ (See Table 1).

Table 1: Sector and employment by informality condition

		Employment	
		Formal	Informal
Sector	Formal	Self-employed & employers	-
		Employees	Employees
		Domestic workers	Domestic workers
		-	Unpaid family worker
Informal		-	Self-employed & employers
		-	Employees
		-	Unpaid family worker

Source: National Institute of Statistics (INEI), ENAHO.

2.2.1. Hand-to-Mouth and Ricardian households

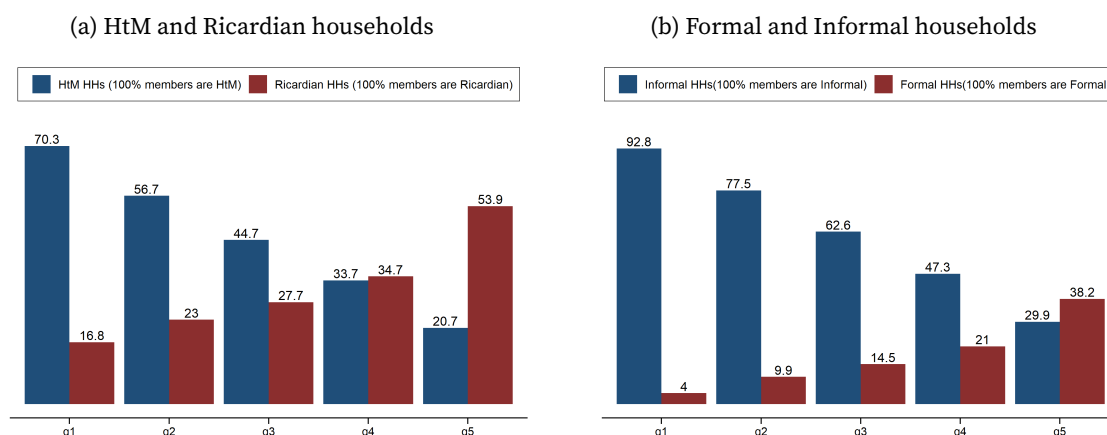
We previously defined hand-to-mouth (HtM) individuals as those lacking access to financial products, specifically those without bank accounts, while Ricardian individuals are those with at least one bank account. Some may reasonably argue that individuals within the same household can differ in their access to bank accounts. Therefore, we grouped individuals by household and created two categories: HtM households and Ricardian households. HtM households are those where none of the members holds a bank account, while Ricardian households are those where all members have at least one bank account.

Figure 3a shows the distribution of HtM and Ricardian households across income quintiles. The blue bar represents HtM households, while the red bar represents Ricardian households. The gap between the blue and red bars reflects the percentage of households in an intermediate category—those where some members have a bank account while others do not. The figure clearly shows that in the bottom 20%, most households are entirely HtM, whereas in the top 20%, most households are entirely Ricardian. The graph highlights a clear pattern: poorer households tend to be HtM, while wealthier households tend to be Ricardian.

Fact 1 *Low-income households tend to be HtM, while high-income households tend to be Ricardian.*

¹⁴See the Annex B.2 for a detailed discussion about the process of estimating informality.

Figure 3: Household Types by Income Quintiles (2012–2023)



Note 1: Panel (a): Hand-to-Mouth (HtM) individuals are defined as those who report not holding any bank account. The blue bars represent households where all members are HtM, while the red bars represent households where all members are Ricardian. The gap between 100% and the combined total of the blue and red bars corresponds to households with a mix of both HtM and Ricardian members. Panel (b): The blue bar indicates households where all members are informal workers, while the red bar shows households where all members are formal workers. The gap between 100% and the combined total of these bars reflects households with a mix of both formal and informal workers. Note 2: In both graphs, q1 to q5 represent quintiles 1 to 5. Both figures show the percentage of households that meet the definition within each income quintile. For example, in Panel (a), q1 indicates that, among all households in this quintile, 70.3% are HtM, 16.8% are Ricardian, and the remainder are mixed households. Source: ENAHO – updated methodology.

2.2.2. Informality and income distribution

The next figure presents informal and formal employment across income quintiles. First, we identified individuals holding informal and formal jobs and then grouped them into households. We define "informal households" as those where all members hold informal jobs, and "formal households" as those where all members hold formal jobs. In Figure 3b, the blue bar represents households where all members are informal workers, while the red bar represents those where all members are formal workers. The gap between 100% and the combined total of the blue and red bars reflects households with both formal and informal workers, explaining why the sum does not equal 100%.

One striking observation from Figure 3b is the high prevalence of informality in the bottom 20% of the income distribution (quintile 1), where more than 90% of households are entirely informal. Interestingly, informality remains significant even in the top 20%, with at least one-third of households consisting entirely of informal workers. In the top quintile, most households are mixed, meaning they have at least one member in the informal sector and one in the formal sector. Figure 3b also shows that informality is heavily concentrated in the bottom 20%, 40%, and 60% of the income distribution, indicating that it is more prevalent among poorer households. Conversely, formality becomes more common as household income increases¹⁵.

¹⁵See Annex B.3 for a more in-depth discussion of income and consumption distribution between formal and informal households.

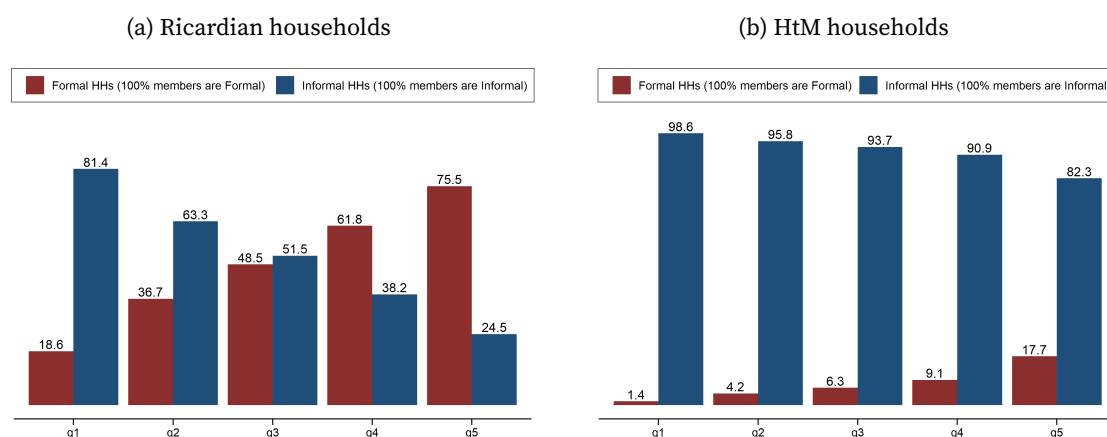
Fact 2 *Informal households are heavily concentrated among low-income households, and this proportion decreases as income increases.*

2.2.3. Informality and Hand-to-Mouth

To conclude our analysis, we focus on the characterization of HtM households by their formality status—whether they are formal or informal. As shown in Figure 4, these households are divided into two main groups: Ricardian and HtM, with further subcategories of formal and informal. Importantly, the combined total of the blue (informal) and red (formal) bars sums to 100%, as mixed households—those with both formal and informal members—are excluded. For Ricardian households, Figure 4 reveals a distinct pattern across the income distribution: informal Ricardian households are predominantly found in the bottom 20%, while formal Ricardian households are concentrated in the top 20%. This distribution shows that, although Ricardian households are evenly divided between formal and informal overall, their composition diverges significantly at the income extremes. In contrast, HtM households show a strong tendency toward informality across all income levels. Even in the top 20% of the income distribution, where formality might be expected to dominate, over 80% of these households remain informal¹⁶.

Fact 3 *HtM households are overwhelmingly informal, while Ricardian households are evenly divided between formal and informal overall.*

Figure 4: HtM and Ricardian households by income quintiles and informality (2015-2023)



Note 1: Panel (a) shows Ricardian households classified as either formal or informal. Mixed households, which include both formal and informal workers, are excluded so that the blue and red bars always sum to 100%. Panel (b) shows Hand-to-Mouth (HtM) households, also classified as either formal or informal, with mixed households removed to ensure the blue and red bars sum to 100%. Note 2: In both graphs, q1 to q5 represent quintiles 1 to 5. Both figures show the percentage of households that meet the definition within each income quintile. For example, in Panel (a), q1 indicates that, among all Ricardian households in this quintile, 81.4% are informal households, and 18.6% are formal households. Source: ENAHO – updated methodology.

¹⁶See the Annex B.5 for a discussion on formal and informal households by income quintiles and HtM during the period 2015 to 2023.

2.3. Marginal Propensity to Consume

Having analyzed the cross-sectional data, we conclude, based on Fact 1, Fact 2, and Fact 3, that the strong correlation observed in Figure 2, using cross-country data, is supported by the microdata and is therefore not spurious. With this understanding of informality, we must consider its consequences. If most informal workers are HtM, they likely have a higher Marginal Propensity to Consume (MPC) than other groups, as HtM individuals are more responsive to income fluctuations due to limited access to financial services.

Our central hypothesis is that workers that are informal will exhibit a higher MPC than those that are not informal. To test this hypothesis, we will estimate the MPC using Peruvian panel data from the ENAHO survey. Although the ENAHO data has been available since 2011, the crucial question of whether households hold a bank account was only introduced in 2015. Therefore, as this variable is essential for distinguishing between HtM and Ricardian households, our analysis will focus on the 2015–2022 waves (Table 2). In the following 2.3.1 and 2.3.2 sections, we will outline the econometric model used to estimate the MPC, detailing each step of the analysis.

Table 2: Waves of the ENAHO panel data with financial inclusion variables

	2015	2016	2017	2018	2019	2020	2021	2022
wave 1	x	x	x	x	x			
wave 2		x	x	x	x	x		
wave 3			x	x	x	x	x	
wave 4				x	x	x	x	x
wave 5					x	x	x	x

Note: The ENAHO survey tracks individuals for up to five years, as indicated by an "x" in the tracking table.

2.3.1. Panel estimation

In this section, we will regress the following econometric model, where i represents individual workers and t represents years.

$$\begin{aligned} \Delta C_{it} = & \alpha_0 \Delta Y_{it} + \alpha_1 INF_{it} + \alpha_2 QYT_{it} \\ & + \alpha_3 (\Delta Y_{it} \times INF_{it}) + \alpha_4 (\Delta Y_{it} \times QYT_{it}) \\ & + X'_{it} \beta + \alpha_i + \gamma_t + u_{it} \quad (1) \end{aligned}$$

The variables in the equation include the one-year change in household expenditure per capita (annual, in real PEN), denoted as ΔC_{it} , and the one-year change in household net total income per capita (annual, in real PEN), represented by ΔY_{it} . The variable INF_{it} is an indicator that equals 1 if all household members in the individual's household are informal workers, and 0 otherwise. The equation also incorporates individual and time fixed effects, α_i and γ_t , respectively. Additionally, the model controls for various factors through the vector X'_{it} , which includes age, age², sex, education, sector, type of job, size of firm, region, and their com-

binations. The income quintile, ranging from 1 to 5, is represented by QYT_{it} . By including these controls and focusing on the interaction term, we aim to isolate the effect of informality on consumption, particularly in response to income changes. Additionally, it is important to mention that, to capture the difference between formal and informal workers, we excluded individuals who switched between informal and formal labor during the observation period.

The purpose of Equation 1 is to estimate how changes in income affect consumption, controlling for whether the household is informal, the income quintile, and other demographic and job-related factors. The key parameter of interest is α_3 , which captures the interaction between income change and informality. We hypothesize that α_3 will be significant and positive, indicating that for households with informal jobs, a similar change in income leads to a greater increase in consumption.

The results presented in Tables 3 and 4 offer critical insights from 2011 to 2022, with a particular focus on differences between formal and informal workers. These tables are key to understanding consumption behavior dynamics, especially in relation to financial inclusion, which was systematically recorded only from 2015 onward. This temporal division allows for a more nuanced analysis: Table 3 covers 2011 to 2022, providing a broader context, while Table 4 focuses on 2015 to 2022, reflecting the period with complete financial inclusion data. Both tables are structured to enable a detailed comparison of how income changes affect consumption. The dependent variable, the change in per-capita expenditure, is analyzed using three distinct definitions of consumption. The first definition, in columns 1 to 3, includes total household expenditure per-capita. The second, in columns 4 to 5, focuses on monetary expenditures, excluding in-kind transactions. The third, in columns 6 to 7, uses the definition of expenditure on nondurable goods and services from [Guntin et al. \(2023\)](#), offering a comparative perspective based on established literature. The models are estimated using panel fixed effects with robust standard errors.

For simplicity, we will refer to α_3 as the marginal propensity to consume (MPC), acknowledging that this reflects correlation rather than causality, as we do not have an exogenous source of income. However, we still believe this exercise is valuable, as it demonstrates that informal workers exhibit a relatively stronger relationship between income and consumption compared to formal workers.

In the baseline estimation presented in column 3 of Table 3, a 1-percentage-point increase in income leads to a 27 percentage point rise in consumption. For informal workers, this increase is amplified by an additional 9 percentage points, reflecting their higher MPC relative to formal workers. Table 4 reinforces these findings, suggesting that the differential impact of informality becomes even more pronounced in later years, with the MPC for informal workers up to 17 percentage points higher than that of formal workers (see column 2). This consistent pattern across different periods, consumption definitions, and controls underscores the robustness of the results and highlights the significant role of informality in shaping the MPC.

It is important to note that these estimates may be influenced by the nature of income shocks, whether transitory or permanent. The difficulty in distinguishing between these types

Table 3: Annual MPC (2011-2022)

<i>dep var: ΔC_{it}, expenditure per capita (Annual, real PEN)</i>							
Total			Monetary Expenditure		Nondurable Goods		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔY_{it}	0.27*** (0.011)	0.15*** (0.029)	0.27*** (0.040)	0.07*** (0.022)	0.15*** (0.032)	0.07*** (0.021)	0.15*** (0.032)
$\Delta Y_{it} \times INF_{it}$		0.15*** (0.031)	0.09*** (0.033)	0.14*** (0.023)	0.10*** (0.026)	0.14*** (0.023)	0.10*** (0.026)
Controls							
INF_{it}		YES	YES	YES	YES	YES	YES
QYT_{it}			YES		YES		YES
$\Delta Y_{it} \times QYT_{it}$			YES		YES		YES
$region \times year$	YES	YES	YES	YES	YES	YES	YES
$X'_{it}\beta$	YES	YES	YES	YES	YES	YES	YES
id-FE	YES	YES	YES	YES	YES	YES	YES
time-FE	YES	YES	YES	YES	YES	YES	YES

Note: X_{it} includes age, age², sex, education, sector, type of job, size of firm, and region. N=13,898. All estimations use robust standard errors. Significance levels are indicated as follows: *** p<0.01, **p<0.05, *p<0.1.

of shocks raises questions about the interpretation of the estimated MPC. Additionally, there may be concerns regarding the identification strategy. To address these issues, the paper proposes a structural model designed to disentangle the effects of transitory and permanent shocks, while also providing a more reliable identification strategy for estimating the MPC. The next section will explore the construction of this model and its potential implications for analyzing the MPC.

2.3.2. MPC: structural estimation

Following [Hong \(2023\)](#), we estimate the MPC with respect to transitory income shocks using three moment conditions based on the Generalized Method of Moments (GMM)¹⁷. The moment conditions are as follows:

$$\mathbb{E} [\kappa Y_{it} - C_{it}] = 0 \quad (2)$$

$$\mathbb{E} [\Delta c_{it} - \alpha - \psi \Delta y_{it}] = 0 \quad (3)$$

$$\mathbb{E} [\Delta y_{it+1} (\Delta c_{it} - \alpha - \psi \Delta y_{it})] = 0 \quad (4)$$

where y_{it} and c_{it} represent the unpredictable components of income and consumption, respectively. Y_{it} and C_{it} are income and consumption in levels, κ is the mean-consumption-to-mean-income ratio, and ψ is the elasticity of consumption with respect to income. After estimating κ, ψ, α and their variance-covariance matrix, we can derive the MPC by calculating

¹⁷This structural approach, known as the covariance restriction, was first implemented in a seminal paper by [Blundell et al. \(2008\)](#). Refer to the Annex C.3 for a detailed explanation of their methodology.

Table 4: Annual MPC (2015-2022)

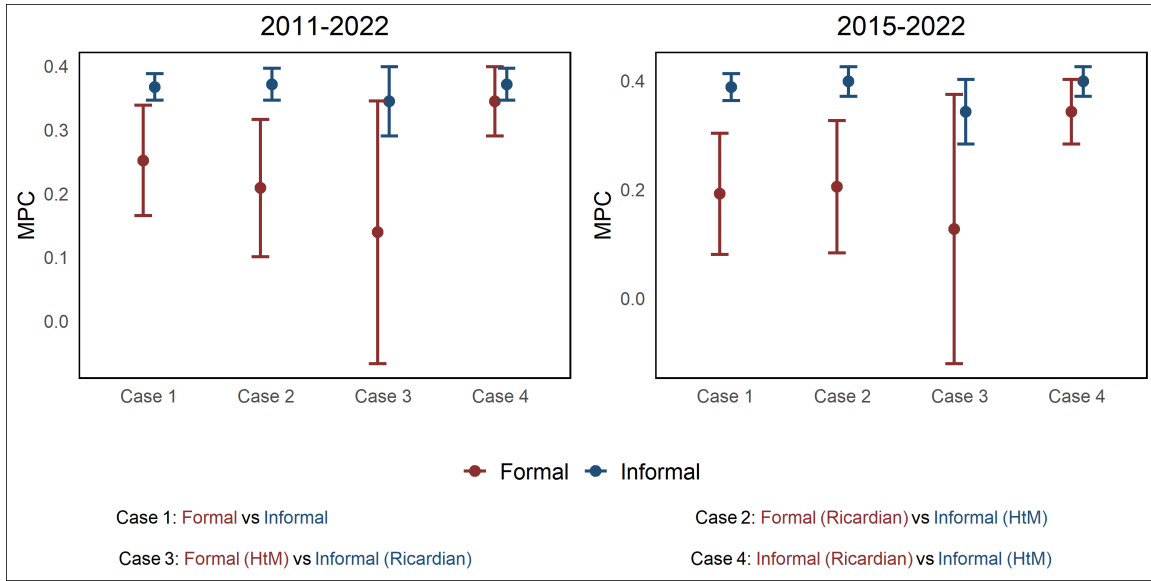
<i>dep var: ΔC_{it}, expenditure per capita (Annual, real PEN)</i>							
	Total			Monetary Expenditure		Nondurable Goods	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔY_{it}	0.27*** (0.012)	0.14*** (0.032)	0.27*** (0.044)	0.06*** (0.023)	0.16*** (0.034)	0.06*** (0.023)	0.16*** (0.034)
$\Delta Y_{it} \times INF_{it}$		0.17*** (0.034)	0.09** (0.036)	0.15*** (0.025)	0.10*** (0.028)	0.15*** (0.025)	0.10*** (0.028)
Controls							
INF_{it}		YES	YES	YES	YES	YES	YES
QYT_{it}			YES		YES		YES
$\Delta Y_{it} \times QYT_{it}$			YES		YES		YES
$region \times year$	YES	YES	YES	YES	YES	YES	YES
$X'_{it}\beta$	YES	YES	YES	YES	YES	YES	YES
id-FE	YES	YES	YES	YES	YES	YES	YES
time-FE	YES	YES	YES	YES	YES	YES	YES

Note: X_{it} includes age, age², sex, education, sector, type of job, size of firm, and region. N=11,715. All estimations use robust standard errors. Significance levels are indicated as follows: *** p<0.01, **p<0.05, *p<0.1.

$MPC = \kappa\psi$. Before applying this methodology to the ENAHO panel data, we excluded individuals who transitioned between formal and informal jobs. It is important to clarify that "informal workers" refers to individuals from households where all members are employed informally, while "formal workers" refers to those from households where all members are employed formally. Additionally, due to data availability on bank accounts, we divided our analysis into two periods: the full sample from 2011–2022 and the period from 2015–2022. The rationale for this division is that 2015 was the year when the ENAHO survey began including questions related to financial access, resulting in incomplete data on bank account holdings in earlier waves. Additionally, similar to Section 2.3.1, we excluded individuals who switched between informal and formal labor during the observation period.

Figure 5 illustrates the annual MPC to transitory income across four cases: Case 1 compares formal and informal workers, Case 2 compares informal HtM workers with formal Ricardian workers, Case 3 compares informal Ricardian workers with formal HtM workers, and Case 4 compares informal HtM workers with informal Ricardian workers. As shown in Figure 5, the MPC for formal workers is lower than that of informal workers, with the difference being particularly pronounced when comparing informal HtM workers with formal Ricardian workers. Cases 3 and 4 reveal no significant differences between the compared groups, and overall, Figure 5 demonstrates that the MPC is higher for informal workers, which aligns with the results from the panel estimation in section 2.3.1.

Figure 5: Annual MPC to Transitory Income



Note: The graph presents the annual Marginal Propensity to Consume (MPC) out of transitory income using a "covariance restriction" methodology for the Peruvian economy. The intervals are shown with 90% confidence. We define four cases: Case 1 compares Informal vs. Formal workers; Case 2 compares Informal (HtM) vs. Formal (Ricardian) workers; Case 3 compares Informal (Ricardian) vs. Formal (HtM) workers; and Case 4 compares Informal (HtM) vs. Informal (Ricardian) workers. The definition of consumption is the total household expenditure per-capita.

2.4. Income of formal and informal workers

From Section 2.3, we concluded that the MPC is higher for informal workers compared to formal workers. This naturally leads to the next question: Are informal workers' incomes more sensitive to business cycles? In other words, during a recession, are informal workers more significantly impacted in terms of income? Conversely, what happens when the economy is booming—do informal workers experience a larger income response? If so, we can affirm that informal workers are indeed more sensitive to economic fluctuations. This characteristic will be important later when we analyze the interaction between income volatility and a high MPC.

To examine changes in informal income during business cycles, we use the same panel data from Section 2.3 and calculate the average income for informal and formal workers. It is important to note that during the study period (2012–2022), the Peruvian economy did not experience any recessions or negative growth, except for the downturn caused by COVID-19. Therefore, we use the COVID-19 recession as an event study to analyze how formal and informal incomes behave during downturns, and the subsequent recovery period to assess income changes during an economic rebound. Our hypothesis is that the income of informal workers would decline more sharply than income of formal workers.

The evolution of income for these two groups of workers is illustrated in Figure 6, which highlights the recession period with a vertical gray zone. This panel also uses 2019 as the baseline year to compare the income trends for these groups. Panel (a) reveals two key in-

sights. First, it shows a sharper drop in income for informal workers compared to formal workers during the recession, underscoring their high sensitivity to economic shocks. This suggests that informal workers, who often lack job security, are disproportionately affected by economic downturns. Second, while both groups experienced income declines during the recession, their post-recession recovery patterns diverged significantly. Informal workers saw their incomes recover more quickly than formal workers. These two findings suggest that informal workers' income exhibits greater volatility and, therefore, they are more exposed to economic cycles than formal workers. Panel (b) shows a similar pattern when comparing two other groups: Formal-Ricardian and Informal-HtM workers. In fact, the income recovery of Informal-HtM workers is even more pronounced after the recession than in Panel (a).

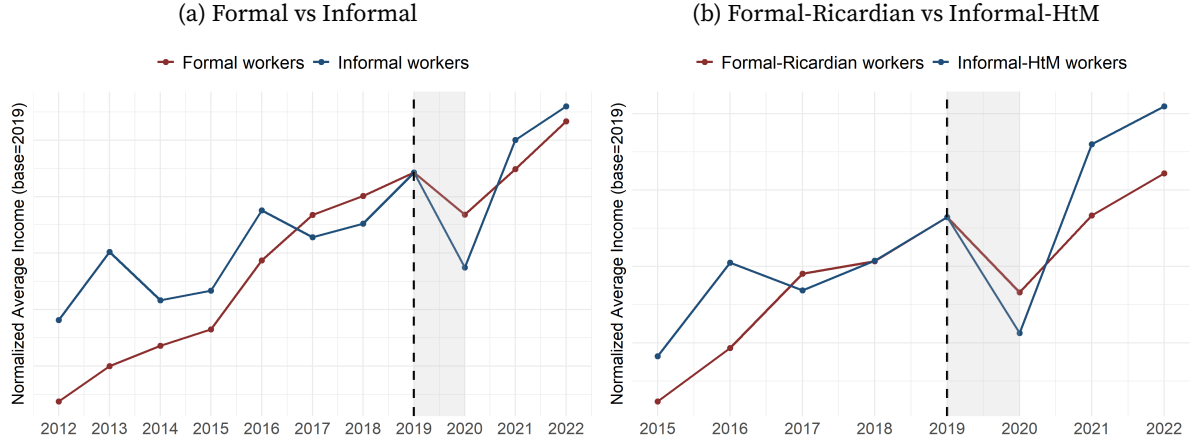
One potential critique of Figure 6 is that the pandemic disproportionately affected sectors with higher levels of informality. To address this, Figure 6 compares income changes across various sectors during 2019–2020. Blue dots indicate sectors where informal workers experienced greater income declines than formal workers, while red dots represent sectors where formal workers were more adversely affected than informal workers¹⁸.

The findings confirm that in most sectors, informal workers experienced more significant income declines than formal workers. For instance, in sectors such as manufacturing and construction, where both formal and informal workers suffered income losses, the decline was more pronounced for informal workers. In agriculture, formal workers saw an increase in income, while informal workers experienced a decrease. Interestingly, exceptions to this trend were found in sectors like commerce and real estate, where formal workers were more adversely affected, possibly due to sector-specific dynamics that insulated informal workers to some extent.

2.5. Total Consumption and Income

Finally, it is important to assess whether the consumption and income generated by informal households are significant at the aggregate level. Some may argue that despite high labor informality, informal consumption is not substantial enough to have macroeconomic consequences. To address this critique, we use the ENAHO data to measure the composition of consumption and income by household type. Figure 8 presents the results: from 2012 to 2022, informal households accounted for 58.1% of total income and 58.5% of total consumption. In other words, the microdata suggest that nearly 60% of the nation's aggregate consumption and income are generated by informal households. Additionally, mixed households—where members hold both formal and informal jobs—contribute approximately 21% to total consumption and income, leaving only about 20% attributable to formal households. These findings suggest that informal households are not merely a marginal part of the economy but are central to its overall dynamics, potentially playing a significant macroeconomic role.

Figure 6: Normalized Average Income (2015-2022): base=2019



Note: The figure shows the average income of workers in urban areas during the 2019–2020 recession, with the recession period highlighted in grey. The base year is 2019, meaning incomes are set equal in 2019 for comparison purposes. In Panel (a), workers are divided into two main groups: formal and informal workers. In Panel (b), workers are divided into two main groups: Formal-Ricardian and Informal-HtM workers. Source: ENAHO – updated methodology.

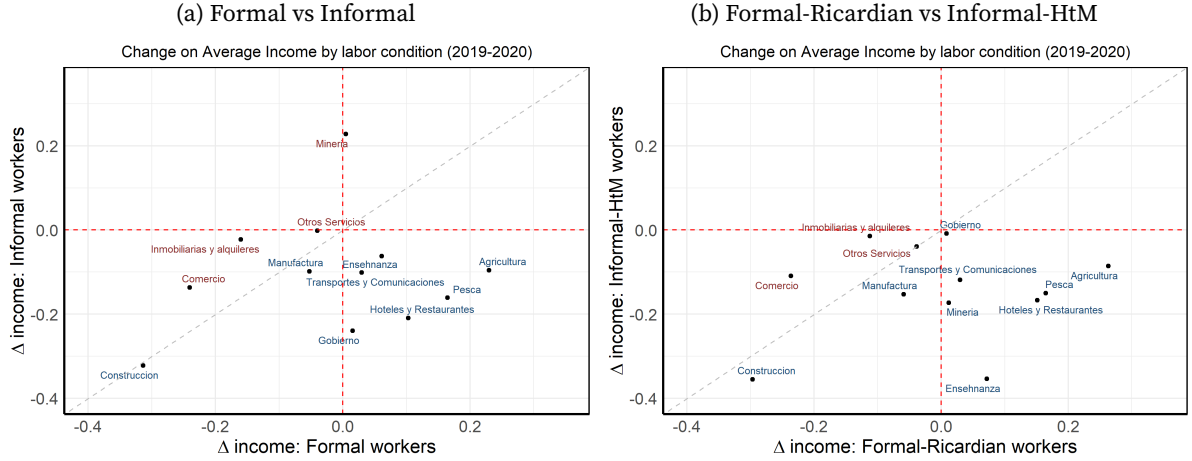
3. Theoretical Framework

In the previous section, we used household-level data to gain insights into consumption patterns and the informal labor market. Building on these findings, we introduce a theoretical framework to explore how labor informality influences the transmission mechanism of monetary policy. To this end, we develop two models: a simple toy model and a TANK (Two-Agent New Keynesian) model. We chose the TANK model as our baseline, adhering to the principle that ‘simpler is better,’ as it captures the key elements of our theory without unnecessary complexity.

The rest of the section is organized as follows: First, in Section 3.1, we present the toy model, which provides intuition about the primary mechanisms by which labor market dynamics affect monetary policy. This model assumes fixed prices, a closed economy, and no government—deliberate simplifications designed to clarify the core mechanisms. Next, in Section 3.2, we introduce the TANK model, which distinguishes between two types of households: HtM and Ricardian, both of which participate in formal and informal labor markets. In this framework, prices are determined endogenously, and the interest rate is set by monetary policy.

¹⁸We excluded individuals who switched jobs between industries during the period from 2019 to 2020.

Figure 7: Δ Average Income by economic sectors (2019-2020)



Note: The figure shows the change in the average income of workers during the 2019–2020 recession, categorized by sector in urban areas. It excludes individuals who switched jobs between industries during this period. Panel (a) presents the average income of two types of workers: formal and informal. Blue dots indicate sectors where informal workers fared worse than formal workers, while red dots indicate sectors where formal workers fared worse than informal workers. Panel (b) presents the average income of two types of workers: Formal-Ricardian and Informal-HtM. Blue dots indicate sectors where Informal-HtM workers fared worse than Formal-Ricardian workers, while red dots indicate sectors where Formal-Ricardian workers fared worse than Informal-HtM workers. Source: ENAHO – updated methodology.

3.1. Toy model: simple multiplier/Keynesian cross

To simplify our model, we assume: (i) a closed economy, (ii) no government spending, (iii) no investment, and (iv) fixed prices. Under these assumptions, aggregate demand is driven solely by aggregate consumption. Since prices are fixed, the only variable to be determined is total output. Let τ represent the proportion of households working in the informal sector, and $1 - \tau$ represent those in the formal sector. Therefore, total output Y must be equal to aggregate consumption C , such that:

$$Y = \tau C^I + (1 - \tau) C^F \quad (5)$$

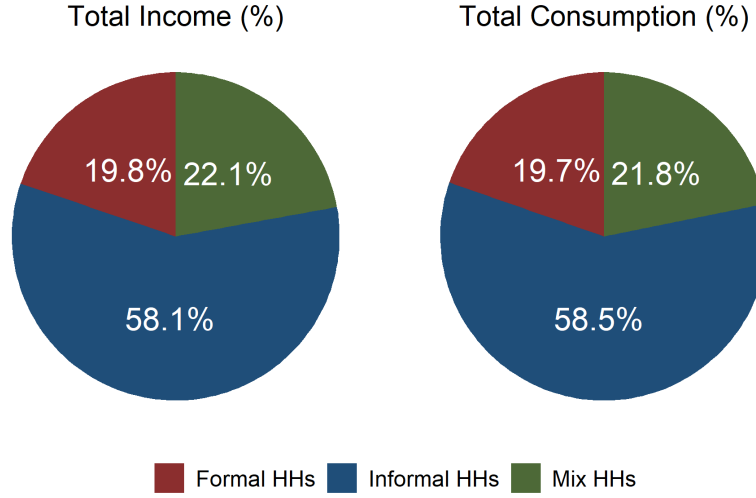
where C^F is formal consumption and C^I is informal consumption. After some algebraic manipulation¹⁹, and rearranging terms, we derive the multiplier:

$$\frac{dY}{d\epsilon} = \frac{1}{1 - \left[\tau \theta^I \gamma^I \text{MPC}_I + (1 - \tau) \theta^F \gamma^F \text{MPC}_F \right]} \quad (6)$$

Equation (6) illustrates the multiplier effect resulting from a shock to aggregate demand, such as a monetary policy shock ($d\epsilon$). This multiplier depends on several factors, including the Marginal Propensity to Consume (MPC), defined as $\text{MPC}_j = \frac{\partial C^j}{\partial Y^j}$, $j = \{I, F\}$; the income elasticity of each sector relative to the overall economy, $\gamma^j = \frac{\partial Y^j}{\partial Y} \frac{Y}{Y^j}$; the sector's relative size

¹⁹See Appendix D.1 for a detailed explanation of the derivation.

Figure 8: Consumption and Income (2012-2022)



Note: Formal households (Formal HHs) are those where all members are formal workers. Informal households (Informal HHs) are those where all members are informal workers. Mixed households (Mix HHs) have a combination of both formal and informal workers. Source: ENAHO – updated methodology.

compared to aggregate income, represented by $\theta^j = \frac{Y^j}{Y}$; and the proportion of households employed in the informal sector, $\tau \in [0, 1]$.

Thus, assuming that both the proportion of households (τ) and the size of the informal sector relative to aggregate output (θ) remain stable, the key variables influencing the multiplier are the marginal propensity to consume (MPC) and income elasticity (γ). If the MPC is high but the income elasticity is low, the multiplier may not increase. Therefore, to achieve a higher multiplier, both MPC and elasticity must be high—conditions that are more likely to be met in the informal sector, as discussed in Section 2. This intuition holds even if we consider multiple types of households, rather than just two (see Appendix D.2). Additionally, from Equation (6), we can see that if the Central Bank ignores the existence of informality, it may underestimate the true multiplier of its policies.

That said, while this model simplifies the understanding of how the interaction between MPC and income elasticity can increase the multiplier, it is not complex enough to capture the dynamics of a monetary shock, such as intertemporal substitution, or to differentiate between partial and general equilibrium. To address these limitations, we propose using a TANK model that incorporates informality in the next subsection.

3.2. TANK model

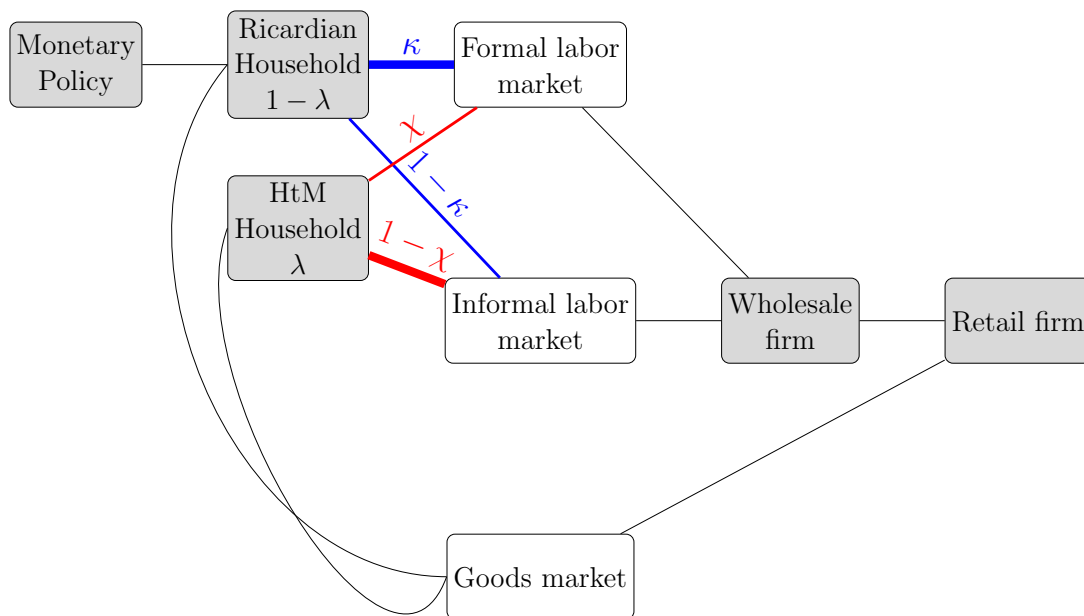
In this subsection, we explore a TANK (Two-Agent New Keynesian) model. Figure 9 presents a flowchart of the model, highlighting the primary components and their interactions within the economy. In this simplified version of a closed economy, there is no government or capital. The model includes five key agents: the central bank, which sets monetary policy; two types of households—Ricardian households, which optimize intertemporally, and HtM households, which consume their entire income; and two types of firms—wholesale firms and retail firms.

Figure 9 also illustrates three types of markets: the formal labor market, the informal labor market, and the goods market. The parameters κ and χ represent the shares of Ricardian households and HtM households participating in the formal labor market, respectively. We assume that λ percent of households are HtM, while $1 - \lambda$ percent are Ricardian.

The flowchart begins with the central bank's monetary policy decisions. When the central bank increases interest rates, it directly affects Ricardian households through the *intertemporal substitution channel*, or *partial equilibrium effect*, as these households adjust their consumption in response to the rate changes. This reduction in Ricardian households' consumption impacts retail firms, and in turn, wholesale firms, reducing their demand for both formal and informal labor. The contraction in the informal labor market particularly affects HtM households, whose consumption is directly tied to their labor income. As labor income for these households declines, their consumption also falls, creating an *indirect effect*, or *general equilibrium effect*, through the labor income channel.

The TANK model captures both the partial equilibrium effects, driven primarily by Ricardian households' responses to interest rates, and the general equilibrium effects, where changes in labor income affect HtM households. In summary, Ricardian households are sensitive to interest rate changes, while HtM households are mainly affected by changes in labor income.

Figure 9: TANK model: Interactions between formal and informal labor markets



Note: The flowchart illustrates the TANK model's dynamics, emphasizing the effects of monetary policy on formal and informal labor markets. It shows how changes in interest rates directly impact Ricardian households, reducing demand in the goods market and lowering demand for both formal and informal labor. This contraction particularly affects hand-to-mouth households, whose reduced labor income leads to declines in consumption, creating broader economic effects. The parameters κ and χ represent the shares of Ricardian and hand-to-mouth households participating in the formal labor market, respectively, while λ denotes the proportion of households that are hand-to-mouth, with $1 - \lambda$ representing Ricardian households.

3.2.1. The model

Ricardian households. We assume the existence of a continuum of infinitely-lived Ricardian households. These households derive utility solely from the amount of goods they consume (C_t^R) and the number of hours they work (N_t^R). Specifically, we assume the representative Ricardian household's preferences are described by the following utility function:

$$U_t^R = \max_{C_t^R, N_t^R, B_t} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t^R)^{1-\psi}}{1-\psi} - \frac{(N_t^R)^{1+\varphi}}{1+\varphi} \right] \quad (7)$$

Here, the superscript “R” stands for Ricardian households, $\beta \in (0, 1)$ is the discount factor, $\psi > 0$ is the inverse of the intertemporal elasticity of substitution (or a parameter representing constant relative risk aversion), and $\varphi > 0$ is the inverse of the (Frisch) labor supply elasticity. Ricardian consumption is defined by a CES aggregate of varieties $z \in (0, 1)$, given by:

$$C_t^R = \left[\int_0^1 C_t^R(z)^{\frac{\varepsilon-1}{\varepsilon}} dz \right]^{\frac{\varepsilon}{\varepsilon-1}} \quad (8)$$

where $\varepsilon > 0$ is the elasticity of substitution among differentiated goods. Since Ricardian households have access to financial markets, allowing them to borrow and lend, they are subject to the following budget constraint:

$$\int_0^1 C_t^R(z) P_t(z) dz + \frac{B_t}{P_t} = \frac{W_t^F}{P_t} \kappa N_t^R + \frac{W_t^I}{P_t} (1 - \kappa) N_t^R + \frac{B_{t-1}}{P_t} (1 + i_t) + \Gamma_t^R \quad (9)$$

where: B_t represents nominal bonds held at time t ; $P_t(z)$ is the price of the variety z ; W_t^F and W_t^I denote nominal wages in formal and informal sectors, respectively; κN_t^R is the fraction of labor allocated to the formal sector; $(1 - \kappa) N_t^R$ is the fraction of labor allocated to the informal sector; i_t is the nominal interest rate; and Γ_t^R represents income from real profits. The problem of the representative Ricardian household is to choose allocations $\{C_t^R, N_t^R, B_t\}_{t=0}^{\infty}$ to maximize the utility function (7) subject to the budget constraint (9), given a sequence of prices, profits, and bonds. From this optimization problem, we derive the following first-order conditions (FOCs):

$$\frac{W_t^R}{P_t} = (C_t^R)^{\psi} (N_t^R)^{\varphi} \quad (10)$$

$$1 = \beta \mathbb{E}_t \left(\frac{C_{t+1}^R}{C_t^R} \right)^{-\psi} \left(\frac{P_t}{P_{t+1}} (1 + i_t) \right) \quad (11)$$

$$\frac{W_t^R}{P_t} \equiv \kappa \left(\frac{W_t^F}{P_t} \right) + (1 - \kappa) \frac{W_t^I}{P_t} \quad (12)$$

Equation (10) represents the optimal labor supply, while equation (11) is the Euler equation. Notice that equation (12) shows that the Ricardian real wage can be represented as a combination of the formal real wage, $\left(\frac{W_t^F}{P_t}\right)$, and the informal real wage, $\left(\frac{W_t^I}{P_t}\right)$, weighted by κ . To obtain the optimal demand for variety z , we minimize the expenditure $\int_0^1 C_t^R(z) P_t(z) dz$ subject to the CES aggregation technology (8). The resulting demand for variety z is:

$$C_t^R(z) = \left[\frac{P_t(z)}{P_t} \right]^{-\epsilon} C_t^R \quad (13)$$

where $P_t \equiv \left[\int_0^1 P_t(z)^{1-\epsilon} dz \right]^{\frac{1}{1-\epsilon}}$ is the price index.

Hand-to-Mouth (HtM) households. Similar to the case of Ricardian households, we assume the existence of a continuum of infinitely-lived hand-to-mouth (HtM) households²⁰. These HtM households derive utility solely from the amount of goods they consume (C_t^H) and the number of hours they work (N_t^H). Specifically, we assume that the representative HtM household's preferences are described by the following utility function:

$$U_t^H = \max_{N_t^H} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t^H)^{1-\psi}}{1-\psi} - \frac{(N_t^H)^{1+\gamma}}{1+\gamma} \right] \quad (14)$$

Here, the superscript “H” stands for HtM households, $\beta \in (0, 1)$ is the discount factor, $\psi > 0$ is the inverse of the intertemporal elasticity of substitution (or a parameter representing constant relative risk aversion), and $\gamma > 0$ is the inverse of the (Frisch) labor supply elasticity. HtM consumption is defined by a CES aggregate of varieties $z \in (0, 1)$, given by:

$$C_t^H = \left[\int_0^1 C_t^H(z)^{\frac{\epsilon-1}{\epsilon}} dz \right]^{\frac{\epsilon}{\epsilon-1}} \quad (15)$$

where $\epsilon > 0$ is the elasticity of substitution among differentiated goods. Since HtM households lack access to financial markets, holding neither assets nor liabilities, their consumption depends entirely on their current labor income:

$$\int_0^1 C_t^H(z) P_t(z) dz = \frac{W_t^F}{P_t} \chi N_t^H + \frac{W_t^I}{P_t} (1 - \chi) N_t^H \quad (16)$$

where $P_t(z)$ is the price of the variety z ; W_t^F and W_t^I denote nominal wages in formal and informal sectors, respectively; χN_t^H is the fraction of labor allocated to the formal sector; $(1 - \chi) N_t^H$ is the fraction of labor allocated to the informal sector. Given that HtM households cannot borrow or save, the only variable they can choose is the number of hours supplied. Therefore, the problem of the representative HtM household is to choose allocations

²⁰The literature refers to these households using various terms, such as rule-of-thumb or non-Ricardian households, and they are often labeled as non-asset holders in studies on limited asset market participation (e.g., [Bilbiie, 2008](#); [Galí et al., 2004](#)).

$\{N_t^H\}_{t=0}^{\infty}$ to maximize the utility function (14), subject to the budget constraint (16) and given a sequence of prices. From this optimization problem, we derive the following first-order conditions (FOCs):

$$\frac{W_t^H}{P_t} = (C_t^H)^{\psi} (N_t^H)^{\gamma} \quad (17)$$

$$C_t^H = \frac{W_t^H}{P_t} N_t^H \quad (18)$$

$$\frac{W_t^H}{P_t} = \chi \left(\frac{W_t^F}{P_t} \right) + (1 - \chi) \frac{W_t^I}{P_t} \quad (19)$$

Equation (17) represents the optimal labor supply, while equation (18) shows the total HtM consumption, illustrating that their consumption is directly tied to their labor earnings, as they cannot access financial markets. Similarly to the case of Ricardian households, equation (19) shows that the HtM real wage can be represented as a combination of the formal real wage $\left(\frac{W_t^F}{P_t} \right)$ and the informal real wage $\left(\frac{W_t^I}{P_t} \right)$, weighted by χ . To derive the optimal demand for variety z , we minimize the expenditure $\int_0^1 C_t^H(z) P_t(z) dz$ subject to the CES aggregation technology (15). The resulting demand for variety z is:

$$C_t^H(z) = \left[\frac{P_t(z)}{P_t} \right]^{-\epsilon} C_t^H \quad (20)$$

Wholesale Firms. In this model, a continuum of wholesale firms indexed by $j \in (0, 1)$ operates in a competitive market, with each firm acting as a price taker. The production function employed by these firms exhibits returns to scale $\alpha > 0$ and is solely dependent on the total number of hours worked, N_t . For the sake of simplification, we assume that formal and informal hours are perfect substitutes in the production function. Intuitively, the firm hires two types of workers under different contracts. The first, known as a formal contract, includes various rigidities, such as hiring and firing costs. The second, labeled informal, is more flexible, allowing either the firm or the worker to terminate the agreement at any time without penalty. This approach aligns with the insider-outsider theory of the labor market, which highlights the differences in protections and rigidities between insider (formal) and outsider (informal) workers. Although formal and informal workers often differ in their education and skill levels, we assume perfect substitutability between the two types of labor for simplicity. The firm's profit is represented as:

$$\Gamma_t^W(j) = \frac{P_t^W}{P_t} Y_t^W(j) - \frac{W_t^F}{P_t} N_t^F(j) - \frac{W_t^I}{P_t} N_t^I(j) - \frac{\sigma_F}{2} \left(\frac{N_t^F(j)}{N_{t-1}^F(j)} - 1 \right)^2 \quad (21)$$

$$Y_t^W(j) = A_t N_t^\alpha(j) \quad (22)$$

$$N_t(j) = N_t^F(j) + N_t^I(j) \quad (23)$$

where $Y_t^W(j)$ represents the wholesale output of firm j , and P_t^W is the price of intermediate goods. Since the firm operates under perfect competition, $P_t^W(j) = P_t^W$. A_t denotes productivity, and $\Gamma_t^W(j)$ represents the real profits from the normal operations of the wholesale firm j . Equation (21) suggests that the firm hires both formal and informal workers, meaning it must pay wages that depend on the equilibrium in these labor markets. However, there is a key difference: informal contracts do not impose any penalties for dissolution, while formal contracts do. As seen in equation (21), having a formal contract introduces a quadratic adjustment cost. This means that any changes in the demand for formal jobs from one period to the next—whether for hiring or firing—generate additional costs that reduce profits. We assume that these costs are not absorbed by any party, and thus, they represent wasted resources. The importance of this quadratic cost in the profit function is determined by the parameter $\sigma_F > 0$. We refer to $\sigma_F > 0$ as the *firing cost parameter* because it dictates how much deviations in formal employment will affect the firm's profits. On the other hand, equation (22) presents a standard Cobb-Douglas production function. Finally, equation (23) shows the condition of perfect substitutability between formal and informal labor, which was explained earlier. Under these conditions, the wholesale firm maximizes the following profit function:

$$J_t^W(j) = \max_{N_t^F(j), N_t^I(j)} \left\{ \mathbb{E}_t \sum_{k=0}^{\infty} Q_{t,t+k} \Gamma_{t+k}^W(j) \right\} \quad (24)$$

where $Q_{t,t+k} \equiv \beta^k \frac{MU_{t+k}}{MU_t}$ is the stochastic discount factor, and MU_{t+k} is the marginal utility of consumption at period $t+k$. By maximizing (24) subject to the constraints in equations (21)–(23), we derive the following first-order conditions (FOCs):

$$\phi_t \frac{\alpha Y_t^W}{N_t} = \frac{W_t^I}{P_t} \quad (25)$$

$$\phi_t \frac{\alpha Y_t^W}{N_t} = \frac{W_t^F}{P_t} + \sigma_F \Theta_t^F \quad (26)$$

$$\Theta_t^F \equiv \left(\frac{N_t^F}{N_{t-1}^F} - 1 \right) \frac{1}{N_{t-1}^F} - \mathbb{E}_t Q_{t,t+1} \left(\frac{N_{t+1}^F}{N_t^F} - 1 \right) \frac{N_{t+1}^F}{(N_t^F)^2} \quad (27)$$

where $\phi_t \equiv \frac{P_t^W}{P_t}$ is the marginal cost. Equation (25) defines the demand for informal employment, while equation (26) defines the demand for formal employment. Notice that equation (26) includes an additional component, the marginal firing cost for formal jobs (Θ_t^F), which does not appear in (25). This extra term arises from the quadratic adjustment cost of formal labor in equation (27). Finally, as seen in equations (25)–(27), we have eliminated the index j , as all wholesale firms face identical conditions, leading to identical FOCs.

Retail firms. Retail firms purchase intermediate goods from wholesale firms and transform them into differentiated goods for final consumption using the technology $Y_t(z) = Y_t^W(z)$. In

the goods market, supply must equal demand, so $Y_t(z) = C_t(z) = \lambda C_t^H(z) + (1 - \lambda) C_t^R(z)$ ²¹. Therefore, retail firms face a negatively sloped demand curve for their products, which can be expressed as:

$$Y_t(z) = \left[\frac{P_t(z)}{P_t} \right]^{-\varepsilon} Y_t \quad (28)$$

From equation (28), we deduce that these firms operate in a monopolistic competition environment, giving retail firms the power to set prices. However, we assume that retail firms face a Calvo pricing mechanism. In other words, in each period, retail firms have an exogenous probability of changing their prices at period t , denoted by $1 - \theta$. Therefore, the real profit of retail firms is given by $\Gamma_t^R(z)$.

$$\Gamma_t^R(z) = \max_{P_t(z)} \mathbb{E}_t \sum_{k=0}^{\infty} \theta^k Q_{t,t+k} \left[\frac{P_{t+k}(z)}{P_{t+k}} - \phi_{t+k} \right] Y_{t+k}(z) \quad (29)$$

The problem for the retail firm is to find the optimal price $P_t(z)$ that maximizes (29), subject to the demand constraint in (28). After solving the problem and following the approach of [Benigno and Woodford \(2005\)](#), the first-order conditions (FOCs) can be written using auxiliary variables Λ_t and Ω_t :

$$1 = \theta (1 + \pi_t)^{\varepsilon-1} + (1 - \theta) \left(\frac{\varepsilon}{\varepsilon - 1} \right)^{1-\varepsilon} \left(\frac{\Lambda_t}{\Omega_t} \right)^{1-\varepsilon} \quad (30)$$

$$\Lambda_t = \phi_t Y_t + \theta \mathbb{E}_t \left[\left(\frac{P_{t+1}}{P_t} \right)^{\varepsilon} Q_{t+1,t} \Lambda_{t+1} \right] \quad (31)$$

$$\Omega_t = Y_t + \theta \mathbb{E}_t \left[\left(\frac{P_{t+1}}{P_t} \right)^{\varepsilon-1} Q_{t+1,t} \Omega_{t+1} \right] \quad (32)$$

where $\Pi_t \equiv \frac{P_t}{P_{t-1}}$ is the inflation rate. Equations (30)–(32) represent the recursive form of the Phillips curve.

Central Bank. The central bank follows a Taylor rule for setting the nominal interest rate. In this paper, we use a generic and simplified Taylor rule, which takes the following form:

$$\frac{1 + i_t}{1 + \bar{i}} = \left(\frac{\Pi_t}{\bar{\Pi}} \right)^{\phi_{\pi}} \left(\frac{Y_t}{\bar{Y}} \right)^{\phi_y} \exp(\varepsilon_t) \quad (33)$$

where $\bar{i}$, $\bar{\Pi}$, and $\bar{Y}$ represent the steady-state of the nominal interest rate, inflation, and output, respectively. The parameters $\phi_{\pi} \geq 0$ and $\phi_y \geq 0$ determine the central bank's response to deviations in inflation and output, respectively. Finally, ε_t is a monetary policy shock, which we assume follows an AR(1) process $\varepsilon_t = \rho \varepsilon_t + \xi_t$, $\xi_t \sim N(0, \sigma_{\varepsilon}^2)$.

Clearing market. The market clearing conditions imply that aggregate labor is a weighted sum of hours worked by HtM households and Ricardian households, which also holds true for ag-

²¹See annex E.1 for proof.

gregate consumption. Specifically, these conditions are represented as:

$$N_t = \lambda N_t^H + (1 - \lambda) N_t^R \quad (34)$$

$$C_t = \lambda C_t^H + (1 - \lambda) C_t^R \quad (35)$$

where λ represents the weight factor. Furthermore, we can show that the aggregate output is:

$$Y_t = C_t + \frac{\sigma_F}{2} \left(\frac{N_t^F}{N_{t-1}^F} - 1 \right)^2 \quad (36)$$

Equation (36) illustrates that the quadratic cost term reflects a resource waste, as $\sigma_F > 0$. One possible interpretation is that society, comprising both Ricardian and HtM households, collectively agrees to consume less to finance the cyclical labor insurance provided by formal contracts. Next, we define the market clearing conditions for both formal and informal labor markets. The total formal labor supply is the weight sum of the hours supplied by HtM households ($\lambda \chi N_t^H$) and Ricardian households ($(1 - \lambda) \kappa N_t^R$). Similarly, the total informal supply follows the same structure. Thus, the market clearing conditions are given by:

$$N_t^F = \lambda \chi N_t^H + (1 - \lambda) \kappa N_t^R \quad (37)$$

$$N_t^I = \lambda (1 - \chi) N_t^H + (1 - \lambda) (1 - \kappa) N_t^R \quad (38)$$

$$N_t = N_t^F + N_t^I \quad (39)$$

These equations (37)-(39) ensure that the total labor supply is the sum of formal and informal hours worked by both HtM and Ricardian households. Finally, we assume that in the aggregate, $B_t = 0$.

General equilibrium A general equilibrium in a competitive economy, given the initial asset positions B_{t-1} and a specified monetary policy rule (33), consists of a sequence of allocations $\left\{ Y_t, C_t, C_t^R, C_t^H, N_t, N_t^R, N_t^H, N_t^F, N_t^I \right\}_{t=0}^{\infty}$ and prices $\left\{ \phi_t, W_t^R, W_t^H, W_t^F, W_t^I, i_t \right\}_{t=0}^{\infty}$ such that the following conditions are satisfied:

- *Ricardian household problem:* Given prices, the allocation solves the Ricardian household's optimization problem, maximizing utility as described in equation (7), subject to the budget constraint in equation (9).
- *Hand-to-Mouth (HtM) household problem:* The allocation also solves the Hand-to-Mouth household's utility maximization problem, as specified in equation (14), subject to the income constraint in equation (16).
- *Retail firms' problem:* Retail firms maximize profits by solving the optimization problem described in equation (29), subject to the production constraint in equation (28).
- *Wholesale firms' problem:* Wholesale firms maximize profits according to equation (21).

- *Market clearing conditions: The equilibrium allocations ensure that markets clear at each time t , as described by the conditions in equations (34) to (39), ensuring a balance between supply and demand in goods, labor, and financial markets.*

4. Analysis of Equilibrium Dynamics

In this section, we discussed the approach for solving the TANK model. The first step involves log-linearizing²² the model around its steady-state (for the full system of log-linear equations, see the Appendix E.3 and E.5). The next step is to express the model more compactly. By combining all the log-linear equations, we derive a system of stochastic difference equations, which can be reduced as follows:

$$X_t = \Psi_1 E_t[X_{t+1}] + \Psi_0 \Sigma_t \quad (40)$$

where $X_t \equiv (y_t, c_t, \pi_t, i_t, \phi_t, c_t^R, c_t^H, n_t, n_t^R, n_t^H, n_t^F, n_t^I, w_t^R, w_t^H, w_t^F, w_t^I)'$, with lowercase variables representing log-linearized values and uppercase denoting levels. Note that all the equations in (40) are expressed as log deviations from their steady-state values. Additionally, $\Sigma_t = [\varepsilon_t]$ is a vector of shocks, and the matrices Ψ_1 and Ψ_0 depend on the structural parameters of the model.

From equation (40), it is possible to extract the Euler equation of our model, which is summarized in Table 5. This table highlights how both the standard TANK model, as described by Bilbiie (2008), and the standard RANK model are particular cases of this TANK model with informality. However, due to the complexity of equation (40), a closed-form solution is not feasible. Therefore, we proceed with a quantitative approach, calibrating the model by assigning numerical values to the structural parameters. Section 4.1 details the baseline calibration process, while Section 4.2 presents the impulse-response functions (IRFs) of the model in response to an anticipated monetary shock. Finally, we evaluate the basic IRFs to analyze the model under different scenarios.

4.1. Baseline Calibration

Standard parameters. The baseline calibration of the TANK model is carried out using quarterly frequency data. The discount factor, (β), is set at 0.99, corresponding to a real interest rate of approximately 1 percent in the steady state, in line with Cantore and Freund, 2021; Galí et al., 2004; Castillo et al., 2009; and, Castillo and Montoro, 2012. We assume that the discount factor parameter is equal to both Ricardian and HtM households. For the fraction of firms that do not adjust their prices, (θ), a baseline value of 0.75 is chosen, reflecting previous estimates for both international and Peruvian contexts (Galí et al., 2004, 2007; Castillo et al., 2009)²³. The

²²Log-linearization transforms a variable X_t into its log-linear form as $x_t \equiv \log X_t - \log \bar{X}$, where $\bar{X}$ represents its steady-state value.

²³Although Castillo et al. (2013), using Bayesian estimation in a DSGE model, suggest a lower value of ($\theta = 0.52$) for the Peruvian economy, implying that firms change prices approximately every two quarters.

Table 5: The model: RANK vs TANK

Model	Assumption	Euler Equation
TANK model with informality	$\lambda > 0 \text{ \& } \Upsilon [\cdot] \neq 0$	$c_t = \mathbb{E}_t c_{t+1} - \frac{1-\lambda}{\psi} (i_t - \mathbb{E}_t \pi_{t+1}) + \lambda (c_t^H - \mathbb{E}_t c_{t+1}^H)$ $\left(\frac{\gamma+\psi}{1+\gamma} \right) (c_t^H - \mathbb{E}_t c_{t+1}^H) = \chi (w_t^F - \mathbb{E}_t w_{t+1}^F) + (1-\chi) (w_t^I - \mathbb{E}_t w_{t+1}^I)$ $\Upsilon [\cdot] = w_t^I - w_t^F$
Standard TANK model	$\lambda > 0 \text{ \& } \Upsilon [\cdot] = 0$	$c_t = \mathbb{E}_t c_{t+1} - \left(\frac{1}{\psi} \right) \left(\frac{1-\lambda}{1-\lambda\Omega} \right) (i_t - \mathbb{E}_t \pi_{t+1})$
Standard RANK model	$\lambda = 0 \text{ \& } \Upsilon [\cdot] = 0$	$c_t = \mathbb{E}_t c_{t+1} - \frac{1}{\psi} (i_t - \mathbb{E}_t \pi_{t+1})$

Note: This table summarizes the Euler equations under specific assumptions. For a detailed derivation of the Euler equation, see Annex E.6.

Taylor rule coefficients are set to $(\phi_\pi = 1.5)$ and $(\phi_y = 0.5)$, consistent with empirical findings in the literature ([Castillo et al., 2009](#); [Cantore and Freund, 2021](#))²⁴. The parameters for the monetary policy shock are set at $\rho = 0.5$ and $\sigma_\rho = 0.03$, following [Castillo et al. \(2009\)](#); these values are commonly used in the literature. On the firm side, we assume that the share of labor in the production function is equal to one ($\alpha = 1$), consistent with the linear production function used in [Castillo and Montoro \(2012\)](#). Furthermore, the elasticity of substitution among differentiated goods is set at $\varepsilon = 6$, reflecting a steady-state price markup of 15%. This choice is based on the findings of [Galí et al. \(2004\)](#), [Galí et al. \(2007\)](#), [Castillo et al. \(2009\)](#), and [Cantore and Freund \(2021\)](#) (See table 6).

Table 6: Standard Parameters

Parameter		Interpretation
Phillips Curve Parameters		
β	0.99	Discounting factor
θ	0.75	% of firms who do not update prices
Monetary Policy Parameters		
ϕ_π	1.5	Inflation coefficient in interest rate rule
ϕ_y	0.5	Output coefficient in interest rate rule
ρ	0.5	Persistence of shock of MP
Firms		
α	1	Parameter in production function
ε	6	Elasticity of substitution among differentiated goods

Note: This table presents the parameters used in the TANK model. sources.

²⁴Although [Castillo et al. \(2013\)](#) propose a lower value for $(\phi_y = 0.1)$

Labor market. Regarding the labor markets, we set the inverse of the Frisch elasticity, γ and φ , equal to 2, reflecting an inelastic labor supply. This value is within the range of estimates found in the literature that use microdata to estimate the Frisch elasticity²⁵. It is also close to some Bayesian estimations, such as [Castillo et al. \(2013\)](#), who estimated an inverse Frisch elasticity of approximately 2.15 for the Peruvian economy. However, other studies have preferred to use a lower value for the inverse Frisch elasticity to satisfy the Blanchard and Kahn conditions, which establish local conditions for the existence and uniqueness of a solution in a DSGE model²⁶. Also, in this study, we assume that the inverse of the Frisch elasticity is equal for both Ricardian and HtM households. This assumption is made for two reasons. First, it clarifies the results by ensuring that any differences between Ricardian and HtM households arise from differences in the marginal propensity to consume (MPC) and labor rigidity, rather than from differences in Frisch elasticities. Second, there are no empirical studies that estimate the Frisch elasticity separately for Ricardian and HtM households. The closest available estimates come from [Céspedes and Rendón \(2012\)](#), who found an elasticity of 0.39 (2.56 for its inverse) for formal workers and 0.37 (2.7 for its inverse) for informal workers. However, the difference between these elasticities does not appear to be substantial. Therefore, we consider our assumption that γ and φ are equal to be reasonable (see Table 7).

Formal and informal households. The estimation of the percentage of households that are HtM (λ), the percentage of HtM households with a formal job (χ), and the percentage of Ricardian households with a formal job (κ) were obtained from the ENAHO. In contrast, the *fire cost parameter* (σ_F) was estimated by minimizing the distance between the model's theoretical moments and the empirical moments of the data. Specifically, we minimized the relative standard deviation of total hours worked in formal versus informal jobs, and the relative standard deviation of formal versus informal hourly wages. For this estimation, we utilized data from the Permanent Employment Survey (EPE), which is collected for the Metropolitan Region of Lima, Peru. Although this survey is not nationally representative and lacks a longitudinal (panel) structure, it has the advantage of providing monthly data on income and employment since January 2002. We used these data to calculate the average monthly income and total hours worked for formal and informal workers²⁷. After calculating these averages, we adjusted for seasonality, as both monthly wages and total hours exhibited strong seasonal patterns. We then converted the monthly data to quarterly data to align with the model's requirements. Next, we applied the one-sided HP filter ([Stock and Watson, 1999](#)) to decompose the data into trend

²⁵For example, [Céspedes and Rendón \(2012\)](#), using data from the Permanent Employment Survey (EPE) in the Metropolitan Lima region, estimated a Frisch elasticity of 0.38 (an inverse elasticity of 2.6). They also found an elasticity of 0.39 (2.56) for formal workers and 0.37 (2.7) for informal workers. Similarly, [Reyna and Céspedes \(2016\)](#), using the National Household Survey (ENAHO), estimated a Frisch elasticity of around 0.26 (3.8 for its inverse), with potentially higher elasticity for lower-income workers, reaching up to 0.42 (2.38 for its inverse).

²⁶For example, [Galí et al. \(2004\)](#) used a value of 1; [Cantore and Freund \(2021\)](#) used a value of 0.05; and [Galí et al. \(2007\)](#) used a value of 0.2.

²⁷We defined informality based on whether a worker had health insurance, as all workers in Peru are legally required to contribute to the public health system. A lack of contribution thus strongly indicates that a worker does not have a formal labor contract. Using this definition, we calculated the average hours worked and hourly wages for formal and informal workers from 2002 to 2019. However, in 2020, due to the pandemic, the government changed the rules, which made this definition of informality less reliable for subsequent periods.

and cyclical components, choosing the one-sided filter because it aligns with the backward-looking solution of a DSGE model. After filtering, we extracted the cyclical components and estimated the standard deviations for each series: formal hours (σ_{NF}), informal hours (σ_{NI}), formal wages (σ_{WF}), and informal wages (σ_{WI}). We then calculated the relative standard deviations: informal hours over formal hours (σ_{NI}/σ_{NF}) and informal wages over formal wages (σ_{WI}/σ_{WF}), which were 1.06 and 3.73, respectively. These findings indicate that informal employment is slightly more volatile than formal employment, while informal wages are significantly more volatile than formal wages. Using this data, we calibrated our TANK model to find theoretical moments for σ_{NF} , σ_{NI} , σ_{WF} , and σ_{WI} . The goal was to find the optimal value of σ_F that minimizes the distance between the theoretical moments of our model and the observed data. After running hundreds of simulations, we found that a value of $\sigma_F = 0.25$ achieved this objective.

Finally, regarding the calibration of the risk aversion parameter ψ (the inverse of the intertemporal elasticity of substitution in a CRRA utility function), we encountered some stability issues. Higher values of ψ led to dynamic instability when the proportion of HtM households (λ) was sufficiently high²⁸. To address this problem, we conducted a determinacy analysis to identify combinations of λ and ψ that satisfy the Blanchard and Kahn conditions. The results, presented in Annex G.2, include graphs showing these combinations. We first examined the case where the *fire cost parameter* (σ_F) is set to 0 and then considered $\sigma_F = 0.25$. The graphs indicate that, when $\lambda = 0.6$, the maximum value of ψ that satisfies the Blanchard and Kahn conditions ranges between 0.1 and 0.15. We found that the inclusion or exclusion of the parameter σ_F has little impact on the required value of ψ ²⁹. Therefore, we chose a risk aversion parameter of 0.1 for this study. In the next section, we show that our results are not sensitive to variations in this parameter. Table 7 summarizes the complete set of estimated parameters used for calibration.

4.2. Monetary shock in a simple TANK model with informality

4.2.1. Effects of Interest Rate Increases on Formal and Informal Sectors

In this section, we show the impulse response functions (IRFs) to an unanticipated monetary shock in the TANK model with informality. The monetary shock is represented by a 100 basis

²⁸The issues of stability and uniqueness in a TANK model were first examined by Galí et al. (2004) and Galí et al. (2007). They found that the dynamic stability of the TANK model is heavily influenced by the proportion of HtM households. As the proportion of HtM households increases, the model requires a stronger response to inflation in the Taylor-rule type equation to achieve uniqueness and stability, compared to the standard Taylor Principle; alternatively, it might require a more passive response to inflation (Bilbiie, 2008). Later, Ascari et al. (2011) and Colciago (2011) demonstrated that incorporating sticky wages into the model can restore the traditional Taylor Principle for achieving uniqueness and stability. However, Motta and Tirelli (2010) showed that this problem re-emerges even with sticky wages if habit persistence is assumed.

²⁹To demonstrate the robustness of our results, we provide impulse response functions (IRFs) under the condition that $\psi = 1$ (see Annex G.2). Given the stability issues discussed in Section 4.1, we set $\lambda = 0.3$ for this case. The results do not change significantly.

Table 7: Estimated Parameters

Parameter		Interpretation	Source
Households			
γ	2	Inverse of Frisch elasticity (HtM HHs)	Castillo et al. (2013)
φ	2	Inverse of Frisch elasticity (Ricardian HHs)	Castillo et al. (2013)
λ	0.60	% of HtM households	Own estimation
χ	0.06	% of HtM who work in formal sector	Own estimation
κ	0.54	% of Ricardian who work in formal sector	Own estimation
σ_F	0.25	Firing cost parameter	Own estimation
ψ	0.10	Relative risk aversion	Determinacy condition

Note: This table presents the parameters used in the TANK model, along with their respective sources.

point increase in nominal interest rates³⁰. The results can be seen in Figure 10, which shows the response of various variables, including aggregate output, inflation, the consumption of HtM households, wages for both formal and informal jobs, total hours worked in formal and informal jobs, and total income for both formal and informal jobs. Also, since all variables are measured in log deviations from their steady state, and the change in interest rate is defined in percentage points (p.p), the y-axis in Figure 10 also reflects changes in percentage points.

Qualitative impact. First, let's examine the dynamics of the variables. To understand these IRFs, illustrated in Figure 10, we can consider the following logic. Consistent with other studies, we propose that the central bank's influence on the economy operates through two main effects: a *direct effect* via interest rates and an *indirect effect* via changes in aggregate income³¹. The direct effect, often called the *partial equilibrium effect*, involves the *intertemporal substitution channel*, a key component in New Keynesian models. This channel suggests that an increase in interest rates incentivizes Ricardian households to save more — that is, to smooth their consumption over time — thereby reducing current consumption.

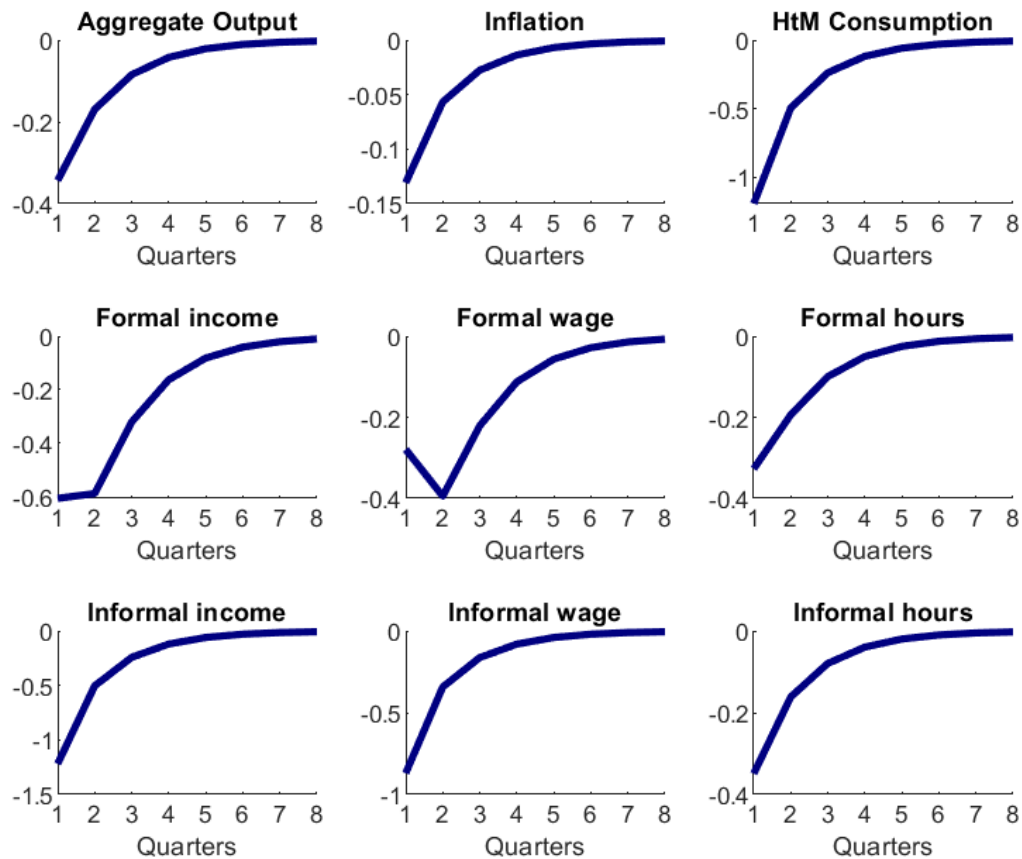
The *indirect effect*, or *general equilibrium effect*, arises because HtM households, who do not hold assets, are not directly affected by changes in interest rates; hence, the *partial equilibrium effect* on them is zero. Instead, their consumption is indirectly influenced by shifts in aggregate demand. The logic is as follows: when Ricardian households reduce their consumption, aggregate demand falls, prompting firms to lower their demand for labor. In our model, a representative firm employs both formal and informal labor, causing the demand for both types of labor to decline. However, due to the rigidity of formal jobs—reflected in the *firing cost parameter*—informal jobs are more severely impacted. Intuitively, formal jobs benefit from greater stability, particularly during economic downturns, providing them with a form of cyclical insurance. As a result, firms are more inclined to cut informal employment, as shown in Figure 10. Consequently, HtM households, who primarily rely on informal jobs, experience

³⁰Given that we are modeling a quarterly interest rate, an annual change of 100 basis points is equivalent to a 25 basis point change per quarter.

³¹Although the concepts of partial and general equilibrium effects have been extensively discussed in the literature (see, for example, the work on HANK models), our model is unique in its incorporation of informality to analyze the transmission mechanism of monetary policy.

a sharper decline in income than Ricardian households, resulting in a more pronounced decrease in their consumption. This further reduction in consumption amplifies the decrease in aggregate output and inflation.

Figure 10: Monetary shock: unexpected rise on interest rate



Note: The total income for each job type is simply the summation of the respective wage and hours worked. Thus, we define formal income as $w_t^F + n_t^F$ and informal income as $w_t^I + n_t^I$.

Quantitative impact. Let us focus on the quantitative impact of an interest rate change on various economic variables. The model predicts that a 1-percentage-point increase in the interest rate leads to a decrease in aggregate output by 0.34 percentage points and an decrease in inflation by 0.13 percentage points, as shown in Table 8. These estimates align with several empirical studies of the Peruvian economy. For instance, [Pérez Rojo and Rodríguez \(2024\)](#) estimate that a 1-percentage-point increase in the nominal interest rate results in a maximum decline of 0.28 percentage points in output and 0.10 percentage points in inflation. Similarly, [Portilla et al. \(2022\)](#) find a maximum decrease of 0.55 percentage points in output and 0.12 percentage points in inflation, while [Alvarado Silva et al. \(2024\)](#) report a maximum output decline of 0.30 percentage points and an inflation decrease of 0.15 percentage points. [Pérez Forero \(2015\)](#) also

identifies a maximum decline of 0.15 percentage points in output and 0.10 percentage points in inflation (see Table 9). Moreover, Table 8 indicates that informal wages are more volatile than formal wages, reflecting a sharper response to interest rate changes.

Table 8: An unexpected increase on interest rate on selected variables

Variable				Impact Q1			
Variable				Impact Q1			
Aggregate output	y_t	-0.34	p.p	Formal wage	w_t^F	-0.28	p.p
Inflation	π_t	-0.13	p.p	Informal wage	w_t^I	-0.87	p.p
HtM consumption	c_t^H	-1.19	p.p	Formal hours	n_t^F	-0.32	p.p
HtM income	$w_t^H + n_t^H$	-1.19	p.p	Informal hours	n_t^I	-0.34	p.p

Note: We use the impact of an unexpected increase of 0.25 p.p on interest rate on the first quarter of the selected variables.

Table 9: A 1 p.p. increase in the interest rate: Empirical effects vs. TANK model effects

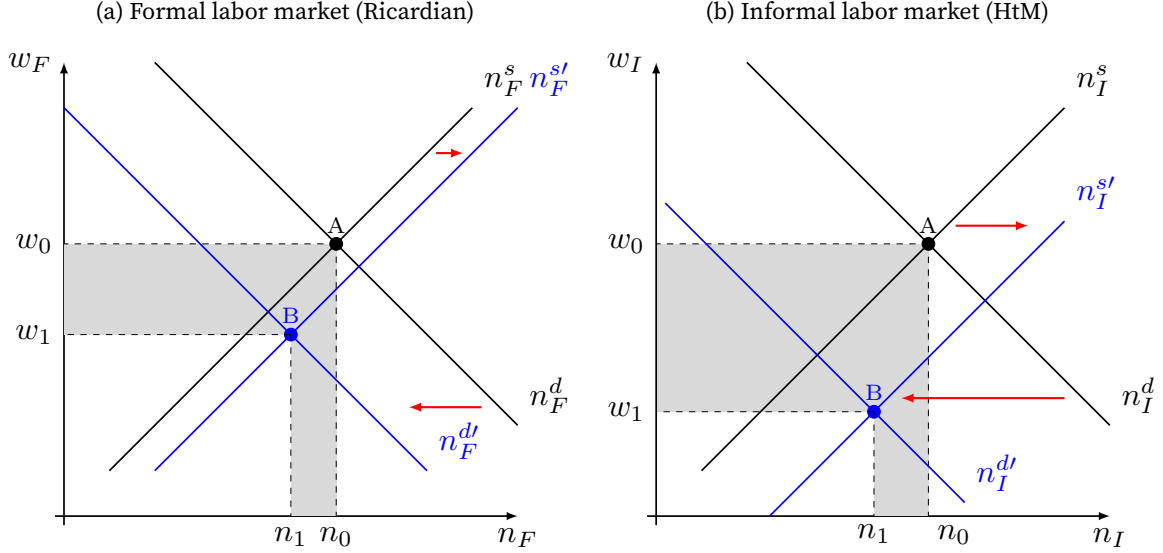
Source	Output	Inflation
Pérez Rojo and Rodríguez (2024)	-0.28	-0.10
Portilla et al. (2022)	-0.55	-0.12
Alvarado Silva et al. (2024)	-0.30	-0.15
Pérez Forero (2015)	-0.15	-0.10
Average empirical	-0.32	-0.12
TANK with informality	-0.34	-0.13

Note: We analyze the impact of an unexpected 0.25 percentage point (p.p.) increase in the interest rate during the first quarter. All variables are measured in quarters and percentage points. This table compares the average maximum decline in output and inflation resulting from a 1 p.p. increase in the interest rate. In doing so, we compare the empirical results of monetary policy shocks using Peruvian data with the outcomes of our TANK model, as described in Figure 10.

However, an important question arises: given that our model assumes formal labor faces certain rigidities, why do formal jobs change so little while wages react so significantly? In other words, if firms incur costs when hiring or firing formal workers, we would expect informal employment to be significantly more volatile than formal employment. Yet, the model suggests that informal wages are the variable that reacts the most (see Table 9). To explain this, we offer a simple rationale: HtM households, which cannot access credit to smooth their consumption, can still mitigate a larger decline in consumption by adjusting their labor supply. Therefore, when the demand for informal jobs declines more sharply than the demand for formal jobs, HtM households respond by increasing their labor supply more than Ricardian households. The combination of a larger reduction in labor demand and a greater shift in labor supply for HtM households explains why, in equilibrium, informal employment varies almost as much

as formal employment, but informal wages are much more volatile than formal wages. This idea is illustrated in Figure 11, which shows similar shifts in both the formal and informal labor markets. As seen in Figure 11, wage changes are more pronounced for informal than for formal households.

Figure 11: Income effect on labor supply



Note: In the figure, w represents the wage per hour, and n represents the number of hours worked. Point A shows the initial equilibrium before the monetary shock, while point B reflects the new equilibrium after both direct and indirect impacts. The gray area represents the total income loss in the new equilibrium. The arrows indicate the direction of shifts in labor demand and supply. The graph shows that the reduction in labor demand is more pronounced for informal jobs than for formal jobs. It also demonstrates that if the increase in labor supply is more significant for informal jobs, then at the new equilibrium (point B), the change in employment (in hours) is roughly equal between formal and informal jobs. Also, wages would decline more sharply for informal jobs, emphasizing that informal wages are more volatile than formal wages.

4.2.2. Decomposition of the Transmission Channels in the Peruvian Labor Market

Output and inflation. In this subsection, we examine the model from section 4.2.1 to disentangle the contributions of informality and HtM households to the impulse response functions (IRFs). We use the same parameters as in Section 4.2.1 but modify the composition of HtM households (λ), formal HtM households (χ), and formal Ricardian households (κ) (see parameter details in the annex: Tables A11 and A12). Figure 12 illustrates the IRFs in response to an unexpected increase in the nominal interest rate using a CRRA (Constant Relative Risk Aversion) utility function. On the other hand, Figure 14a illustrates the IRFs using a GHH (Greenwood-Hercowitz-Huffman) utility function. Each case focuses on aggregate output and inflation, while Figure 14 extends the analysis to the labor market, covering formal and informal wages and hours worked.

As shown in Figures 12, 14a, and 14, there are four lines with different colors, each representing a different model. The blue dashed line represents the RANK (Representative Agent

New Keynesian) model, which assumes there are no HtM households ($\lambda = 0$) and that Ricardian households are equally distributed between formal ($\kappa = 0.5$) and informal jobs ($\chi = 0.5$). This RANK model serves as the baseline. The other three lines represent different TANK (Two-Agent New Keynesian) models. The first TANK model, represented by the red line, assumes that 60% of households are HtM ($\lambda = 0.6$), with both Ricardian and HtM households equally split between formal ($\kappa = 0.5, \chi = 0.5$) and informal jobs. This means that 50% of Ricardian households are in formal jobs, and similarly, 50% of HtM households are in formal jobs. The second TANK model, shown by the green line, also assumes that 60% of households are HtM ($\lambda = 0.6$), but allocates most Ricardian households to informal jobs ($\kappa = 0.1$) and most HtM households to formal jobs ($\chi = 0.9$). This allocation implies that 10% of Ricardian households are in formal jobs, while 90% of HtM households are in formal jobs. Although this distribution is the opposite of what is observed in the data, it serves a useful purpose for comparison. The third TANK model, represented by the black line, maintains the same proportion of HtM households ($\lambda = 0.6$) but assumes that most Ricardian households have formal jobs ($\kappa = 0.9$), while most HtM households are in informal jobs ($\chi = 0.1$). This means that 90% of Ricardian households are in formal jobs, while only 10% of HtM households are in formal jobs.

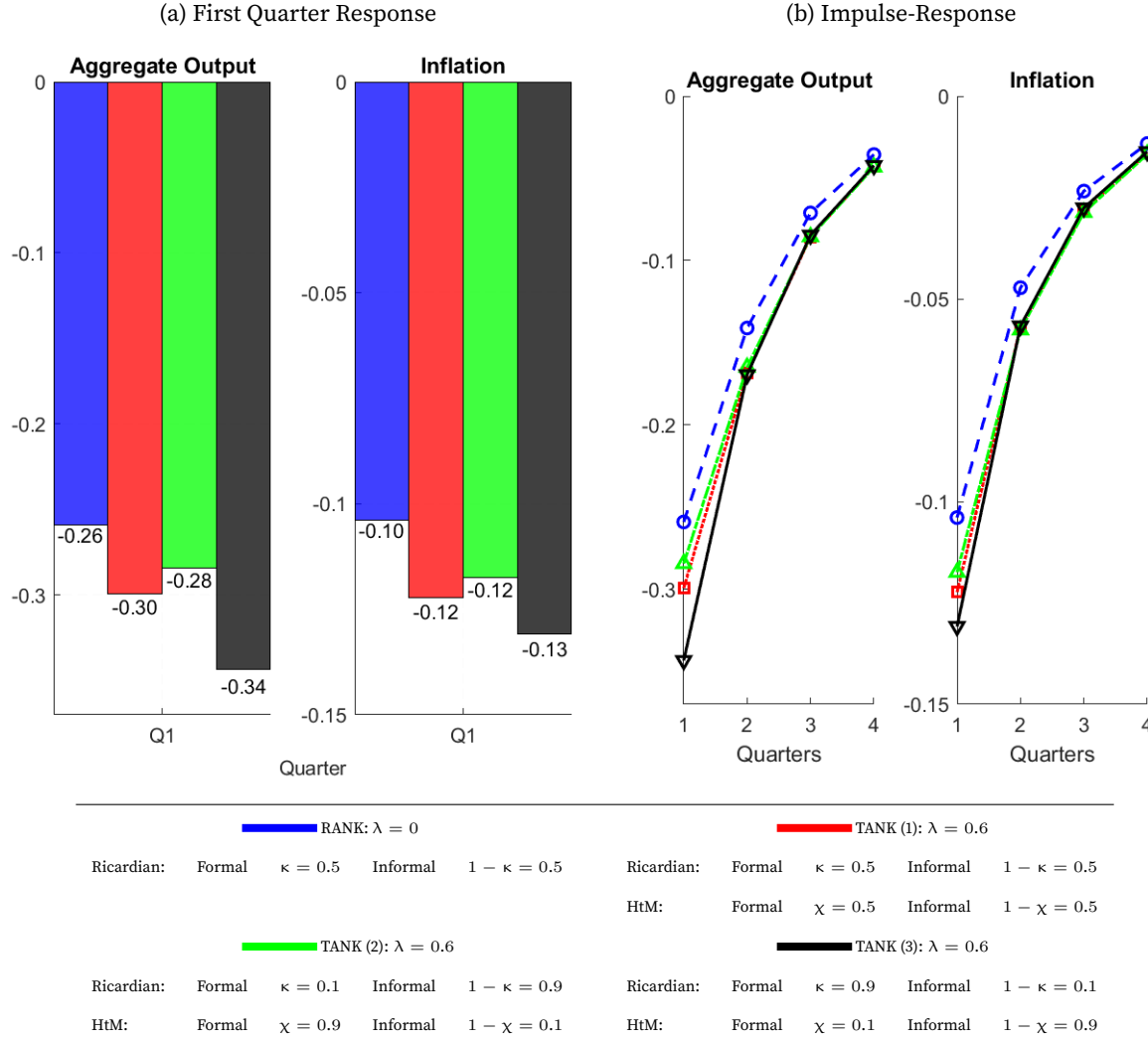
To understand the impact of monetary policy on different household types, we begin by analyzing the Constant Relative Risk Aversion (CRRA) utility function presented in Figure 12. We first examine the RANK model, represented by the blue line, which primarily captures the direct or partial equilibrium effects of monetary policy through the intertemporal substitution channel. In the RANK model, all households are assumed to be Ricardian, with half employed in the formal sector and the other half in the informal sector. Under this baseline scenario, an increase in the interest rate leads to a decrease in aggregate output and inflation.

The key point is how the transmission of monetary policy changes when there is a significant proportion of HtM households. For example, if 60% of households are HtM, as observed in the Peruvian case, how does this affect the central bank's transmission mechanism? To explore this, we compare the RANK model with a version where the only differing parameter is the proportion of HtM households, while the distribution of households across formal and informal sectors remains the same. This comparison is between the RANK model (blue line) and the TANK (1) model, represented by the red line. The TANK (1) model demonstrates that the presence of HtM households strengthens the transmission of monetary policy. The gap between the blue and red lines indicates that a larger share of HtM households makes monetary policy more effective, all else being equal. This difference reflects the general equilibrium, or indirect, effect of monetary policy (see Figure 12a).

Having captured the traditional two channels of monetary policy transmission, the direct and indirect effects, we now examine how the interaction between HtM households and informality may alter the transmission mechanism. Using TANK (1) as the new baseline, we ask: Given that 60% of households are HtM, how does a change in the distribution of household types across formal and informal labor markets affect monetary policy transmission? To explore this, we create two additional models: TANK (2) and TANK (3). The difference between these models lies in their bias toward one of the labor markets. TANK (2) reflects a scenario

where most HtM households are formal workers, while TANK (3) represents a case where most HtM households are informal workers.

Figure 12: Unexpected rise on interest rate (CRRA utility function): output and inflation



Note: The graphs show the dynamics of total output and inflation over four quarters under different economic models (RANK and three variants of TANK) and CRRA utility function. The RANK (Representative Agent New Keynesian model), represented by the blue dashed line, assumes no HtM households ($\lambda = 0$) and an equal split of Ricardian households between formal ($\kappa = 0.5$) and informal jobs ($\chi = 0.5$). The TANK (Two-Agent New Keynesian) models include three variants, each with different allocations: TANK (1), shown by the red line, assumes that HtM households make up 60% ($\lambda = 0.6$) of the total, with both Ricardian and HtM households equally split between formal ($\kappa = 0.5, \chi = 0.5$) and informal jobs ($1 - \kappa = 0.5, 1 - \chi = 0.5$). TANK (2), depicted by the green line, also assumes that HtM households constitute 60% ($\lambda = 0.6$) of the total, but with most Ricardian households in informal jobs ($\kappa = 0.1$) and most HtM households in formal jobs ($\chi = 0.9$). TANK (3), represented by the black line, maintains the same proportion of HtM households ($\lambda = 0.6$) but assumes most Ricardian households have formal jobs ($\kappa = 0.9$) while most HtM households have informal jobs ($\chi = 0.1$).

We first compare TANK (1) with TANK (2) to examine how a reduction in the interaction between informality and HtM households affects monetary policy transmission. As shown in Figure 12a, the impact of monetary policy is weaker in TANK (2) compared to TANK (1), primarily because a smaller proportion of HtM households are employed in the informal sector,

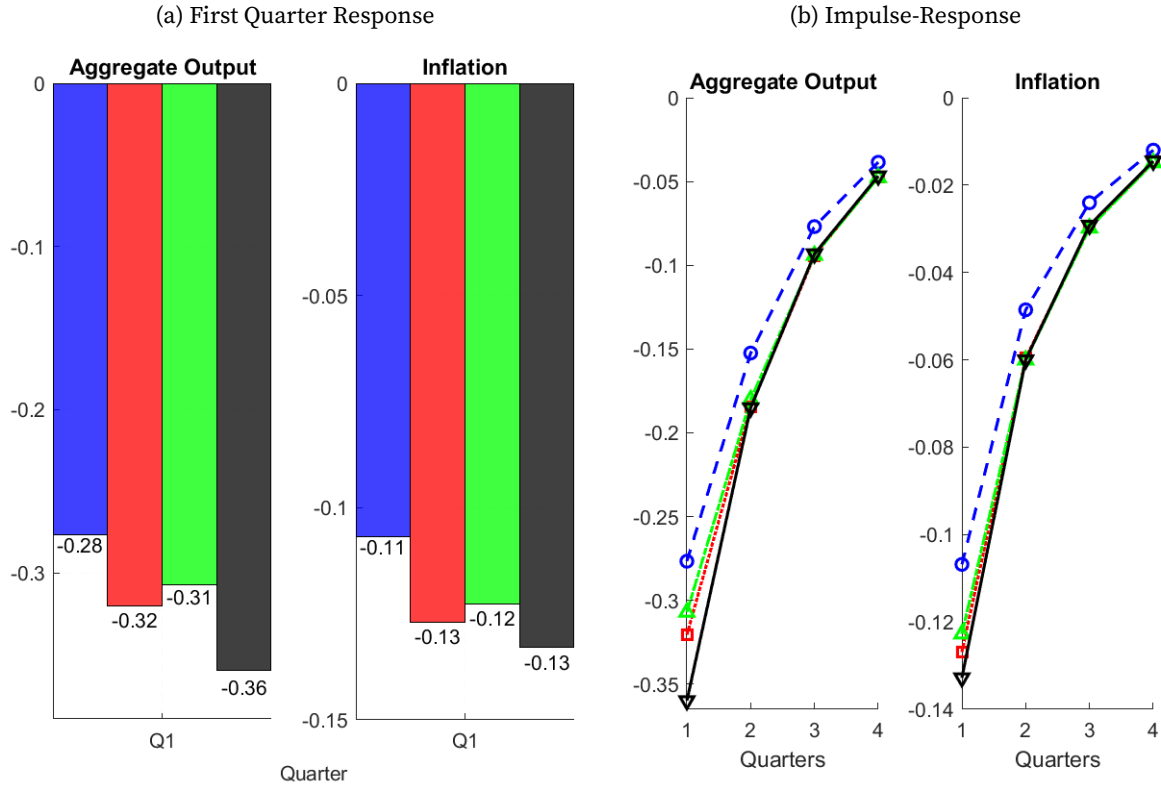
reducing the overall general equilibrium effect. Next, we examine what happens when we increase the interaction between informality and HtM households, as observed in Peruvian data, by comparing TANK (1) with TANK (3). This scenario results in a greater initial impact on both aggregate output and inflation, as seen by the difference between the red (TANK (1)) and black (TANK (3)) lines. Therefore, the interaction between HtM households and informal employment enhances the transmission power of monetary policy (see Figure 12a). Specifically, our model predicts an increase in monetary policy effectiveness by approximately 4 percentage points compared to TANK (1), and nearly 8 percentage points stronger than the RANK model. While the effect on inflation is somewhat weaker than on output, the interpretation remains the same. Overall, the distribution of HtM households amplifies the transmission of monetary policy.

Let us now focus on Figure 14a, which uses the GHH (Greenwood, Hercowitz, and Huffman) utility function—a distinctive utility specification that eliminates the income effect on labor supply. In other words, under GHH preferences, the labor supply does not shift when wages decrease. In figure 14a, we apply the same parameters as in Figure 12 (see Table A12 for details) but use the GHH utility function instead of the CRRA utility function. The blue, green, red, and black lines retain the same meaning as in figure 12. As shown, a similar pattern emerges: the interaction between informality and HtM households amplifies the effects of monetary policy on both aggregate output and inflation. But why does the GHH utility function exhibit a slightly larger effect on output? Since GHH preferences eliminate the income effect on labor supply, informal employment becomes more volatile, leading to a stronger output reaction to shocks.

Labor Market. Another important point is how the labor market behaves under the same conditions as in Figure 12. Figure 14 examines both informal and formal labor markets, with the line colors maintaining the same meanings as in Figure 12. Focusing on Panel (a) of Figure 14, we observe that informal wages are more volatile than formal wages, which is consistent with the data. Meanwhile, informal hours are only slightly more volatile than formal hours. This raises the question: why are informal hours only marginally more volatile than formal hours, given that adjustment costs apply exclusively to formal jobs? Theoretically, we would expect greater volatility in informal hours. The reason, as shown in Figure 11, is a rightward shift in the labor supply curve, which dampens the volatility of employment.

Thus, when using the GHH utility function instead of the standard CRRA function, we find two key outcomes: first, the volatility of both formal and informal wages remains relatively stable compared to the CRRA utility function. Second, without the income effect on labor supply, informal hours become more volatile than formal hours, aligning with the explanation provided in Figure 11.

Figure 13: Unexpected rise on interest rate (GHH utility function): output and inflation



Note: The meaning of the the colors are the same than figure 12. However, in this case, the utility function used is GHH.

4.2.3. Decomposition of the Transmission Channels in the U.S. Labor Market

Finally, we propose an exercise that models the U.S. economy to analyze how changes in the percentage of HtM households or shifts in the composition of formal and informal employment could affect the Federal Reserve's transmission power³². This analysis is illustrated in Figure 15. As explained in Section 4.2.2, Figure 15 includes four different lines, each represented by a distinct color: one for the RANK model and three for the TANK models. Although the methodology is similar to that in Section 4.2.2, the baseline assumptions differ.

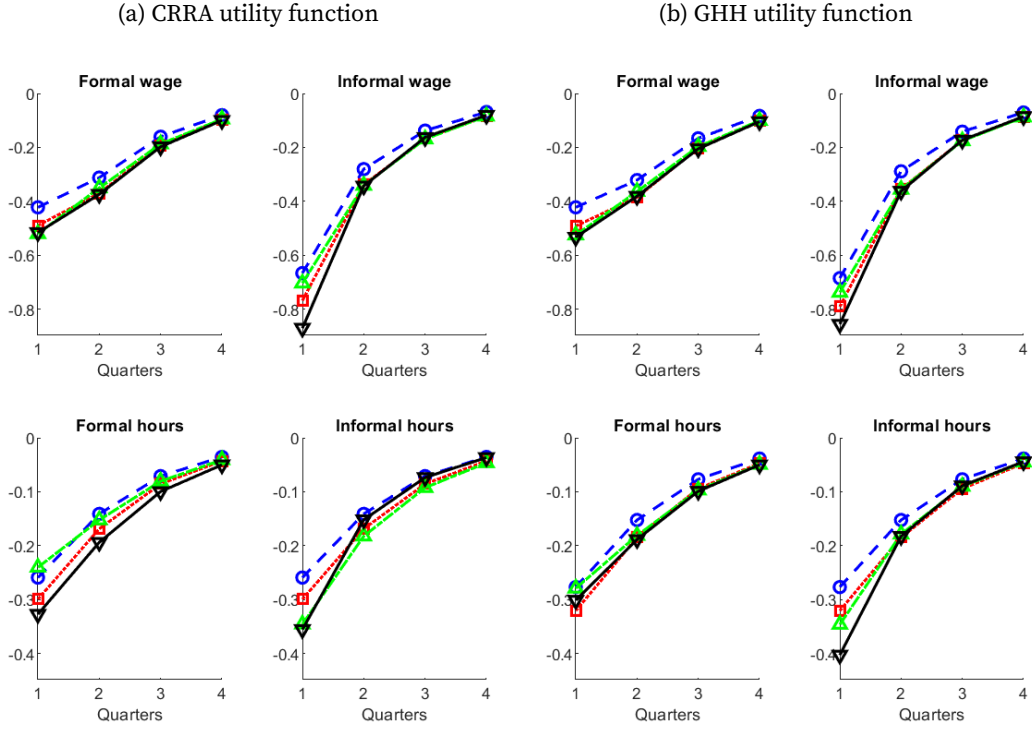
We begin with Panel (a), where the total proportion of HtM households is set to 10% ($\lambda = 0.1$). For the U.S., we assume this λ aligns closely with the definition of poor hand-to-mouth (P-HtM) households. According to Kaplan et al. (2014), the proportion of P-HtM households in the U.S. and other developed countries is around 10%. Hence, the TANK (1), TANK (2), and TANK (3) models are estimated using $\lambda = 0.1$. Additionally, based on estimates from Bracha and Burke (2014), the informal labor participation rate for full-time workers in the U.S. is around 11%³³. For this exercise, we assume a 10% informality rate, applied equally across both Ricardian and HtM households, setting $\kappa = 0.9$, $\chi = 0.9$. These values establish our baseline cases.

Now, let us examine the models. The RANK model (blue line) assumes that P-HtM house-

³²See annex, table A13, for parameter details

³³Calculated as a simple average of participation in personal services, consignment sales, online sales, and property rentals. As shown in Figure 3, Bracha and Burke (2014).

Figure 14: Unexpected rise on interest rate: labor market

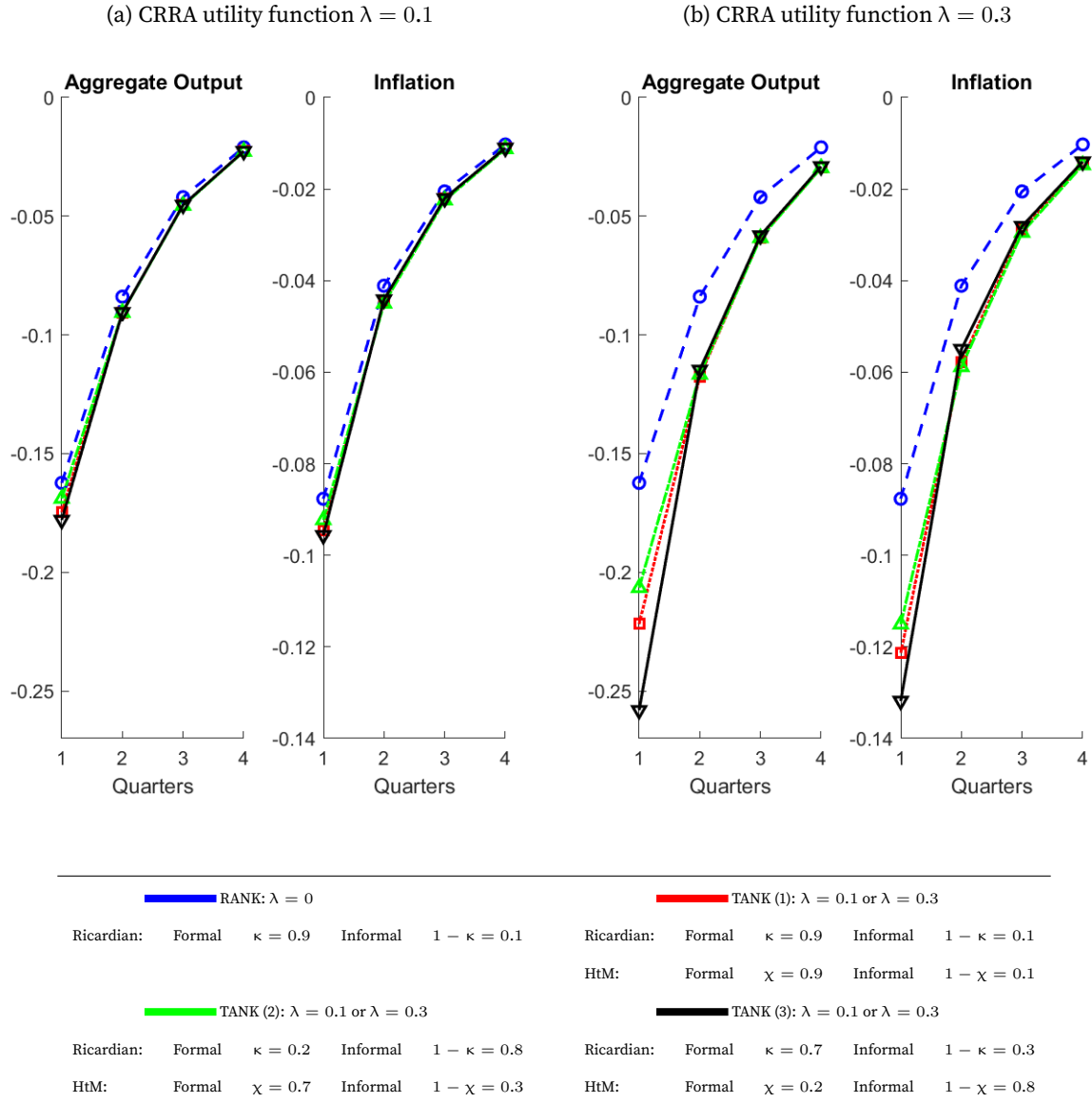


Note: The graphs show the dynamics of formal and informal wages and hours over four quarters under different economic models (RANK and three variants of TANK) and utility functions (CRRA and GHH). The meaning of the the colors are the same than figure 12.

holds do not exist. The TANK (1) model (red line) assumes that P-HtM and Ricardian households are equally formal, with $\kappa = 0.9$ and $\chi = 0.9$. TANK (2) represents a situation where the informalization of the U.S. labor market disproportionately affects Ricardian households, making them more informal relative to P-HtM households. Although this scenario is unlikely, it is included for completeness. TANK (3), on the other hand, presents a more plausible case: here, the informalization of the labor market significantly impacts P-HtM households more than Ricardian households, resulting in the rate of informal employment among P-HtM households increasing from 10% to 80%. Thus, TANK (3) assumes that 80% of P-HtM households in the U.S. will be employed informally.

Focusing on Panel (a), we compare TANK (1) (red line) with TANK (3) (black line). If the proportion of P-HtM households remains stable at 10%, but labor market informality increases (for example, due to new regulations that raise firing costs and make the labor market more rigid), there is no substantial change in the Federal Reserve's transmission power. However, as shown in Panel (b), if both the proportion of P-HtM households increases from 10% ($\lambda = 0.1$) to 30% ($\lambda = 0.3$) and labor market informality expands, the Federal Reserve's impact on GDP and inflation is significantly enhanced. This suggests that the interaction between informality and the proportion of P-HtM households would amplify the Federal Reserve's transmission power.

Figure 15: Unexpected rise on interest rate: output and inflation



Note: The graphs show the dynamics of total output and inflation over four quarters under different economic models (RANK and three variants of TANK) and different proportions of hand-to-mouth households (λ). The RANK (Representative Agent New Keynesian model), represented by the blue dashed line, assumes no HtM households, and Ricardian households are divided between formal ($\kappa = 0.9$) and informal jobs ($\chi = 0.9$). The TANK (Two-Agent New Keynesian) models include three variants with different allocations: TANK (1), shown by the red line, assumes that both Ricardian and HtM households are divided between formal ($\kappa = 0.9, \chi = 0.9$) and informal jobs ($1 - \kappa = 0.1, 1 - \chi = 0.1$). TANK (2), depicted by the green line, assumes that most Ricardian households have informal jobs ($\kappa = 0.2$) while most HtM households have formal jobs ($\kappa = 0.7$). TANK (3), represented by the black line, assumes most Ricardian households have formal jobs ($\kappa = 0.7$) while most HtM households have informal jobs ($\chi = 0.2$).

5. Conclusions

In conclusion, this paper highlights the important link between labor informality and monetary policy—two topics that are not often studied together. By addressing gaps in the existing research, such as the lack of data on informality and the need for improved models to better understand informal labor markets, we help clarify how informal employment influences the transmission of monetary policy. This approach provides a more accurate understanding of monetary policy's impact, particularly in developing economies where informality plays a larger role.

First, the lack of reliable data on labor informality poses a significant challenge for researchers and policymakers. Using data from Peru's National Household Survey (ENAHU), this paper provides a detailed examination of how labor informality affects household consumption and employment. Our findings reveal that more than 90% of hand-to-mouth households work in the informal sector, while about 50% of Ricardian households are employed in the formal sector.

Second, our results on the marginal propensity to consume (MPC) highlight important differences between informal and formal households. Informal households tend to have a much higher MPC, particularly in response to transitory income. Additionally, our analysis of business cycle dynamics shows that informal workers experience larger income fluctuations, especially during economic downturns. This suggests that informal workers are more vulnerable during recessions.

Third, this paper introduces and calibrates a Two-Agent New Keynesian (TANK) model to better capture the role of informal labor markets. This model divides households into Ricardian and hand-to-mouth groups, reflecting the dual nature of labor markets in developing economies. Our simulations show that informal labor amplifies the effects of monetary shocks because hand-to-mouth households in the informal sector are highly sensitive to changes in income, leading to larger effects on production.

These findings have clear policy implications. In economies with a large informal labor sector, monetary policy has stronger effects on both inflation and output compared to economies where most workers hold formal jobs. Policymakers need to consider the structure of labor markets—especially the vulnerability of informal workers—when implementing monetary policy. Ignoring these factors could result in unintended consequences, such as overheating the economy or misjudging inflationary pressures.

Nevertheless, important questions remain unanswered, as they fall beyond the scope of this paper. For instance, the interaction between fiscal policies, such as fiscal rules, and informal labor markets requires further analysis. Additionally, a deeper investigation into the relationship between monetary policy and informal credit markets, and how monetary transmission affects informal credit rates, is needed. An extension of this paper could also involve analyzing optimal monetary policy in the context of informal labor markets.

In summary, this paper provides an important step toward developing models that account for differences in labor markets, particularly in developing countries where informality is widespread. By combining detailed household data with a more refined economic framework,

we offer a clearer understanding of how informal labor markets shape the effects of monetary policy. However, further progress will depend on the availability of better and more detailed data on labor informality.

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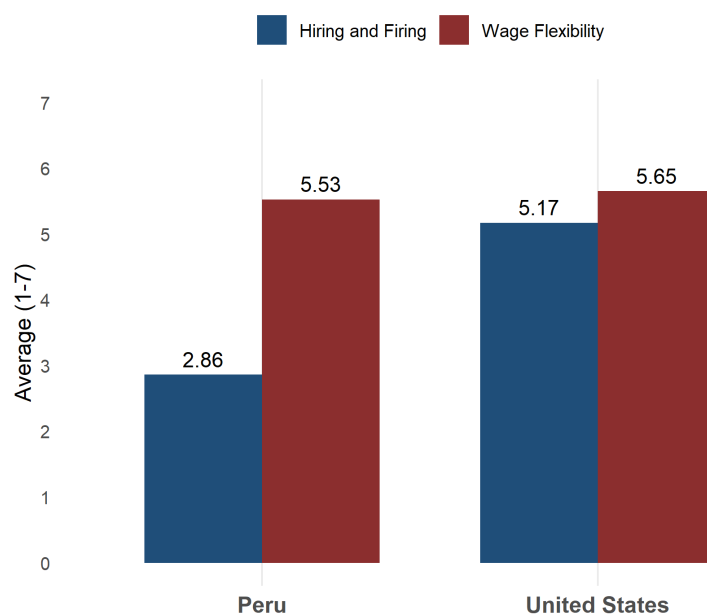
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Online Appendix

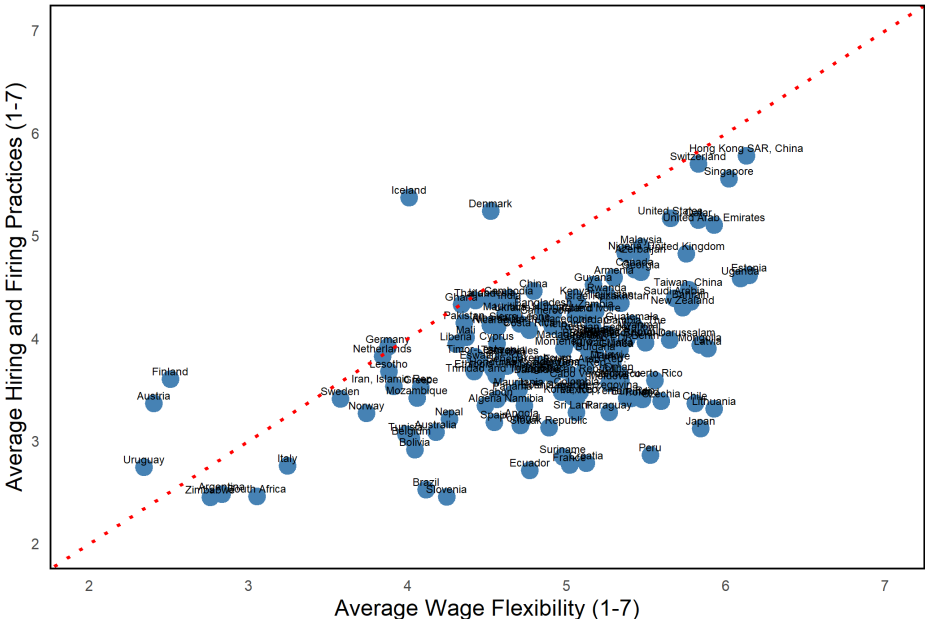
Appendix A. Annex Subsection 2.1

Figure A1: Average Wage Flexibility and Hiring/Firing Practices (2012-2019): USA and Peru



Notes: We use the Global Competitiveness Index (GCI), focusing on the "Efficient Labor Markets" pillar. Within this, we examine two sub-categories: (1) Hiring and firing practices, rated from 1 to 7 (with 7 being the best), and (2) Flexibility of wage determination, also rated from 1 to 7 (with 7 representing the highest flexibility).

Figure A2: Average Wage Flexibility and Hiring/Firing Practices (2012-2019)



Notes: We use the Global Competitiveness Index (GCI), focusing on the "Efficient Labor Markets" pillar. Within this, we examine two sub-categories: (1) Hiring and firing practices, rated from 1 to 7 (with 7 being the best), and (2) Flexibility of wage determination, also rated from 1 to 7 (with 7 representing the highest flexibility). The red dotted line represents a 45-degree line.

Appendix B. Annex Subsection 2.2

B.1. Modules we used in the ENAHO

In total, we have utilized data from 19 different modules of the survey. The first five modules collect detailed information on household and member characteristics, including housing materials, civil status, age, education, health, employment, and income (Modules 01: Characteristics of the Housing and the Household; 02: Characteristics of the Household Members; 03: Education; 04: Health; 05: Employment and Income). Twelve modules focus on household expenditures, capturing data on a broad spectrum of spending categories, from basic needs like food and beverages to transportation, recreation, culture, and more (Modules 07: Food and Beverage Expenditures; 08: Charitable Institutions; 09: Housing Maintenance; 10: Transportation and Communications; 11: Housing Services; 12: Recreation, Entertainment, and Cultural Services; 13: Clothing and Footwear; 15: Transfer Expenditures; 16: Furniture and Household Goods; 17: Other Goods and Services; 18: Household Equipment; 78: Personal Care Goods and Services). The final two modules provide summary data and insights into institutional variables (Modules 34: Summaries (calculated variables); 85: Governance, Democracy, and Transparency). In this paper, we specifically use Module 34 to calculate total household expenditure and Module 05 to obtain employment and income information. Through these modules, we can determine whether a worker is employed in the formal or informal sector.

B.2. Estimation of informality in the ENAHO

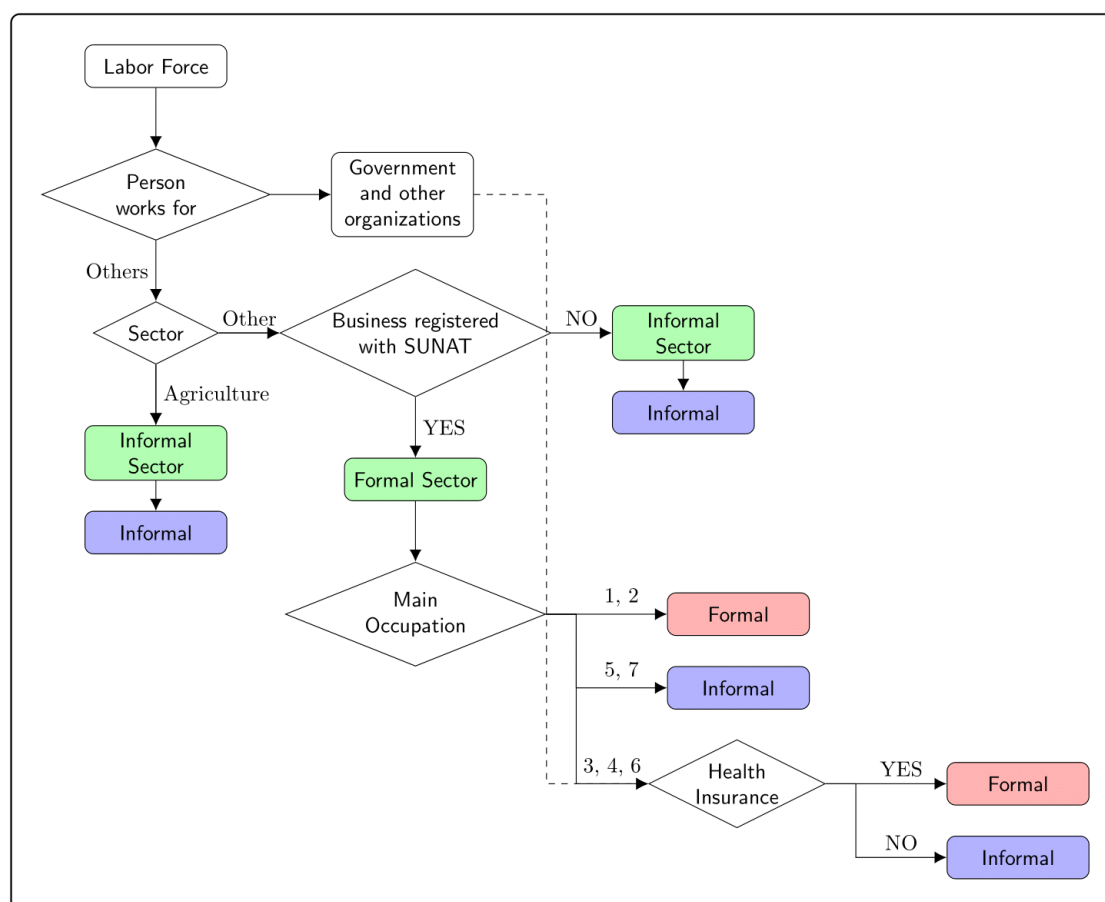
To determine whether a job is formal or informal, we follow a specific procedure, as illustrated in Figure A3, which outlines the steps for segmenting the labor force by sector and informal employment. The first step involves asking whether the individual works for the government or other institutions such as the armed forces, police, public administration, or state-owned enterprises. If they do not work for the government, we then inquire about the sector in which they are employed. If the person works in the agricultural sector, their employment is automatically classified as informal. However, if the worker is not in the agricultural sector, the next step is to determine the registration status of the business providing the job. If the business is officially registered, the worker is categorized as being in the formal sector; if not, the worker is assumed to be in the informal sector.

While we assume that all workers in the informal sector are informal workers, not all workers in the formal sector are considered formal. To clarify this distinction, we ask an additional question regarding the individual's main occupation. The options include employer, self-employed, white-collar worker, blue-collar worker, unpaid family worker, domestic worker, and others. If the main occupation is "employer" or "self-employed," the job is automatically classified as formal. Conversely, if the occupation falls under the categories of unpaid family worker or "others," it is classified as informal. For occupations classified as white-collar worker, blue-collar worker, or domestic worker, we ask an additional question about health insurance. In Peru, health insurance is mandatory for formal workers. If the worker does not have health insurance, we classify their job as informal. If they confirm that their employer

provides health insurance, the job is categorized as formal.

An additional consideration is that some workers may be classified as informal even if they work for the government. In rare cases, government or government-affiliated enterprises might hire workers without a formal contract or health insurance, technically classifying these workers as informal. Although uncommon, this situation is important for statistical purposes, which is why we distinguish between government employment and other organizations when addressing the health insurance question.

Figure A3: Procedure for segmenting the labor force by sector and informal employment



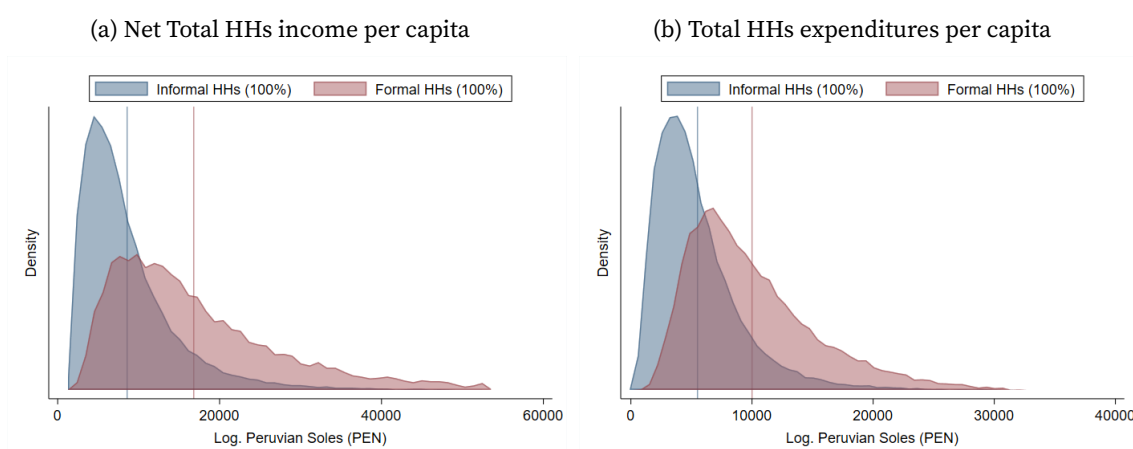
Notes: ENAHO – updated methodology. The categories in the flowchart are: (1) Employer, (2) Self-employed, (3) White-collar worker, (4) Blue-collar worker, (5) Unpaid family worker, (6) Domestic worker, and (7) Other.

B.3. Income and Consumption Distribution

Figure A4 illustrates the distribution of income and consumption among informal and formal households. As defined earlier, "informal households" are those in which all members are employed in informal jobs, while the term "formal households" applies to those where all members hold formal jobs. The data reveal that the income and consumption distributions for both

household types are positively skewed, with formal households typically earning and consuming more than informal households. Two vertical lines in the figure represent the average incomes of informal and formal households, respectively, making it clear that formal households tend to have higher average income and consumption levels. Figure A4 also show that income is generally more volatile than consumption, with formal households experiencing less overall volatility. Furthermore, there is some overlap in the income distributions, indicating that some informal households have incomes exceeding those of certain formal households. Overall, these figures demonstrate that formal households tend to enjoy higher incomes and greater consumption compared to their informal counterparts.

Figure A4: Income and consumption distribution, 2012-2023



Note: HHs stands for Households. Panel (a) shows net income per household member, while Panel (b) shows expenditure per household member. The blue density represents households where all members are informal workers, and the red density represents households where all members are formal workers. Mixed households are excluded. Vertical lines indicate the average for each density. The x-axis is in log Peruvian soles, annual and real. The exchange rate is approximately 3 Peruvian soles per USD.

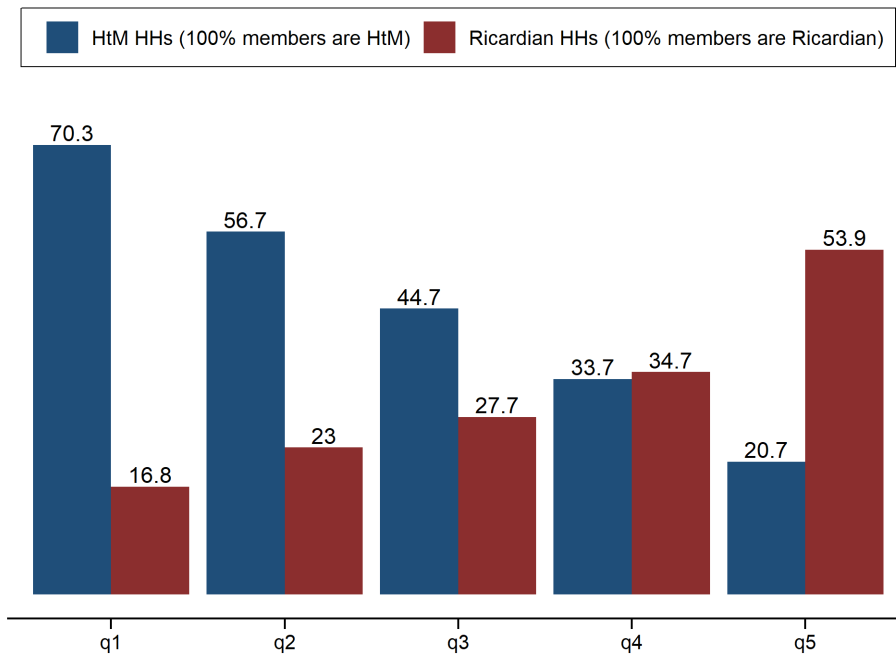
B.4. Different definitions of HtM for Peruvian Data

HtM-1: No Bank Account

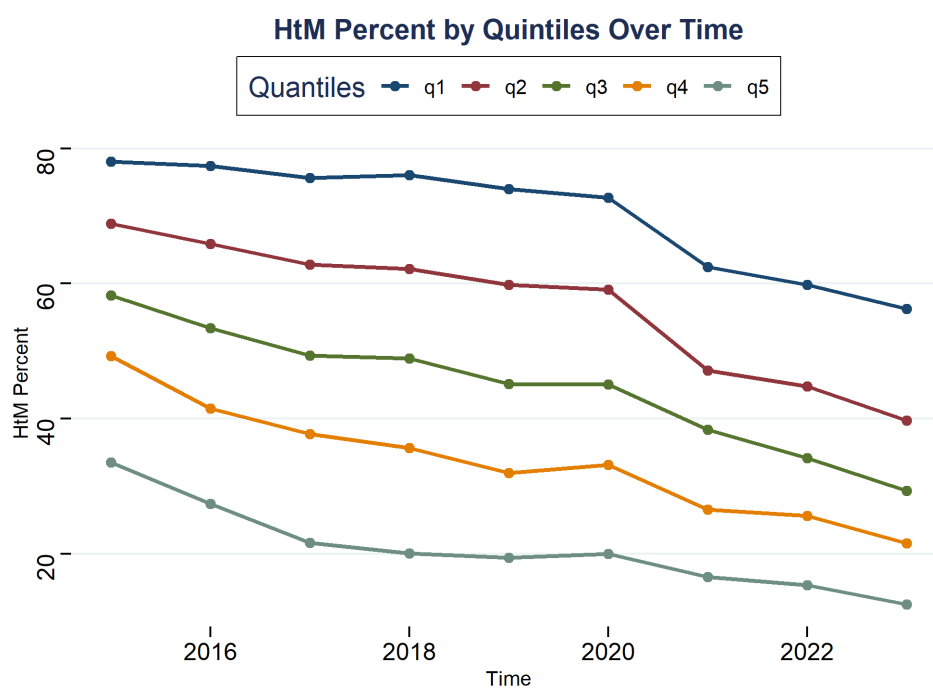
Figure A5: HtM and Ricardian households by income quintiles (2015-2023)

HtM: No Bank Account

(a) Average (2015-2023)



(b) Over time (2015-2023)



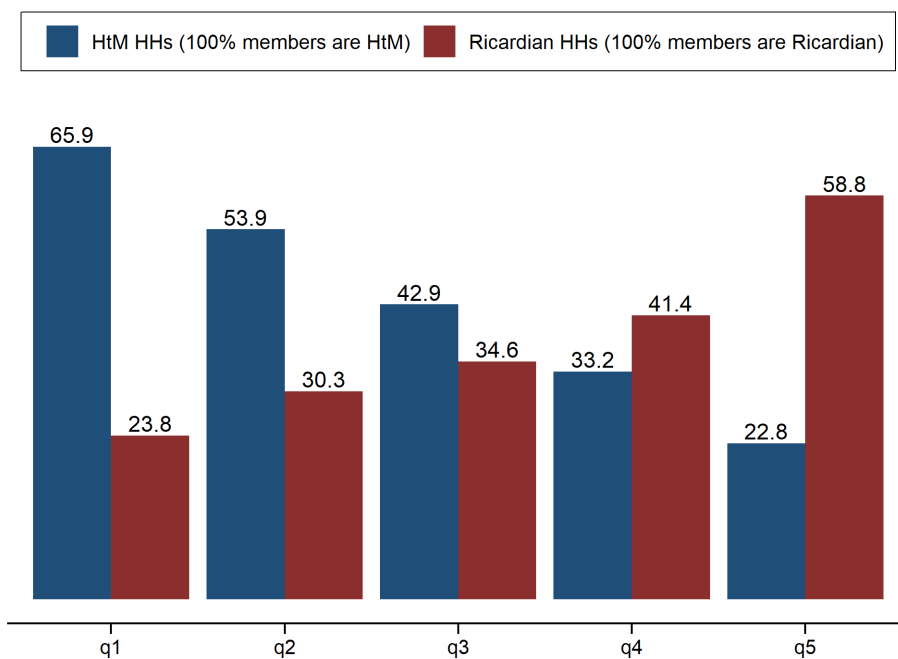
Source: ENAHO- updated methodology.

HtM-2: No Bank Account & No house

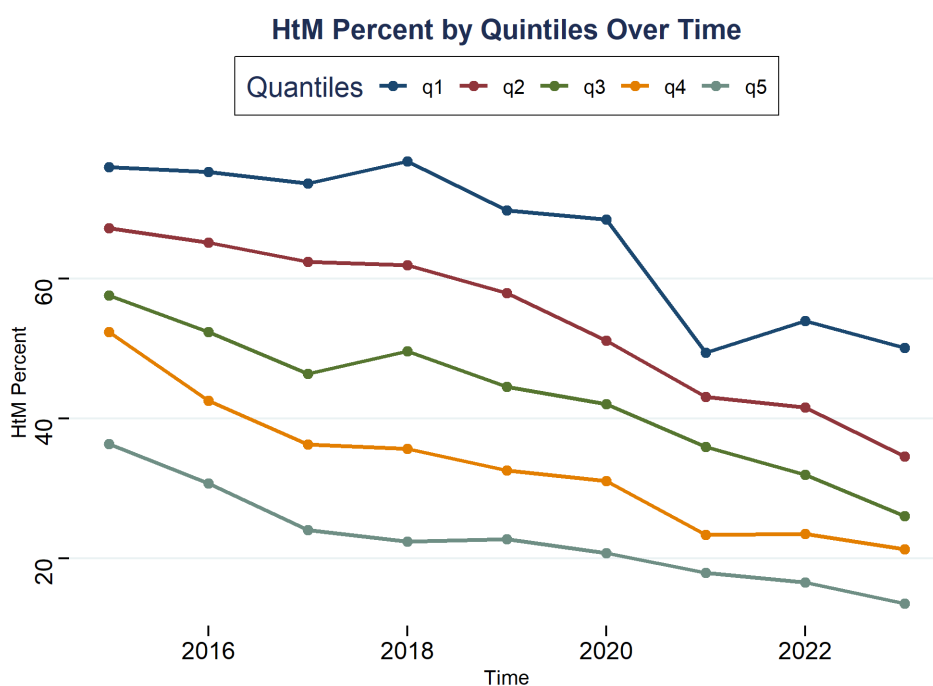
Figure A6: HtM and Ricardian households by income quintiles (2015-2023)

HtM: No Bank Account & No house

(a) Average (2015-2023)



(b) Over time (2015-2023)

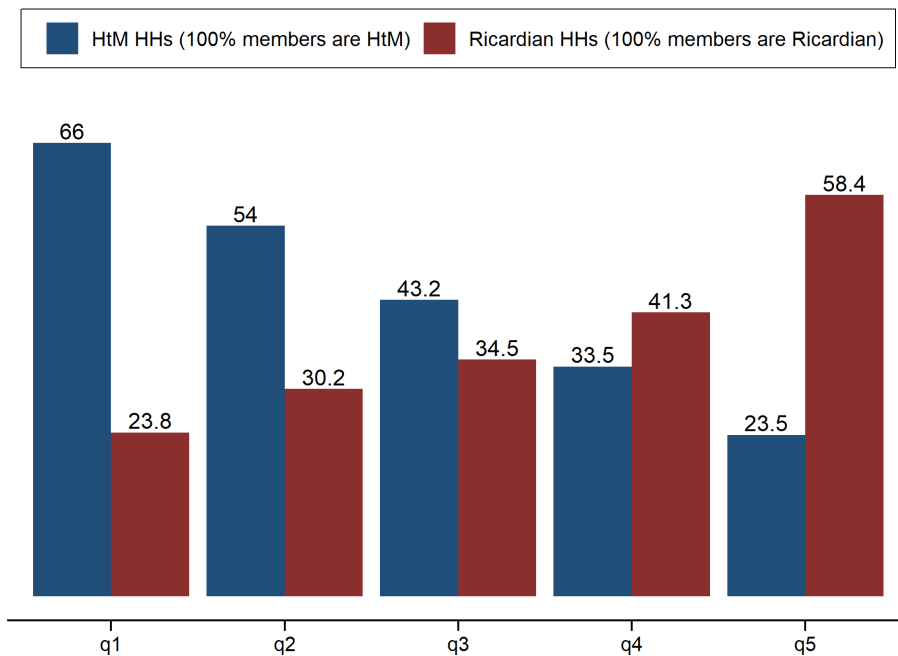


Source: ENAHO- updated methodology.

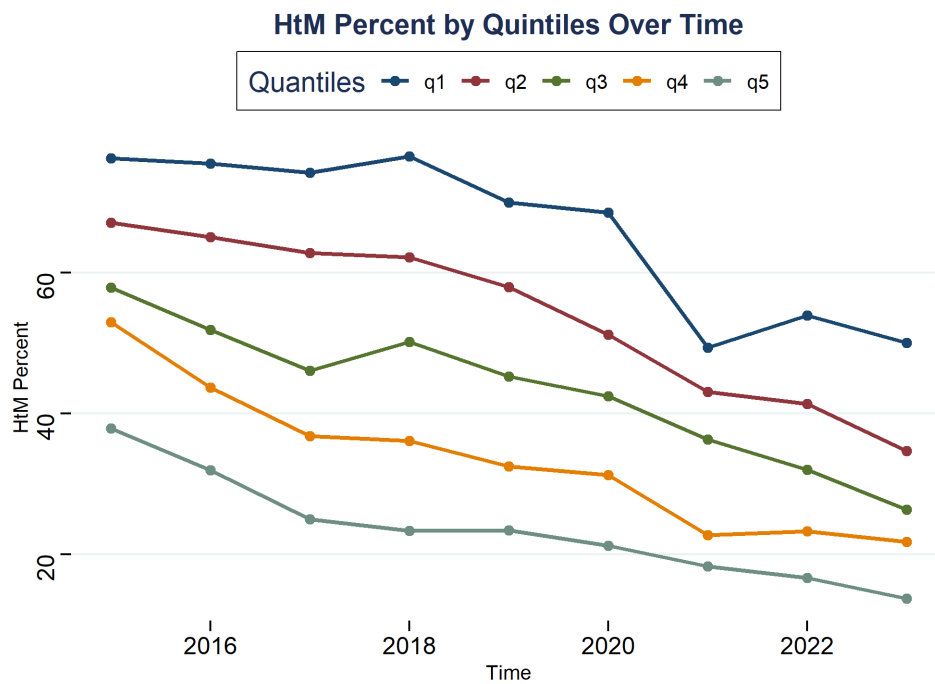
HtM-3: No Bank Account & No house & No Assets

Figure A7: HtM and Ricardian households by income quintiles (2015-2023)
HtM: No Bank Account & No house & No Assets

(a) Average (2015-2023)



(b) Over time (2015-2023)

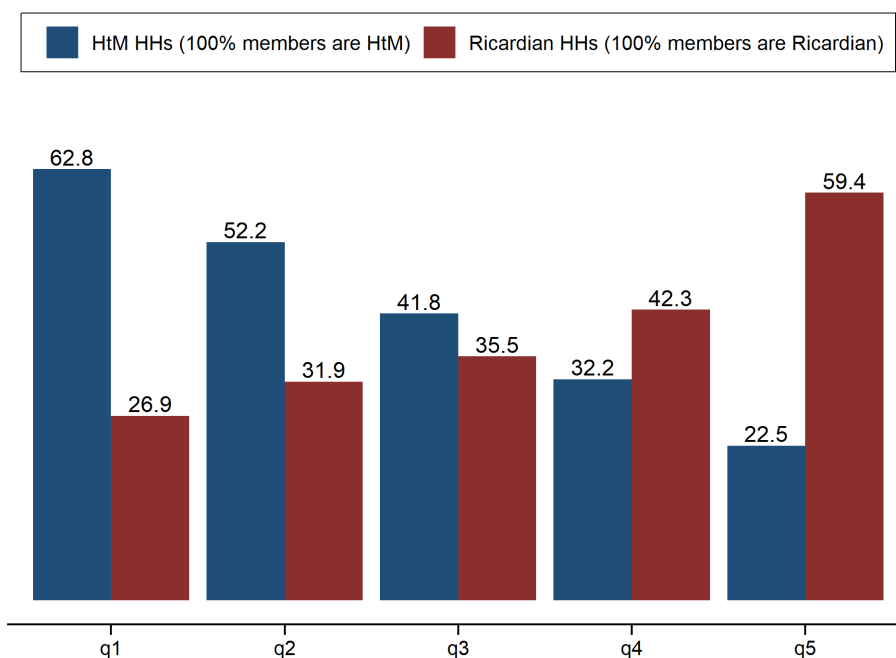


Source: ENAHO- updated methodology.

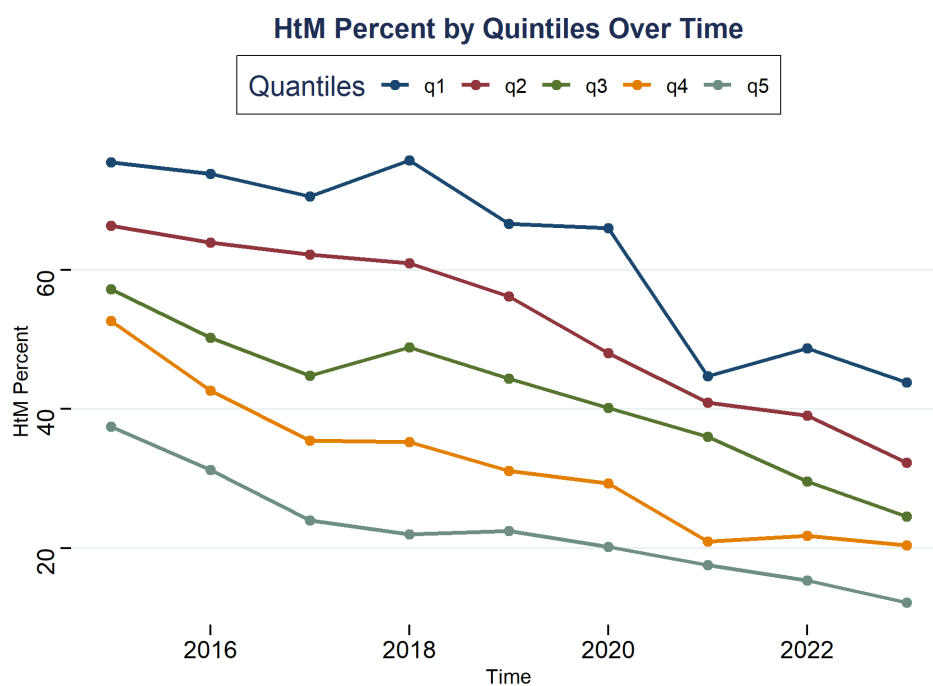
HtM-4: No Bank Account & No house & No Assets & Urban Area

Figure A8: HtM and Ricardian households by income quintiles (2015-2023)
HtM: No Bank Account & No house & No Assets & Urban Area

(a) Average (2015-2023)



(b) Over time (2015-2023)

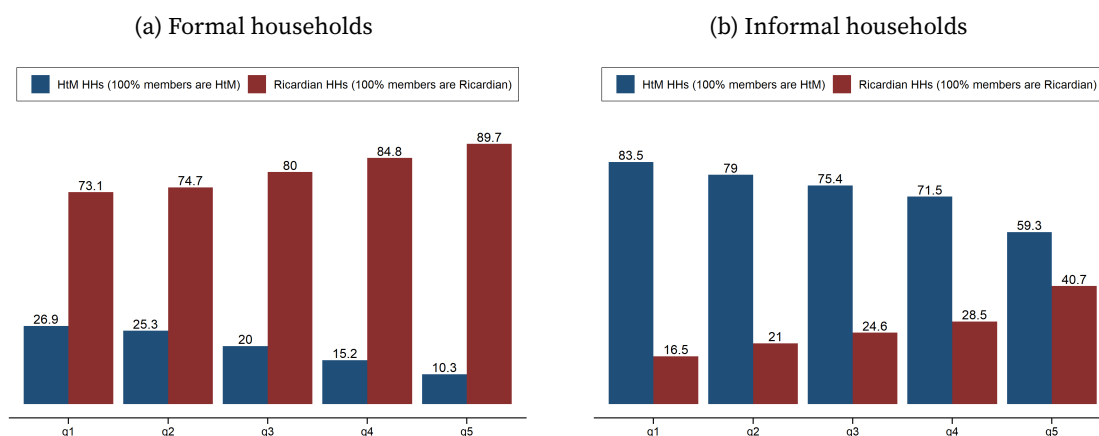


Source: ENAHO- updated methodology.

B.5. Distribution of formal and informal households across different income quintiles: HtM vs Ricardian

Figure A9 further elucidates the analysis in section 2.2.3 by illustrating the distribution of formal and informal households across different income quintiles, distinguishing between HtM and Ricardian households. The first panel shows that formal households are predominantly Ricardian, while the second panel highlights that informal households are primarily HtM. This pattern remains consistent throughout the income distribution. The combined total of the blue and red bars in Figure A9 equals 100%, reflecting the exclusion of mixed households from the analysis.

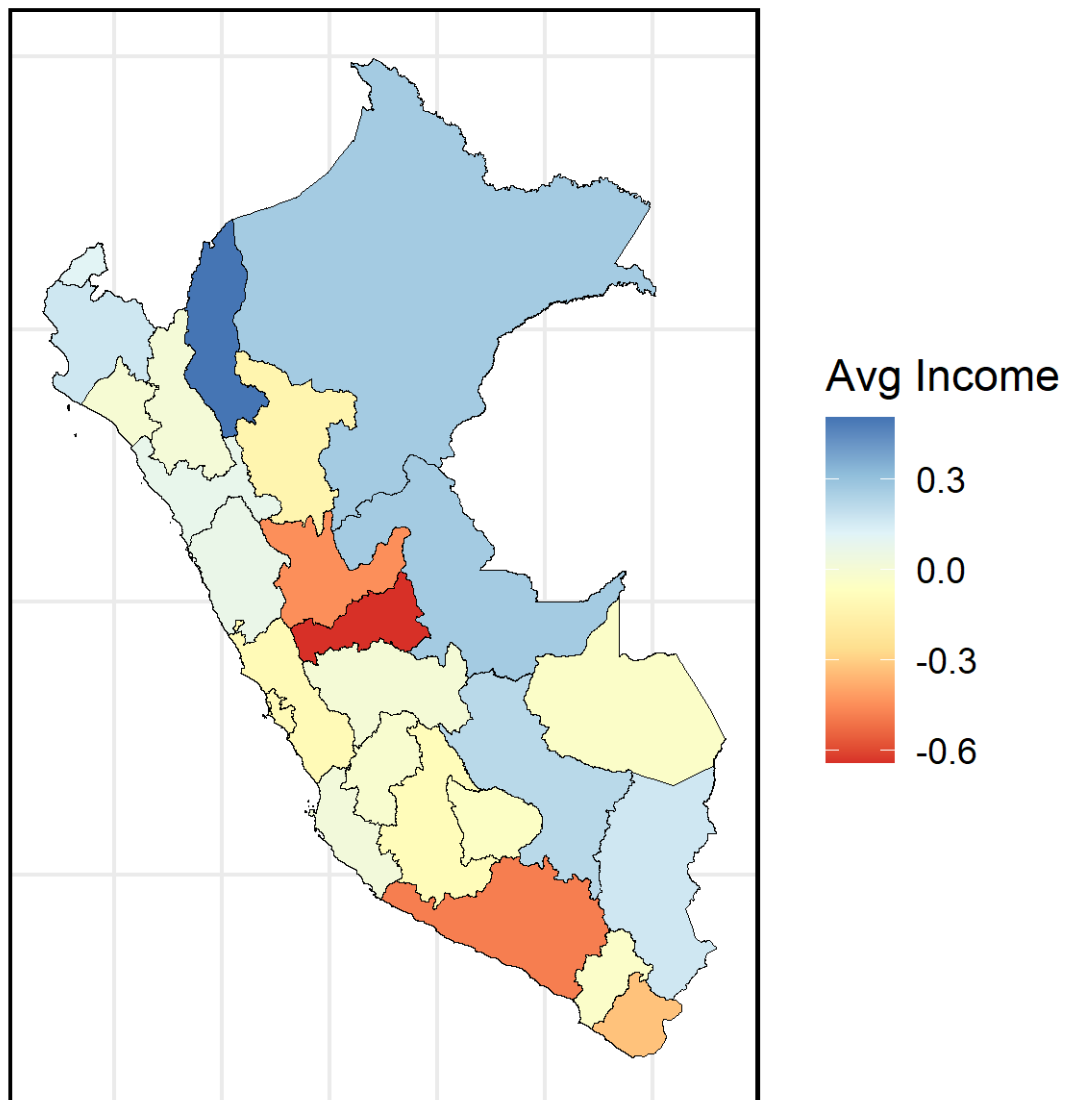
Figure A9: Formal and Informal households by income quintiles and HtM (2015-2023)



Note: Panel (a) shows formal households classified as either Ricardian or HtM. Mixed households, which include both Ricardian and HtM members, are excluded, so the blue and red bars always sum to 100%. Panel (b) shows informal households, also classified as either Ricardian or HtM, with mixed households removed to ensure the blue and red bars sum to 100%. Source: ENAHO – updated methodology.

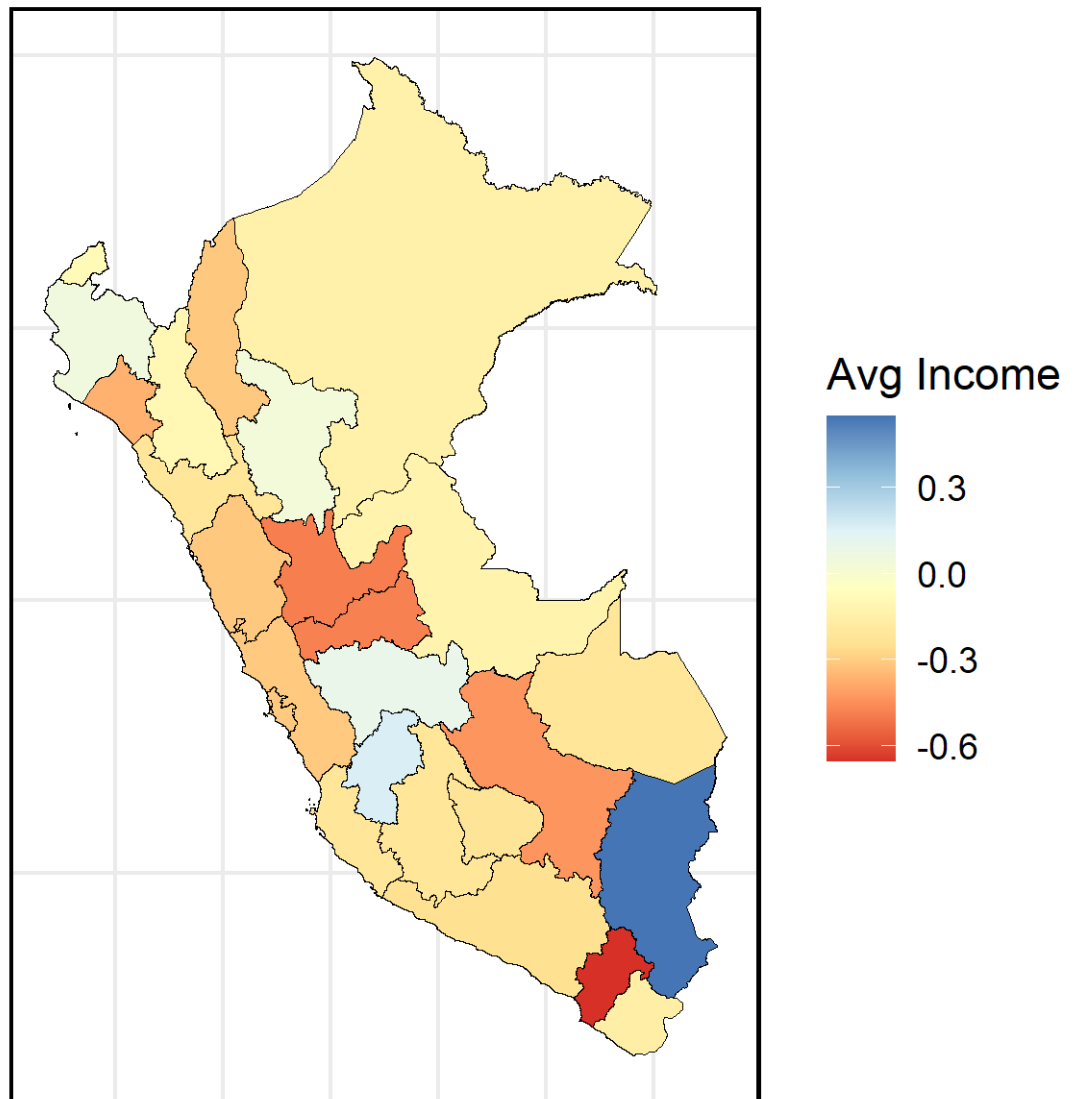
B.6. Income change over business cycles by region

Figure A10: Δ Average Income by geographical region (Formal-Ricardian Households)



Source: ENAHO- updated methodology.

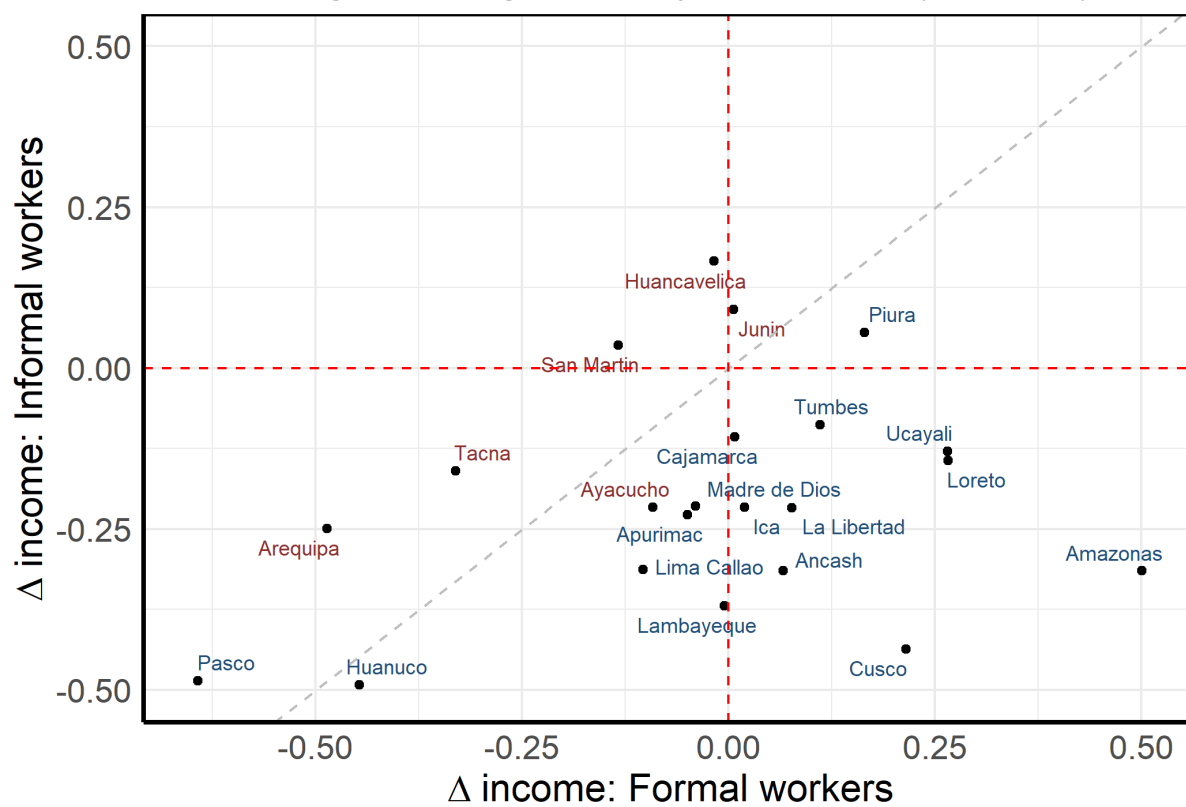
Figure A11: Δ Average Income by geographical region (Informal-HtM Households)



Source: ENAHO- updated methodology.

Figure A12: Δ Average Income by geographical region (2019-2020)

Change on Average Income by labor condition (2019-2020)



Source: ENAHO- updated methodology.

B.7. Some useful parameters for the TANK model

Before implementing the TANK model in the following section, it is crucial to estimate several key parameters. Table A1 details the distribution of households into hand-to-mouth and Ricardian categories from 2015 to 2022. The data shows that approximately 60% of households are classified as hand-to-mouth, while 40% are Ricardian. This indicates that the majority of households in the economy fall into the hand-to-mouth category. Table A2 further examines the interaction between HtM and Ricardian households across the formal and informal sectors. The data reveals that nearly 93% of HtM households are engaged in informal employment, with only about 6% employed formally. In contrast, Ricardian households exhibit a different distribution, with around 54% holding formal jobs and 46% working informally.

Table A1: % of Household who are HtM (2015-2022)

HtM households	$\lambda = 0.6$
Ricardian households	$1 - \lambda = 0.4$

Source: ENAHO- updated methodology.

Table A2: HtM, Ricardian and labor market (2015-2022)

	HtM households	Ricardian households
Formal job	$\chi = 0.06$	$\kappa = 0.54$
Informal job	$1 - \chi = 0.93$	$1 - \kappa = 0.46$
Total	1	1

Source: ENAHO- updated methodology.

B.8. Monetary Policy: formal and informal wages

Alternatively, the study by [Armas et al. \(2023\)](#) allows us to examine the impact of monetary shocks on wages in both formal and informal sectors in Peru. By employing a local projection method, as proposed by [Jordà \(2005\)](#), they estimate impulse response functions (IRFs) to evaluate the effects of an increase in interest rates on real wages for both formal and informal workers before and after the pandemic. Their results, summarized in Figure A13, suggest that monetary policy affects these two labor markets differently, revealing a greater sensitivity in informal wages compared to formal wages, both before and after the pandemic.

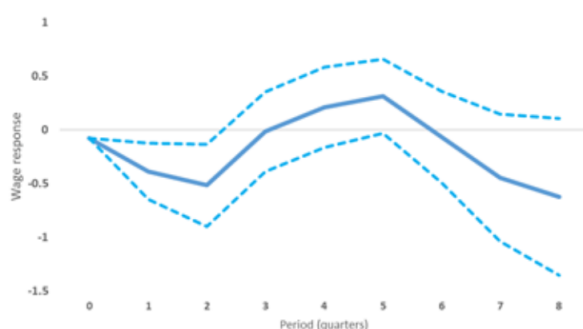
The research conducted by [Armas et al. \(2023\)](#) spans from 2007 to 2022, using quarterly data. The first column in Figure A13 illustrates the pre-pandemic wage responses for formal and informal workers. The analysis shows that, in the short term, informal wages experience

a more pronounced decrease following an interest rate hike compared to formal wages. This stronger initial reaction is likely due to the greater vulnerability of informal workers. However, post-pandemic data in column 2 indicate that formal wages have become more responsive to interest rate changes. Despite this increased sensitivity of formal wages after the pandemic, informal wages remain more responsive to interest rate hikes both before and after the pandemic. This persistent disparity highlights that informal workers are more exposed to monetary shocks.

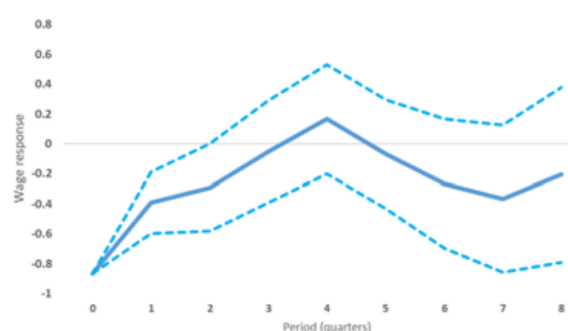
Figure A13: Response of wages to an interest rate shock

(a) Formal wages

A. Formal labour market 2007–19

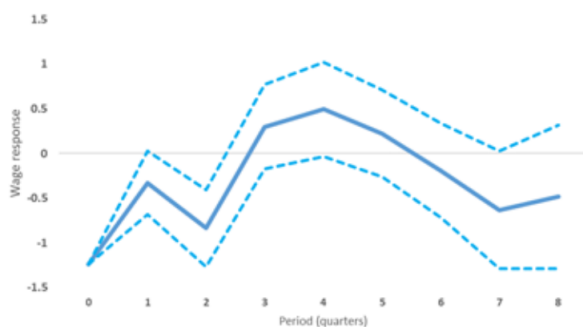


B. Formal labour market 2007–22

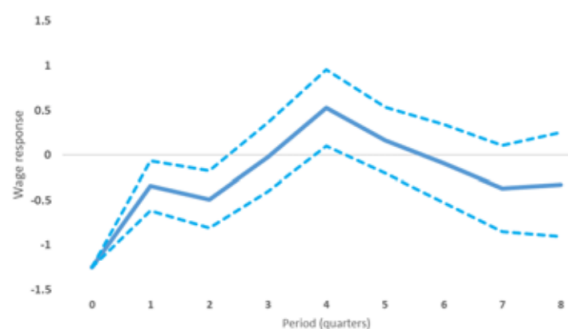


(b) Informal wages

C. Informal labour market 2007–19



D. Informal labour market 2007–22



Source: [Armas et al. \(2023\)](#)

B.9. Labor transitions

Table A3: Peru: average labor transitions, 2008 - 2019 (%)

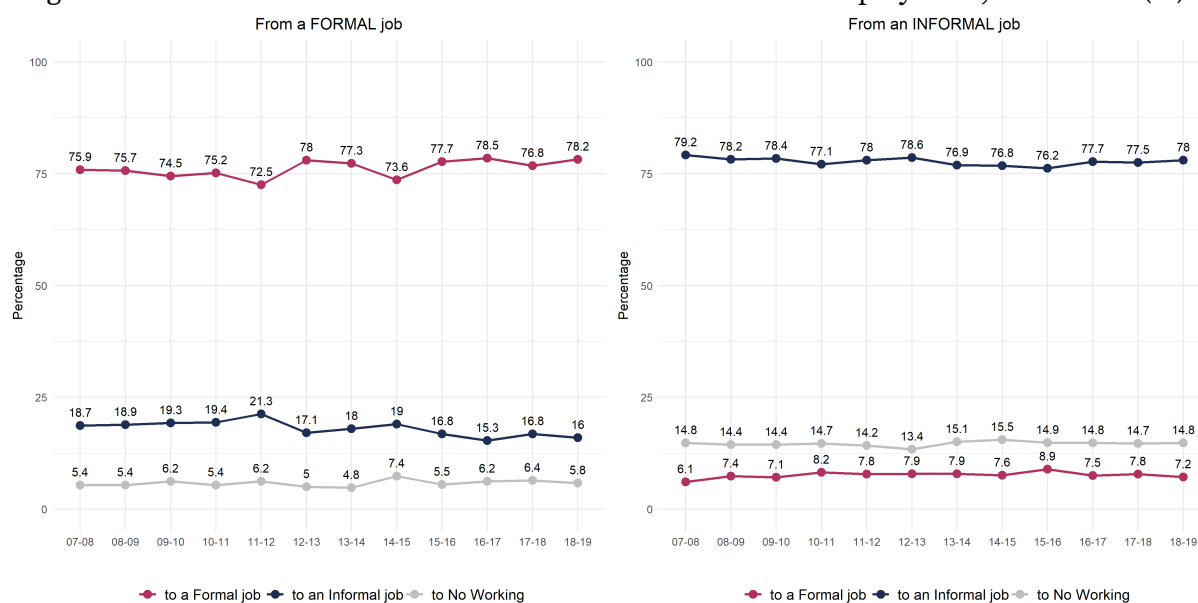
		t+1		
		Formal	Informal	No working
t	Formal	76.2	17.9	5.8
	Informal	7.6	77.7	14.6
	No working	3.5	27.4	69.1

Source: Encuesta Nacional de Hogares, ENAHO, Peru.

F1. It is more difficult to transit from informal job to formal job.

F2. It is more likely to go to informal employment than no working (unemployment+no labour force)

Figure A14: Peru: labor transitions from formal and informal employment, 2008 - 2019 (%)



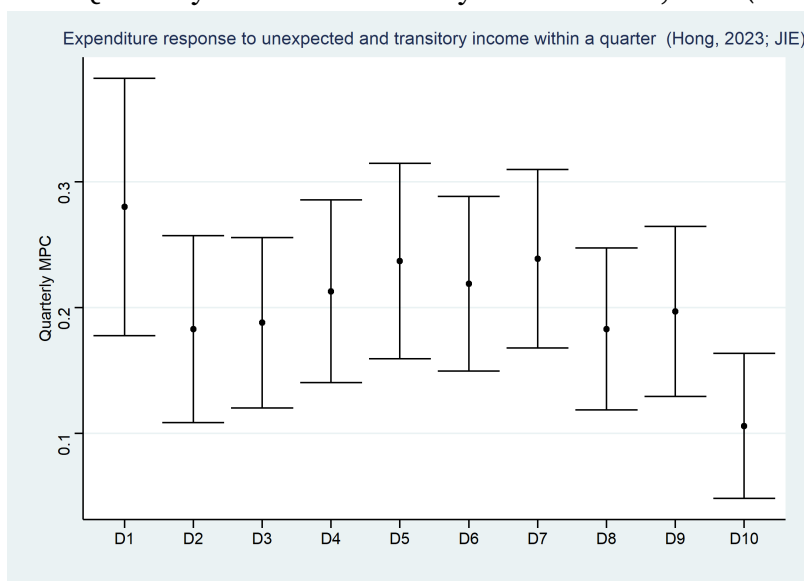
Source: INEI - National Household Survey on Living Conditions and Poverty (ENAHO) panel, 2007-2011, 2011-2015, 2012-2016, 2013-2017, 2014-2018 and 2015-2019. Elaborated by: MTPE - DGPFLIT - Directorate of Supervision and Evaluation (DSE).

Appendix C. Annex Subsection 2.3

C.1. MPC: Hong (2023)

Based on recent research by [Hong \(2023\)](#), figure A15 displays MPC estimates across different income deciles. A notable finding is the significantly higher MPC for the bottom 10% of earners compared to the top 10%, with this difference being statistically significant at the 90% confidence level. Although the MPC estimates vary, they remain relatively stable from the second to the ninth decile.

Figure A15: Quarterly Household MPCs by income decile, Peru (2004-2016)



Source: ENAHO- updated methodology, Peru. [Hong \(2023\)](#).

C.2. MPC: Panel Data

Individual.

Table A4: Annual MPC (2011-2022)

<i>dep var: ΔC_{it}, expenditure per capita (Annual, real PEN)</i>							
Total Expenditure			Monetary Expenditure		Nondurable Goods		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
ΔY_{it}	0.27*** (0.011)	0.15*** (0.029)	0.27*** (0.040)	0.07*** (0.022)	0.15*** (0.032)	0.07*** (0.021)	0.15*** (0.032)
$\Delta Y_{it} \times INF_{it}$		0.15*** (0.031)	0.09*** (0.033)	0.14*** (0.023)	0.10*** (0.026)	0.14*** (0.023)	0.10*** (0.026)
Controls							
INF_{it}		YES	YES	YES	YES	YES	YES
QYT_{it}			YES		YES		YES
$\Delta Y_{it} \times QYT_{it}$			YES		YES		YES
$region \times year$	YES	YES	YES	YES	YES	YES	YES
$X'_{it}\beta$	YES	YES	YES	YES	YES	YES	YES
id-FE	YES	YES	YES	YES	YES	YES	YES
time-FE	YES	YES	YES	YES	YES	YES	YES

Note: X_{it} includes age, age², sex, education, sector, type of job, size of firm, and region. N=13,898. All estimations use robust standard errors. Significance levels are indicated as follows: *** p<0.01, **p<0.05, *p<0.1.

Table A5: Annual MPC (2015-2022)

<i>dep var: ΔC_{it}, expenditure per capita (Annual, real PEN)</i>							
Total Expenditure			Monetary Expenditure		Nondurable Goods		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
ΔY_{it}	0.27*** (0.012)	0.14*** (0.032)	0.27*** (0.044)	0.06*** (0.023)	0.16*** (0.034)	0.06*** (0.023)	0.16*** (0.034)
$\Delta Y_{it} \times INF_{it}$		0.17*** (0.034)	0.09** (0.036)	0.15*** (0.025)	0.10*** (0.028)	0.15*** (0.025)	0.10*** (0.028)
Controls							
INF_{it}		YES	YES	YES	YES	YES	YES
QYT_{it}			YES		YES		YES
$\Delta Y_{it} \times QYT_{it}$			YES		YES		YES
$region \times year$	YES	YES	YES	YES	YES	YES	YES
$X'_{it}\beta$	YES	YES	YES	YES	YES	YES	YES
id-FE	YES	YES	YES	YES	YES	YES	YES
time-FE	YES	YES	YES	YES	YES	YES	YES

Note: X_{it} includes age, age², sex, education, sector, type of job, size of firm, and region. N=11,715. All estimations use robust standard errors. Significance levels are indicated as follows: *** p<0.01, **p<0.05, *p<0.1.

Table A6: Annual MPC (2016-2022)

<i>dep var: ΔC_{it}, expenditure per capita (Annual, real PEN)</i>							
Total Expenditure				Monetary Expenditure		Nondurable Goods	
(1)	(2)	(3)		(4)	(5)	(6)	(7)
ΔY_{it}	0.27*** (0.014)	0.13*** (0.035)	0.29*** (0.049)	0.05** (0.025)	0.17*** (0.038)	0.05* (0.024)	0.17*** (0.038)
$\Delta Y_{it} \times INF_{it}$		0.19*** (0.036)	0.10** (0.041)	0.16*** (0.027)	0.11*** (0.031)	0.16*** (0.027)	0.11*** (0.031)
Controls							
INF_{it}		YES	YES	YES	YES	YES	YES
QYT_{it}			YES		YES		YES
$\Delta Y_{it} \times QYT_{it}$			YES		YES		YES
$region \times year$	YES	YES	YES	YES	YES	YES	YES
$X'_{it}\beta$	YES	YES	YES	YES	YES	YES	YES
id-FE	YES	YES	YES	YES	YES	YES	YES
time-FE	YES	YES	YES	YES	YES	YES	YES

Note: X_{it} includes age, age², sex, education, sector, type of job, size of firm, and region. N=9,364. All estimations use robust standard errors. Significance levels are indicated as follows: *** p<0.01, **p<0.05, *p<0.1.

Households.

Table A7: Annual MPC- only head of the household (2011-2022)

<i>dep var: ΔC_{it}, expenditure per capita (Annual, real PEN)</i>							
Total Expenditure				Monetary Expenditure		Nondurable Goods	
(1)	(2)	(3)		(4)	(5)	(6)	(7)
ΔY_{it}	0.28*** (0.013)	0.17*** (0.036)	0.27*** (0.048)	0.07** (0.027)	0.14*** (0.038)	0.07** (0.027)	0.14*** (0.038)
$\Delta Y_{it} \times INF_{it}$		0.14*** (0.038)	0.08* (0.041)	0.14*** (0.029)	0.10*** (0.033)	0.14*** (0.029)	0.10*** (0.033)
Controls							
INF_{it}		YES	YES	YES	YES	YES	YES
QYT_{it}			YES		YES		YES
$\Delta Y_{it} \times QYT_{it}$			YES		YES		YES
$region \times year$	YES	YES	YES	YES	YES	YES	YES
$X'_{it}\beta$	YES	YES	YES	YES	YES	YES	YES
id-FE	YES	YES	YES	YES	YES	YES	YES
time-FE	YES	YES	YES	YES	YES	YES	YES

Note: X_{it} includes age, age², sex, education, sector, type of job, size of firm, and region. N=9,700. All estimations use robust standard errors. Significance levels are indicated as follows: *** p<0.01, **p<0.05, *p<0.1.

Table A8: Annual MPC- only head of the household (2015-2022)

<i>dep var: ΔC_{it}, expenditure per capita (Annual, real PEN)</i>							
Total Expenditure				Monetary Expenditure		Nondurable Goods	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔY_{it}	0.27*** (0.015)	0.15*** (0.041)	0.28*** (0.053)	0.05* (0.030)	0.14*** (0.041)	0.05 (0.030)	0.14*** (0.041)
$\Delta Y_{it} \times INF_{it}$		0.15*** (0.043)	0.08* (0.046)	0.16*** (0.032)	0.11*** (0.036)	0.16*** (0.032)	0.11*** (0.036)
Controls							
INF_{it}		YES	YES	YES	YES	YES	YES
QYT_{it}			YES		YES		YES
$\Delta Y_{it} \times QYT_{it}$			YES		YES		YES
$region \times year$	YES	YES	YES	YES	YES	YES	YES
$X'_{it}\beta$	YES	YES	YES	YES	YES	YES	YES
id-FE	YES	YES	YES	YES	YES	YES	YES
time-FE	YES	YES	YES	YES	YES	YES	YES

Note: X_{it} includes age, age², sex, education, sector, type of job, size of firm, and region. N=8,171. All estimations use robust standard errors. Significance levels are indicated as follows: *** p<0.01, **p<0.05, *p<0.1.

Table A9: Annual MPC- only head of the household (2016-2022)

<i>dep var: ΔC_{it}, expenditure per capita (Annual, real PEN)</i>							
Total Expenditure				Monetary Expenditure		Nondurable Goods	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ΔY_{it}	0.27*** (0.017)	0.15*** (0.045)	0.29*** (0.058)	0.04 (0.031)	0.14*** (0.045)	0.04 (0.031)	0.14*** (0.046)
$\Delta Y_{it} \times INF_{it}$		0.16*** (0.047)	0.07 (0.050)	0.17*** (0.034)	0.11*** (0.039)	0.17*** (0.034)	0.11*** (0.039)
Controls							
INF_{it}		YES	YES	YES	YES	YES	YES
QYT_{it}			YES		YES		YES
$\Delta Y_{it} \times QYT_{it}$			YES		YES		YES
$region \times year$	YES	YES	YES	YES	YES	YES	YES
$X'_{it}\beta$	YES	YES	YES	YES	YES	YES	YES
id-FE	YES	YES	YES	YES	YES	YES	YES
time-FE	YES	YES	YES	YES	YES	YES	YES

Note: X_{it} includes age, age², sex, education, sector, type of job, size of firm, and region. N=6,560. All estimations use robust standard errors. Significance levels are indicated as follows: *** p<0.01, **p<0.05, *p<0.1.

C.3. Structural estimation: covariance restriction methodology

In a seminal paper, [Blundell et al. \(2008\)](#) introduced a structural methodology, later known as the "covariance restriction," to estimate the consumption response to permanent and transitory income shocks. The method proceeds as follows: first, assume that a household's real (log) income can be decomposed into predictable and unpredictable components.

$$\log Y_{it} = X'_{i,t}\beta + y_{it} \quad (\text{A1})$$

$$\log C_{it} = W'_{i,t}\theta + c_{it} \quad (\text{A2})$$

where $X'_{i,t}$ and $W'_{i,t}$ represent sets of observable characteristics such as age, sex, education, marital status, and employment sector. Next, assume that the unpredictable component of income (y_{it}) can be further decomposed into permanent ($P_{i,t}$) and transitory (v_{it}) parts:

$$y_{it} = P_{i,t} + v_{it} \quad (\text{A3})$$

The permanent income component is assumed to follow a random walk process, while the transitory income component follows a moving average process of order q :

$$P_{i,t} = P_{i,t-1} + \zeta_{it} \quad (\text{A4})$$

$$v_{it} = \sum_{j=0}^q \omega_j \varepsilon_{i,t-j} \quad (\text{A5})$$

Here, ζ_{it} represents a serially uncorrelated shock. Assuming $\omega_0 = 1$, the change in unpredictable income (Δy_{it}) can be expressed as the sum of the permanent income shock (ζ_{it}) and a change in transitory income shock:

$$\Delta y_{it} = \zeta_{it} + \Delta v_{it} \quad (\text{A6})$$

Using equations (A4)–(A6), [Blundell et al. \(2008\)](#) propose the following framework for consumption:

$$\Delta c_{it} = \xi_{it} + \phi \zeta_{it} + \psi \varepsilon_{it} \quad (\text{A7})$$

where $\varepsilon_{it} \perp \zeta_{it}$ and $\varepsilon_{it} \perp \xi_{it}$. This suggests that the log of real (unpredictable) consumption can be explained by three factors: a permanent income shock (ζ_{it}), a transitory income shock (ε_{it}), and an independent innovation term in consumption (ξ_{it}). [Blundell et al. \(2008\)](#) refer to ϕ and ψ as partial insurance or transmission parameters. Specifically, $\phi = \psi = 0$ indicates full insurance (consistent with the complete markets hypothesis), while $\phi = \psi = 1$ corresponds to no insurance case (autarky). The identification of these transmission parameters is as follows:

$$\phi = \frac{\text{Cov} \left(\Delta c_{it}, \sum_{\tau=-1}^1 \Delta y_{it+\tau} \right)}{\text{Cov} \left(\Delta y_{it}, \sum_{\tau=-1}^1 \Delta y_{it+\tau} \right)} \quad (\text{A8})$$

$$\psi = \frac{\text{Cov} \left(\Delta c_{it}, \Delta y_{it+1} \right)}{\text{Cov} \left(\Delta y_{it}, \Delta y_{it+1} \right)} \quad (\text{A9})$$

From (A9), we can estimate the MPC to transitory income. Following the approach outlined by [Hong \(2023\)](#), we begin by defining the mean-consumption-to-mean-income ratio as follows:

$$\kappa = \frac{\mathbb{E} [C_{it}]}{\mathbb{E} [Y_{it}]} \quad (\text{A10})$$

To estimate the MPC with respect to transitory income shocks, we use the following moment conditions, which are estimated using the Generalized Method of Moments (GMM):

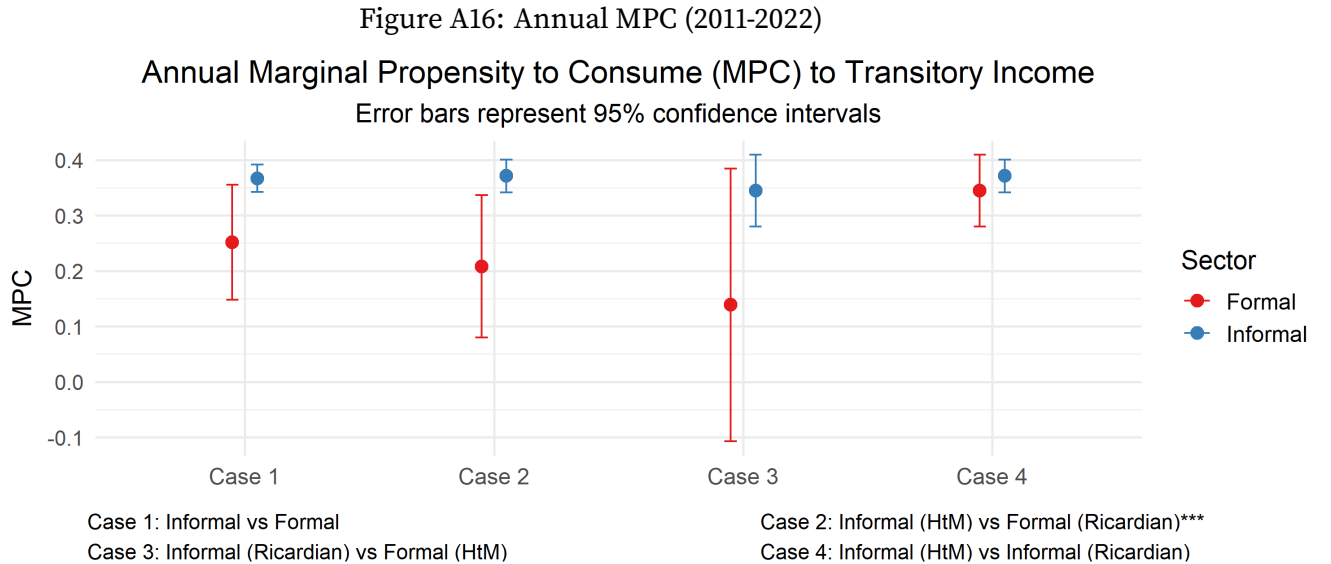
$$\mathbb{E} [\kappa Y_{it} - C_{it}] = 0 \quad (\text{A11})$$

$$\mathbb{E} [\Delta c_{it} - \alpha - \psi \Delta y_{it}] = 0 \quad (\text{A12})$$

$$\mathbb{E} [\Delta y_{it+1} (\Delta c_{it} - \alpha - \psi \Delta y_{it})] = 0 \quad (\text{A13})$$

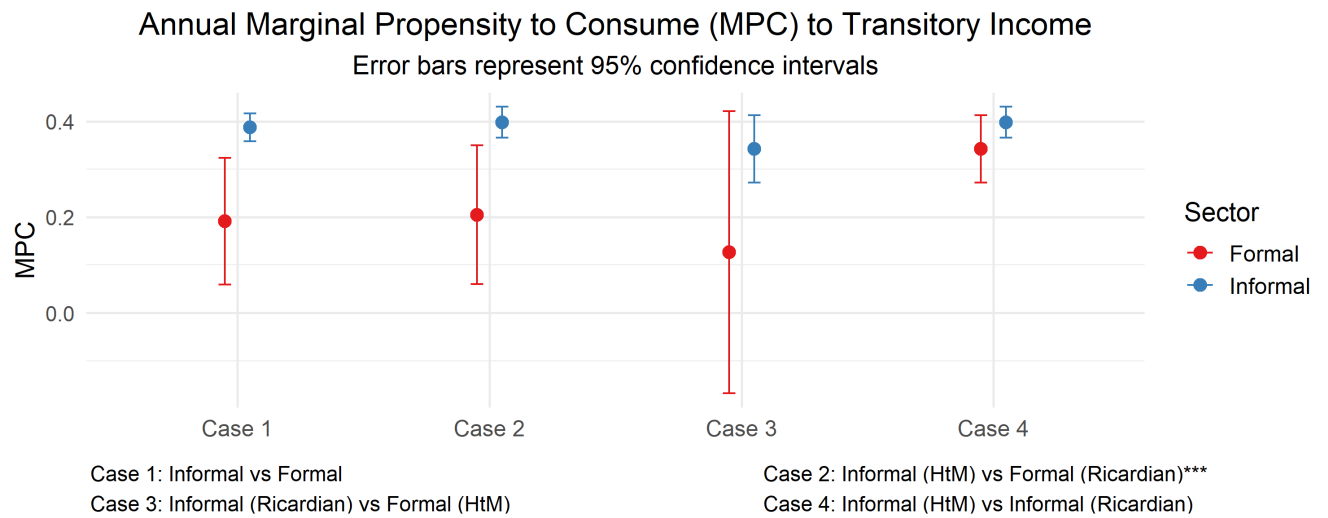
After estimating κ, ψ, α and their variance-covariance matrix, we can derive the MPC estimate and its standard error by calculating $MPC = \kappa \psi$.

C.4. MPC: Structural Estimation



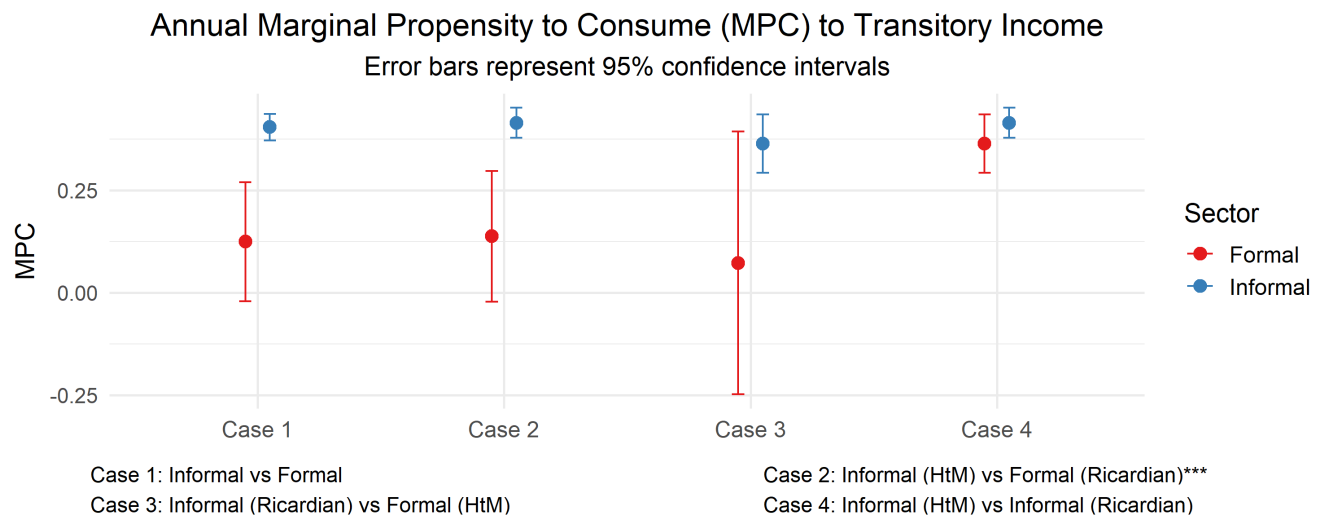
Source: ENAHO- updated methodology.

Figure A17: Annual MPC (2015-2022)



Source: ENAHO- updated methodology.

Figure A18: Annual MPC (2016-2022)



Source: ENAHO- updated methodology.

Appendix D. Annex Subsection 3.1

D.1. Toy model: simple multiplier/Keynesian cross

To simplify our model, we assume: (i) a closed economy, (ii) no government spending, (iii) no investment, and (iv) fixed prices. Under these assumptions, aggregate demand is driven solely by aggregate consumption. Thus, since prices are fixed, the only variable to be determined is the total output. Our objective is to examine how changes in aggregate consumption affect aggregate output. Aggregate consumption, denoted by C , can be divided into two categories: formal consumption (C^F) and informal consumption (C^I). We define aggregate consumption as:

$$C = \tau C_t^I + (1 - \tau) C^F \quad (\text{A14})$$

where τ is the proportion of households working in the informal sector, and $1 - \tau$ represents those in the formal sector. Given our assumptions, total output Y must be equal to aggregate consumption C . Thus:

$$Y = \tau C^I + (1 - \tau) C^F \quad (\text{A15})$$

Now, assume that informal consumption depends solely on informal income (Y^I) and informal income depends on total output, so that $C^I(Y^I(Y))$. Similarly, formal consumption depends on formal income (Y^F), formal income on total output, and an exogenous shock (μ) initially confined to the formal sector, so that, $C^F(Y^F(Y), \mu)$. Combining these, we obtain:

$$Y = \tau C^I(Y^I(Y)) + (1 - \tau) C^F(Y^F(Y), \mu) \quad (\text{A16})$$

Taking the total derivative of this equation with respect to Y , we get:

$$dY = \tau \frac{\partial C^I}{\partial Y^I} \frac{\partial Y^I}{\partial Y} dY + (1 - \tau) \frac{\partial C^F}{\partial Y^F} \frac{\partial Y^F}{\partial Y} dY + (1 - \tau) \frac{\partial C^F}{\partial \mu} \quad (\text{A17})$$

Next, we refine this relationship by multiplying both the numerator and the denominator by Y for both sectors, defining: $d\epsilon \equiv (1 - \tau) \frac{\partial C^F}{\partial \mu}$. Rearranging terms, we derive the multiplier:

$$\frac{dY}{d\epsilon} = \frac{1}{1 - \left[\tau \theta^I \gamma^I \text{MPC}_I + (1 - \tau) \theta^F \gamma^F \text{MPC}_F \right]} \quad (\text{A18})$$

$\text{MPC}_j = \frac{\partial C^j}{\partial Y^j}$	Marginal Propensity to Consume of sector j
$\gamma^j = \frac{\partial Y^j}{\partial Y} \frac{Y}{Y^j}$	Elasticity of Y^j to the aggregate Y
$\theta^j = \frac{Y^j}{Y}$	Relative size of Y^j respect to Y
$\tau \in [0, 1]$	percentage of Informal Households

Equation (A18) illustrates the multiplier effect resulting from a shock to aggregate demand, such as a monetary policy shock. This multiplier depends on several factors: the Marginal Propensity to Consume (MPC), defined as $\text{MPC}_j = \frac{\partial C^j}{\partial Y^j}$, $j = \{I, F\}$; the income elasticity of

each sector relative to the overall economy, $\gamma^j = \frac{\partial Y^j}{\partial Y} \frac{Y}{Y^j}$; the sector's relative size compared to aggregate income, represented by $\theta^j = \frac{Y^j}{Y}$; and the proportion of households employed in the informal sector, τ . From Equation A18, we can see the informal sector's impact on the general multiplier ($\frac{dY}{d\epsilon}$). Assuming the percentage of households (τ) and the size of the informal sector relative to aggregate output (θ) remain stable, the key variables influencing the multiplier are the marginal propensity to consume (MPC) and income elasticity (γ). If the MPC is high but income elasticity is low, the multiplier may not increase significantly. To achieve a higher multiplier, both the MPC and elasticity must be higher, given specific values of θ and τ . Thus, this model highlights that, assuming stable informality and informal labor market size, the income elasticity and MPC are crucial in determining the effectiveness of monetary policy on total output. This intuition remains valid even if we consider multiple types of households, rather than just two (formal and informal).

D.2. A multiplier decomposition

Following [Patterson \(2023\)](#), we define consumption as $c_i(E_i(Y), \theta_i)$, where i denotes individuals. Assuming there is no capital, we can decompose aggregate consumption into two categories: formal consumption (C^F) and informal consumption (C^I). Thus, aggregate consumption is given by:

$$C_t = \tau C_t^I + (1 - \tau) C_t^F \quad (\text{A19})$$

We assume: (i) a closed economy, (ii) no government spending, (iii) no investment, and (iv) fixed prices. Under these assumptions, aggregate demand is driven solely by aggregate consumption. Therefore, aggregate output is defined as:

$$Y = \tau C^I + (1 - \tau) C^F = \tau \sum_i c_i^I(E_i(Y^I), \theta_i) + (1 - \tau) \sum_i c_i^F(E_i(Y^F), \theta_i) \quad (\text{A20})$$

where E_i represents earnings, and θ_i represents other parameters. Taking the total derivative of (A20), we get:

$$dY = (1 - \tau) \sum_i \left(\frac{\partial c_i^F}{\partial E_i^F} \frac{\partial E_i^F}{\partial Y^F} \right) dY^F + (1 - \tau) \sum_i \frac{\partial c_i^F}{\partial \theta_i} d\theta_i + \tau \sum_i \left(\frac{\partial c_i^I}{\partial E_i^I} \frac{\partial E_i^I}{\partial Y^I} \right) dY^I + \tau \sum_j \frac{\partial c_j^I}{\partial \theta_j} d\theta_j \quad (\text{A21})$$

We define $\frac{\partial c_i}{\partial E_i} \equiv \text{MPC}_i$, and $\sum_i \left(\frac{\partial c_i}{\partial \theta_i} d\theta_i \right) \equiv d\epsilon$, which is interpreted as an exogenous shock. Thus, the equation becomes:

$$dY = (1 - \tau) \sum_i \text{MPC}_i^F \frac{\partial E_i^F}{\partial Y^F} \frac{Y^F}{E_i^F} \frac{E_i^F}{Y^F} dY^F + (1 - \tau) d\epsilon^F + \tau \sum_i \text{MPC}_i^I \frac{\partial E_i^I}{\partial Y^I} \frac{Y^I}{E_i^I} \frac{E_i^I}{Y^I} dY^I + \tau d\epsilon^I \quad (\text{A22})$$

Next, we define the elasticity of individual earnings and aggregate MPC as:

$$\gamma_i \equiv \frac{\partial E_i}{\partial Y} \frac{Y}{E_i} \quad (\text{A23})$$

Assuming $(1 - \tau) d\varepsilon^F + \lambda d\varepsilon^I = d\varepsilon$, we have:

$$dY = (1 - \tau) \sum_i \gamma_i^F \frac{E_i^F}{Y^F} MPC_i^F dY^F + \tau \sum_i \gamma_i^I \frac{E_i^I}{Y^I} MPC_i^I dY^I + d\varepsilon \quad (A24)$$

Now, let's define $\frac{Y^F}{Y} = \theta^F$. Then, $dY^F = Y d\theta^F + \theta^F dY$. Assuming $d\theta^F = 0$, it follows that $dY^F = \theta^F dY$. Substituting this into the previous equation, we get:

$$dY = (1 - \tau) \sum_i \gamma_i^F \frac{E_i^F}{Y^F} MPC_i^F \theta^F dY + \tau \sum_i \gamma_i^I \frac{E_i^I}{Y^I} MPC_i^I \theta^I dY + d\varepsilon \quad (A25)$$

Rearranging terms:

$$\frac{dY}{d\varepsilon} = \frac{1}{1 - (1 - \tau) \theta^F \sum_i \gamma_i^F \frac{E_i^F}{Y^F} MPC_i^F + \tau \theta^I \sum_i \gamma_i^I \frac{E_i^I}{Y^I} MPC_i^I} \quad (A26)$$

We know that $\mathbb{E}[X] = \sum_i X_i P(X_i)$. Additionally, we assume that $P(x_i) \equiv \frac{E_i}{Y}$. Therefore, we have:

$$\frac{dY}{d\varepsilon} = \frac{1}{1 - (1 - \tau) \theta^F \mathbb{E}[\gamma_i^F MPC_i^F] + \tau \theta^I \mathbb{E}[\gamma_i^I MPC_i^I]} \quad (A27)$$

We also know:

$$\mathbb{C}(X, Y) = \mathbb{E}[XY] - \mathbb{E}[X] \mathbb{E}[Y] \quad (A28)$$

Thus,

$$\mathbb{E}[XY] = \mathbb{E}[X] \mathbb{E}[Y] + \mathbb{C}(X, Y) \quad (A29)$$

Substituting (A29) into equation (A27), we get:

$$\frac{dY}{d\varepsilon} = \frac{1}{1 - (1 - \tau) \theta^F \left(\mathbb{E}[MPC_i^F] \mathbb{E}[\gamma_i^F] + \mathbb{C}(MPC_i^F, \gamma_i^F) \right) - \tau \theta^I \left(\mathbb{E}[MPC_i^I] \mathbb{E}[\gamma_i^I] + \mathbb{C}(MPC_i^I, \gamma_i^I) \right)} \quad (A30)$$

Finally, after simplifying and eliminating unnecessary nomenclature, we arrive at the multiplier.

$$\frac{dY}{d\varepsilon} = \frac{1}{1 - \left[(1 - \tau) \theta^F \overline{\gamma^F} \overline{MPC^F} + \tau \theta^I \overline{\gamma^I} \overline{MPC^I} + (1 - \tau) \theta^F \mathbb{C}(MPC_i^F, \gamma_i^F) + \tau \theta^I \mathbb{C}(MPC_i^I, \gamma_i^I) \right]} \quad (A31)$$

$\overline{MPC}^j = \mathbb{E}[MPC_i^j]$	Average Marginal Propensity to Consume of sector j
$\overline{\gamma}^j = \mathbb{E}[\gamma_i^j]$	Average elasticity of sector j and individual i
$\theta^j = \frac{Y^j}{Y}$	Relative size of Y^j respect to Y
$\tau \in [0, 1]$	percentage of Informal Households
$\mathbb{C}(MPC_i^j, \gamma_i^j)$	Covariance between MPC and income elasticity of sector j and individual i

Appendix E. Annex Subsection 3.2

E.1. Demand fro good type z

The total demand for good z can be determined by the following equation:

$$C_t(z) = \lambda C_t^H(z) + (1 - \lambda) C_t^R(z) \quad (\text{A32})$$

From (A32), we obtained the demand for variety z for HtM and Ricardian households:

$$C_t^H(z) = \left[\frac{P_t(z)}{P_t} \right]^{-\varepsilon} C_t^H \quad (\text{A33})$$

$$C_t^R(z) = \left[\frac{P_t(z)}{P_t} \right]^{-\varepsilon} C_t^R \quad (\text{A34})$$

Plugging (A33) and (A34) into (A32) we get

$$C_t(z) = \lambda \left[\frac{P_t(z)}{P_t} \right]^{-\varepsilon} C_t^H + (1 - \lambda) \left[\frac{P_t(z)}{P_t} \right]^{-\varepsilon} C_t^R \quad (\text{A35})$$

By performing a simple algebraic manipulation on equation (A35), we derive:

$$C_t(z) = \left[\frac{P_t(z)}{P_t} \right]^{-\varepsilon} \left(\lambda C_t^H + (1 - \lambda) C_t^R \right) \quad (\text{A36})$$

Finally, given that $C_t = \lambda C_t^H + (1 - \lambda) C_t^R$, we obtain the expression:

$$C_t(z) = \left[\frac{P_t(z)}{P_t} \right]^{-\varepsilon} C_t \quad (\text{A37})$$

E.2. TANK with CRRA utility: system of equations

Ricardian households.

$$\frac{W_t^R}{P_t} = \left(C_t^R \right)^\psi \left(N_t^R \right)^\varphi \quad (\text{A38})$$

$$\frac{W_t^R}{P_t} = \kappa \left(\frac{W_t^F}{P_t} \right) + (1 - \kappa) \frac{W_t^I}{P_t} \quad (\text{A39})$$

$$1 = \beta \mathbb{E}_t \left(\frac{C_{t+1}^R}{C_t^R} \right)^{-\psi} \left(\frac{P_t}{P_{t+1}} (1 + i_t) \right) \quad (\text{A40})$$

HtM households.

$$\frac{W_t^H}{P_t} = \left(C_t^H \right)^\psi \left(N_t^H \right)^\gamma \quad (\text{A41})$$

$$\frac{W_t^H}{P_t} = \chi \left(\frac{W_t^F}{P_t} \right) + (1 - \chi) \frac{W_t^I}{P_t} \quad (\text{A42})$$

$$C_t^H = \frac{W_t^H}{P_t} N_t^H \quad (\text{A43})$$

Wholesale firms.

$$\phi_t \frac{\alpha Y_t^W}{N_t} = \frac{W_t^F}{P_t} + \sigma_F \Theta_t^F \quad (\text{A44})$$

$$\Theta_t^F = \left(\frac{N_t^F}{N_{t-1}^F} - 1 \right) \frac{1}{N_{t-1}^F} - \mathbb{E}_t Q_{t,t+1} \left(\frac{N_{t+1}^F}{N_t^F} - 1 \right) \frac{N_{t+1}^F}{(N_t^F)^2} \quad (\text{A45})$$

$$\phi_t \frac{\alpha Y_t^W}{N_t} = \frac{W_t^I}{P_t} \quad (\text{A46})$$

$$Y_t^W = A_t N_t^\alpha \quad (\text{A47})$$

$$Y_t^W = Y_t \Delta_t \quad (\text{A48})$$

$$\Delta_t = \int_0^1 \left[\frac{P_t(z)}{P_t} \right]^{-\varepsilon} dz \quad (\text{A49})$$

Retail firms.

$$1 = \theta (1 + \pi_t)^{\varepsilon-1} + (1 - \theta) \left(\frac{\varepsilon}{\varepsilon - 1} \right)^{1-\varepsilon} \left(\frac{\Lambda_t}{\Omega_t} \right)^{1-\varepsilon} \quad (\text{A50})$$

$$\Lambda_t = \phi_t Y_t + \theta \mathbb{E}_t \left[\left(\frac{P_{t+1}}{P_t} \right)^\varepsilon Q_{t+1,t} \Lambda_{t+1} \right] \quad (\text{A51})$$

$$\Omega_t = Y_t + \theta \mathbb{E}_t \left[\left(\frac{P_{t+1}}{P_t} \right)^{\varepsilon-1} Q_{t+1,t} \Omega_{t+1} \right] \quad (\text{A52})$$

Clearing market conditions.

$$Y_t = C_t + \frac{\sigma_F}{2} \left(\frac{N_t^F}{N_{t-1}^F} - 1 \right)^2 \quad (\text{A53})$$

$$N_t = \lambda N_t^H + (1 - \lambda) N_t^R \quad (\text{A54})$$

$$C_t = \lambda C_t^H + (1 - \lambda) C_t^R \quad (\text{A55})$$

$$N_t^F = \lambda \chi N_t^H + (1 - \lambda) \kappa N_t^R \quad (\text{A56})$$

$$N_t^I = \lambda (1 - \chi) N_t^H + (1 - \lambda) (1 - \kappa) N_t^R \quad (\text{A57})$$

$$N_t = N_t^F + N_t^I \quad (\text{A58})$$

E.3. Log-linear equations: TANK with CRRA utility

Ricardian households.

$$w_t^R = \psi c_t^R + \varphi n_t^R \quad (\text{A59})$$

$$w_t^R = \kappa w_t^F + (1 - \kappa) w_t^I \quad (\text{A60})$$

$$c_t^R = \mathbb{E}_t c_{t+1}^R - \frac{1}{\psi} (i_t - \mathbb{E}_t \pi_{t+1}) \quad (\text{A61})$$

HtM households.

$$w_t^H = \psi c_t^H + \gamma n_t^H \quad (\text{A62})$$

$$w_t^H = \chi w_t^F + (1 - \chi) w_t^I \quad (\text{A63})$$

$$c_t^H = w_t^H + n_t^H \quad (\text{A64})$$

Firms.

$$w_t^I = w_t^F + \Psi \left[(n_t^F - n_{t-1}^F) - \beta \mathbb{E}_t (n_{t+1}^F - n_t^F) \right] \quad (\text{A65})$$

$$\phi_t = (1 - \alpha) n_t + w_t^I \quad (\text{A66})$$

$$y_t = \alpha n_t \quad (\text{A67})$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \chi \phi_t \quad (\text{A68})$$

$$\Psi \equiv \frac{\sigma_F}{W_{ss}^F N_{ss}^F}$$

Clearing Market.

$$c_t = y_t \quad (\text{A69})$$

$$c_t = \lambda c_t^H + (1 - \lambda) c_t^R \quad (\text{A70})$$

$$n_t = \left(\frac{N_{ss}^F}{N_{ss}} \right) n_t^F + \left(\frac{N_{ss}^I}{N_{ss}} \right) n_t^I \quad (\text{A71})$$

$$n_t^I = \lambda (1 - \chi) \left(\frac{N_{ss}^H}{N_{ss}^I} \right) n_t^H + (1 - \lambda) (1 - \kappa) \left(\frac{N_{ss}^R}{N_{ss}^I} \right) n_t^R \quad (\text{A72})$$

$$n_t^F = \lambda \chi \left(\frac{N_{ss}^H}{N_{ss}^F} \right) n_t^H + (1 - \lambda) \kappa \left(\frac{N_{ss}^R}{N_{ss}^F} \right) n_t^R \quad (\text{A73})$$

Monetary Policy.

$$i_t = \phi_\pi \pi_t + \phi_y y_t + \varepsilon_t \quad (\text{A74})$$

E.4. TANK with GHH utility: system of equations

Ricardian households.

$$\frac{W_t^R}{P_t} = \vartheta \left(N_t^R \right)^\varphi \quad (\text{A75})$$

$$\frac{W_t^R}{P_t} = \kappa \left(\frac{W_t^F}{P_t} \right) + (1 - \kappa) \frac{W_t^I}{P_t} \quad (\text{A76})$$

$$1 = \beta \mathbb{E}_t \left(\frac{\hat{C}_{t+1}^R}{\hat{C}_t^R} \right)^{-\psi} \left(\frac{P_t}{P_{t+1}} (1 + i_t) \right) \quad (\text{A77})$$

$$\hat{C}_t^R = C_t^R - \vartheta \frac{(N_t^R)^{1+\varphi}}{1+\varphi} \quad (\text{A78})$$

HtM households.

$$\frac{W_t^H}{P_t} = \vartheta (N_t^H)^\gamma \quad (\text{A79})$$

$$\frac{W_t^H}{P_t} = \chi \left(\frac{W_t^F}{P_t} \right) + (1 - \chi) \frac{W_t^I}{P_t} \quad (\text{A80})$$

$$C_t^H = \frac{W_t^H}{P_t} N_t^H \quad (\text{A81})$$

Wholesale firms.

$$\phi_t \frac{\alpha Y_t^W}{N_t} = \frac{W_t^F}{P_t} + \sigma_F \Theta_t^F \quad (\text{A82})$$

$$\Theta_t^F = \left(\frac{N_t^F}{N_{t-1}^F} - 1 \right) \frac{1}{N_{t-1}^F} - \mathbb{E}_t Q_{t,t+1} \left(\frac{N_{t+1}^F}{N_t^F} - 1 \right) \frac{N_{t+1}^F}{(N_t^F)^2} \quad (\text{A83})$$

$$\phi_t \frac{\alpha Y_t^W}{N_t} = \frac{W_t^I}{P_t} \quad (\text{A84})$$

$$Y_t^W = A_t N_t^\alpha \quad (\text{A85})$$

$$Y_t^W = Y_t \Delta_t \quad (\text{A86})$$

$$\Delta_t = \int_0^1 \left[\frac{P_t(z)}{P_t} \right]^{-\varepsilon} dz \quad (\text{A87})$$

Retail firms.

$$1 = \theta (1 + \pi_t)^{\varepsilon-1} + (1 - \theta) \left(\frac{\varepsilon}{\varepsilon - 1} \right)^{1-\varepsilon} \left(\frac{\Lambda_t}{\Omega_t} \right)^{1-\varepsilon} \quad (\text{A88})$$

$$\Lambda_t = \phi_t Y_t + \theta \mathbb{E}_t \left[\left(\frac{P_{t+1}}{P_t} \right)^\varepsilon Q_{t+1,t} \Lambda_{t+1} \right] \quad (\text{A89})$$

$$\Omega_t = Y_t + \theta \mathbb{E}_t \left[\left(\frac{P_{t+1}}{P_t} \right)^{\varepsilon-1} Q_{t+1,t} \Omega_{t+1} \right] \quad (\text{A90})$$

Clearing market conditions.

$$Y_t = C_t + \frac{\sigma_F}{2} \left(\frac{N_t^F}{N_{t-1}^F} - 1 \right)^2 \quad (\text{A91})$$

$$N_t = \lambda N_t^H + (1 - \lambda) N_t^R \quad (\text{A92})$$

$$C_t = \lambda C_t^H + (1 - \lambda) C_t^R \quad (\text{A93})$$

$$N_t^F = \lambda \chi N_t^H + (1 - \lambda) \kappa N_t^R \quad (\text{A94})$$

$$N_t^I = \lambda (1 - \chi) N_t^H + (1 - \lambda) (1 - \kappa) N_t^R \quad (\text{A95})$$

$$N_t = N_t^F + N_t^I \quad (\text{A96})$$

E.5. Log-linear equations: TANK with GHH utility

Ricardian households.

$$w_t^R = \varphi n_t^R \quad (\text{A97})$$

$$w_t^R = \kappa w_t^F + (1 - \kappa) w_t^I \quad (\text{A98})$$

$$c_t^R = \mathbb{E}_t \left(c_{t+1}^R \right) + \frac{\alpha_1}{\alpha_0} \mathbb{E}_t \left(n_t^R - n_{t+1}^R \right) - \frac{1}{\psi \alpha_0} (i_t - \mathbb{E}_t \pi_{t+1}) \quad (\text{A99})$$

$$\alpha_0 \equiv \frac{C_{ss}^R}{\hat{C}_{ss}^R}$$

$$\alpha_1 \equiv (1 + \varphi) \left(\frac{C_{ss}^R - \hat{C}_{ss}^R}{\hat{C}_{ss}^R} \right)$$

$$\hat{C}_{ss}^R \equiv C_{ss}^R - \vartheta \frac{(N_{ss}^R)^{1+\varphi}}{1 + \varphi}$$

HtM households.

$$w_t^H = \gamma n_t^H \quad (\text{A100})$$

$$w_t^H = \chi w_t^F + (1 - \chi) w_t^I \quad (\text{A101})$$

$$c_t^H = w_t^H + n_t^H \quad (\text{A102})$$

Firms.

$$w_t^I = w_t^F + \Psi \left[\left(n_t^F - n_{t-1}^F \right) - \beta \mathbb{E}_t \left(n_{t+1}^F - n_t^F \right) \right] \quad (\text{A103})$$

$$\phi_t = (1 - \alpha) n_t + w_t^I \quad (\text{A104})$$

$$y_t = \alpha n_t \quad (\text{A105})$$

$$\pi_t = \beta \mathbb{E}_t \pi_{t+1} + \chi \phi_t \quad (\text{A106})$$

$$\Psi \equiv \frac{\sigma_F}{W_{ss}^F N_{ss}^F}$$

Clearing Market.

$$c_t = y_t \quad (\text{A107})$$

$$c_t = \lambda c_t^H + (1 - \lambda) c_t^R \quad (\text{A108})$$

$$n_t = \left(\frac{N_{ss}^F}{N_{ss}} \right) n_t^F + \left(\frac{N_{ss}^I}{N_{ss}} \right) n_t^I \quad (\text{A109})$$

$$n_t^I = \lambda (1 - \chi) \left(\frac{N_{ss}^H}{N_{ss}^I} \right) n_t^H + (1 - \lambda) (1 - \kappa) \left(\frac{N_{ss}^R}{N_{ss}^I} \right) n_t^R \quad (\text{A110})$$

$$n_t^F = \lambda \chi \left(\frac{N_{ss}^H}{N_{ss}^F} \right) n_t^H + (1 - \lambda) \kappa \left(\frac{N_{ss}^R}{N_{ss}^F} \right) n_t^R \quad (\text{A111})$$

Monetary Policy.

$$\dot{i}_t = \phi_\pi \pi_t + \phi_y y_t + \varepsilon_t \quad (\text{A112})$$

E.6. Euler equation in a TANK with CRRA utility

In order to derive the Euler equation for the TANK model with informality, we need to begin with the following seven equations:

Ricardian households.

$$w_t^R = \psi c_t^R + \varphi n_t^R \quad (\text{A113})$$

$$w_t^R = \kappa w_t^F + (1 - \kappa) w_t^I \quad (\text{A114})$$

$$c_t^R = \mathbb{E}_t c_{t+1}^R - \frac{1}{\psi} (\dot{i}_t - \mathbb{E}_t \pi_{t+1}) \quad (\text{A115})$$

HtM households.

$$w_t^H = \psi c_t^H + \gamma n_t^H \quad (\text{A116})$$

$$w_t^H = \chi w_t^F + (1 - \chi) w_t^I \quad (\text{A117})$$

$$c_t^H = w_t^H + n_t^H \quad (\text{A118})$$

Firms.

$$w_t^I = w_t^F + \Psi \left[(n_t^F - n_{t-1}^F) - \beta \mathbb{E}_t (n_{t+1}^F - n_t^F) \right] \quad (\text{A119})$$

Now, using equations (A113) to (A115) from the Ricardian households, we can simplify the system into two equations:

$$\kappa w_t^F + (1 - \kappa) w_t^I = \psi c_t^R + \varphi n_t^R \quad (\text{A120})$$

$$c_t^R = \mathbb{E}_t c_{t+1}^R - \frac{1}{\psi} (\dot{i}_t - \mathbb{E}_t \pi_{t+1}) \quad (\text{A121})$$

On the other hand, for the HtM Households, plugging equations (A118) and (A117) into equation (A116) and rearranging, we can reduce the system to a single equation:

$$c_t^H = \left(\frac{1 + \gamma}{\gamma + \psi} \right) \chi w_t^F + \left(\frac{1 + \gamma}{\gamma + \psi} \right) (1 - \chi) w_t^I \quad (\text{A122})$$

Next, given that $c_t = \lambda c_t^H + (1 - \lambda) c_t^R$, we can rearrange this to obtain an expression for c_t^R :

$$c_t^R = \frac{1}{1 - \lambda} c_t - \frac{\lambda}{1 - \lambda} c_t^H \quad (\text{A123})$$

Taking this one period ahead and applying expectations, we have:

$$\mathbb{E}_t c_{t+1}^R = \frac{1}{1-\lambda} \mathbb{E}_t c_{t+1} - \frac{\lambda}{1-\lambda} \mathbb{E}_t c_{t+1}^H \quad (\text{A124})$$

By substituting equations (A123) and (A124) into equation (A121), we obtain:

$$c_t = \mathbb{E}_t c_{t+1} - \frac{1-\lambda}{\psi} (i_t - \mathbb{E}_t \pi_{t+1}) + \lambda (c_t^H - \mathbb{E}_t c_{t+1}^H) \quad (\text{A125})$$

To find an expression for $c_t^H - \mathbb{E}_t c_{t+1}^H$, we start with equation (A122), move one period ahead, and take expectations:

$$\mathbb{E}_t c_{t+1}^H = \left(\frac{1+\gamma}{\gamma+\psi} \right) \chi \mathbb{E}_t w_{t+1}^F + \left(\frac{1+\gamma}{\gamma+\psi} \right) (1-\chi) \mathbb{E}_t w_{t+1}^I \quad (\text{A126})$$

By subtracting equation (A122) from equation (A126) and rearranging terms, we get:

$$\left(\frac{\gamma+\psi}{1+\gamma} \right) (c_t^H - \mathbb{E}_t c_{t+1}^H) = \chi (w_t^F - \mathbb{E}_t w_{t+1}^F) + (1-\chi) (w_t^I - \mathbb{E}_t w_{t+1}^I) \quad (\text{A127})$$

The Euler Equation. Finally, we can summarize all equations from (A113) to (A119) into the following Euler equation, which summarizes the model:

$$c_t = \mathbb{E}_t c_{t+1} - \frac{1-\lambda}{\psi} (i_t - \mathbb{E}_t \pi_{t+1}) + \lambda (c_t^H - \mathbb{E}_t c_{t+1}^H) \quad (\text{A128})$$

$$\left(\frac{\gamma+\psi}{1+\gamma} \right) (c_t^H - \mathbb{E}_t c_{t+1}^H) = \chi (w_t^F - \mathbb{E}_t w_{t+1}^F) + (1-\chi) (w_t^I - \mathbb{E}_t w_{t+1}^I) \quad (\text{A129})$$

$$\Upsilon [\cdot] = w_t^I - w_t^F \quad (\text{A130})$$

where $\Upsilon [\cdot] \equiv \Psi [\Delta n_t^F - \beta \mathbb{E}_t \Delta n_{t+1}^F]$. Now, we can illustrate how the standard TANK and RANK models are particular cases of the TANK model with informality.

- If $\lambda > 0$, $\Upsilon [\cdot] = 0$, this corresponds to the standard TANK model^{A1}:

$$c_t = \mathbb{E}_t c_{t+1} - \left(\frac{1}{\psi} \right) \left(\frac{1-\lambda}{1-\lambda\Omega} \right) (i_t - \mathbb{E}_t \pi_{t+1}) \quad (\text{A131})$$

$$\Omega \equiv \left(\frac{1+\gamma}{\gamma+\psi} \right) \left(\frac{\alpha\psi+\gamma}{\alpha} \right)$$

- If $\lambda = 0$, $\Upsilon [\cdot] = 0$, this gives the standard RANK model:

$$c_t = \mathbb{E}_t c_{t+1} - \frac{1}{\psi} (i_t - \mathbb{E}_t \pi_{t+1}) \quad (\text{A132})$$

^{A1} Assuming that the labor supply elasticity for HtM and Ricardian are the same $\gamma = \varphi$.

Appendix F. Annex Subsection 4.1

F.1. Determinacy analysis

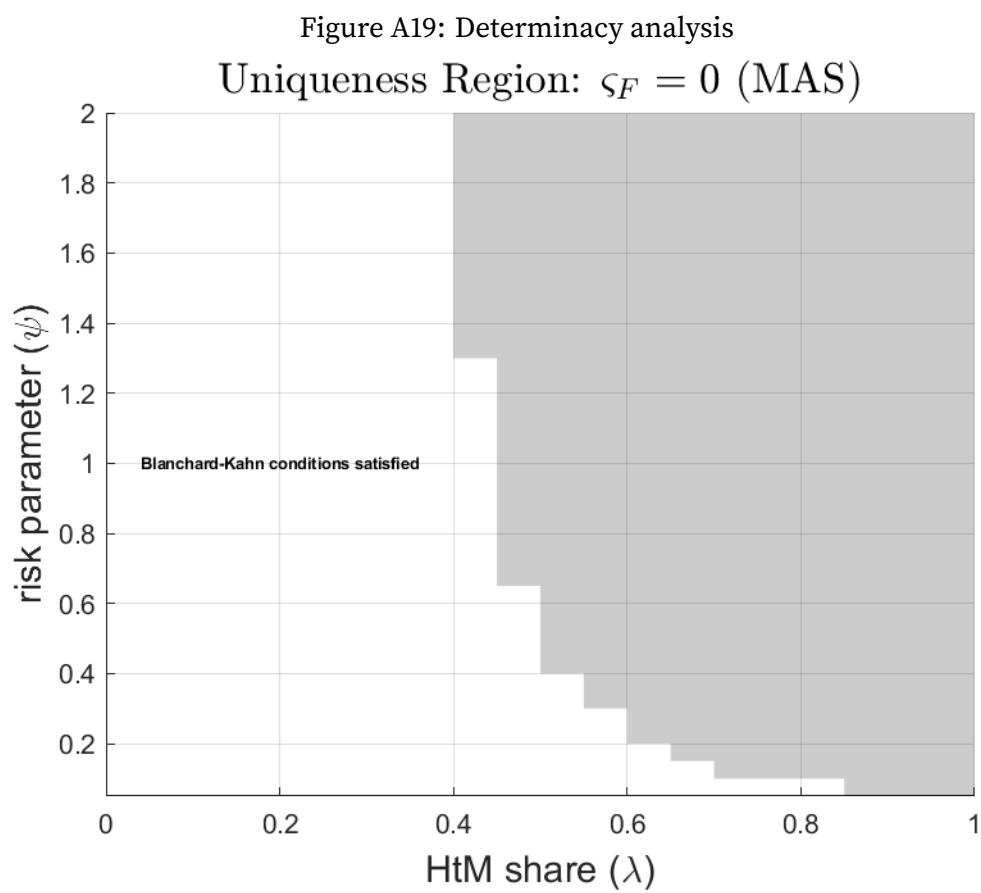
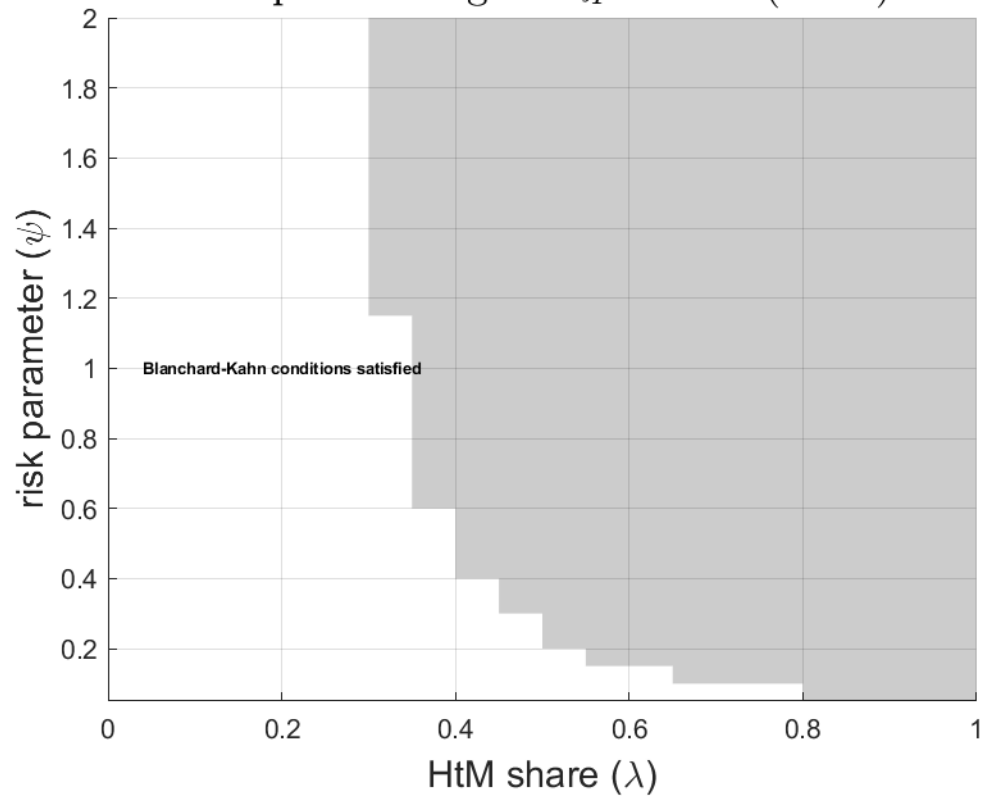


Figure A20: Determinacy analysis

Uniqueness Region: $\varsigma_F = 0.25$ (MAS)



Appendix G. Annex Subsection 4.2

G.1. Multipliers

We can estimate the multiplier of monetary policy. In the context of a TANK model, a multiplier typically refers to the sensitivity of certain economic variables, such as consumption, output, or inflation, to changes in the interest rate. In Table A10, we present both the initial and cumulative multipliers of selected variables in response to changes in the interest rate. Following [Cantore and Freund \(2021\)](#), we define the impact multiplier as $\frac{dy_0}{d\epsilon_0}$ and the cumulative multiplier as $\sum_{s=0}^{\infty} \beta^s \frac{dy_s}{d\epsilon_s}$, where β is the discount factor. The impact multiplier represents the immediate effect of the monetary shock on an endogenous variable, while the cumulative multiplier reflects the total accumulated effect over time, accounting for the discounting of future values. Thus, table A10 should be interpreted as follows: given that the shock is measured in percentage points (p.p.), a reduction of 1 p.p. in the nominal interest rate leads to an immediate change of 1.37 p.p. in total output and 0.52 p.p. in inflation. For the cumulative multiplier, a 1 p.p. reduction in the interest rate over five years results in a cumulative change of 1.36 p.p. in output. The interpretation for other variables is similar. These findings suggest that the monetary multiplier, or elasticity, is comparable to some TANK estimates for the fiscal multiplier.

Table A10: Multiplier in a TANK model with respect to a change in the interest rate

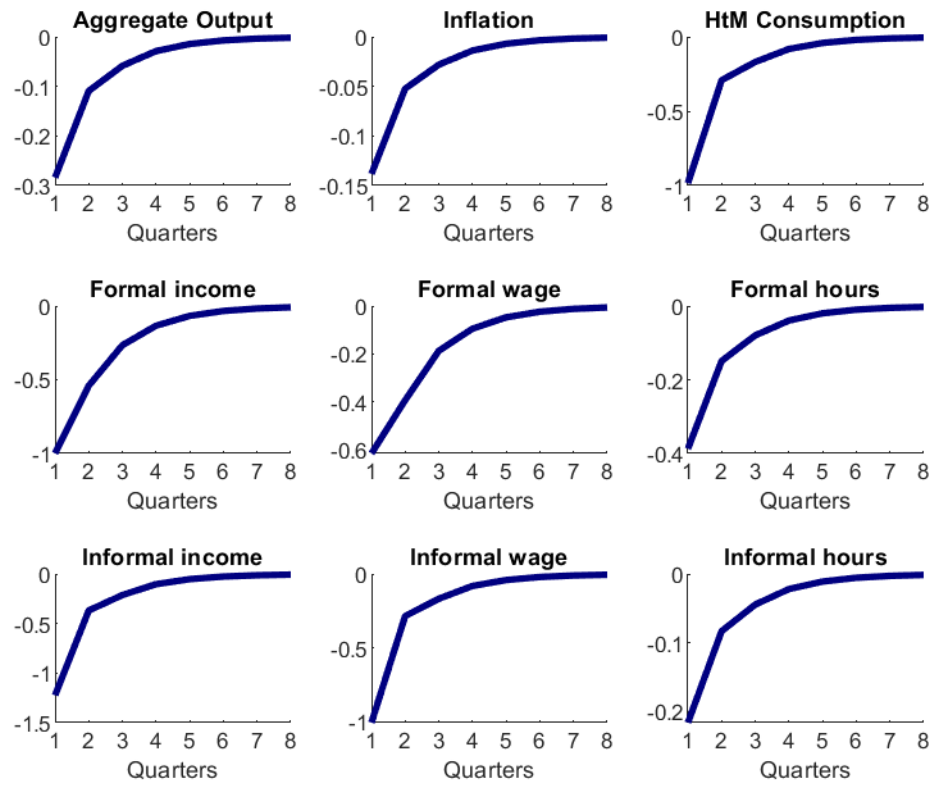
(a) Initial Multiplier					
Variable		Initial Multiplier	Variable		Initial Multiplier
Aggregate output	y_t	1.37	Formal wage	w_t^F	1.12
Inflation	π_t	0.52	Informal wage	w_t^I	3.48
HtM consumption	c_t^H	4.77	Formal hours	n_t^F	1.31
HtM income	$w_t^H + n_t^H$	4.77	Informal hours	n_t^I	1.40

(b) Cumulative Multiplier					
Variable		Cumulative Multiplier	Variable		Cumulative Multiplier
Aggregate output	y_t	1.36	Formal wage	w_t^F	2.23
Inflation	π_t	0.49	Informal wage	w_t^I	3.08
HtM consumption	c_t^H	4.33	Formal hours	n_t^F	1.44
HtM income	$w_t^H + n_t^H$	4.33	Informal hours	n_t^I	1.34

Note: This table summarizes the effects of an unanticipated change on interest rate on selected economic variables in the TANK model. The panel (a) presents the initial multiplier, which measure the immediate response of each variable to the shock. The panel (b) shows the cumulative multiplier, which capture the total accumulated response over a 5-year period. In the context of the model, where the steady-state value of the shock is zero, the impact multiplier is computed as $\frac{dy_0}{d\epsilon_0}$, and the cumulative multiplier as $\sum_{s=0}^{\infty} \beta^s \frac{dy_s}{d\epsilon_s}$, where β is the discount factor. All values are in absolute value.

G.2. TANK-interest rate shock with $\psi = 1$ and $\lambda = 0.3$

Figure A21: Unexpected rise on interest rate: Peruvian economy with $\psi = 1$ and $\lambda = 0.3$



G.2.1. The Peruvian Labor Market

Table A11: Calibrated Parameters for CRRA utility function

Parameter		Interpretation
Phillips Curve Parameters		
β	0.99	Discounting factor
θ	0.75	% of firms who do not update prices
Monetary Policy Parameters		
ϕ_π	1.5	Inflation coefficient in interest rate rule
ϕ_y	0.5	Output coefficient in interest rate rule
ρ	0.5	Persistence of shock of MP
σ_ρ	0.03	S.D of shock of MP
Firms		
α	1	Parameter in production function
ε	6	Elasticity of substitution among differentiated goods
Households		
γ	2	Inverse of Frisch elasticity (HtM HHs)
φ	2	Inverse of Frisch elasticity (Ricardian HHs)
ψ	0.1	Relative risk aversion

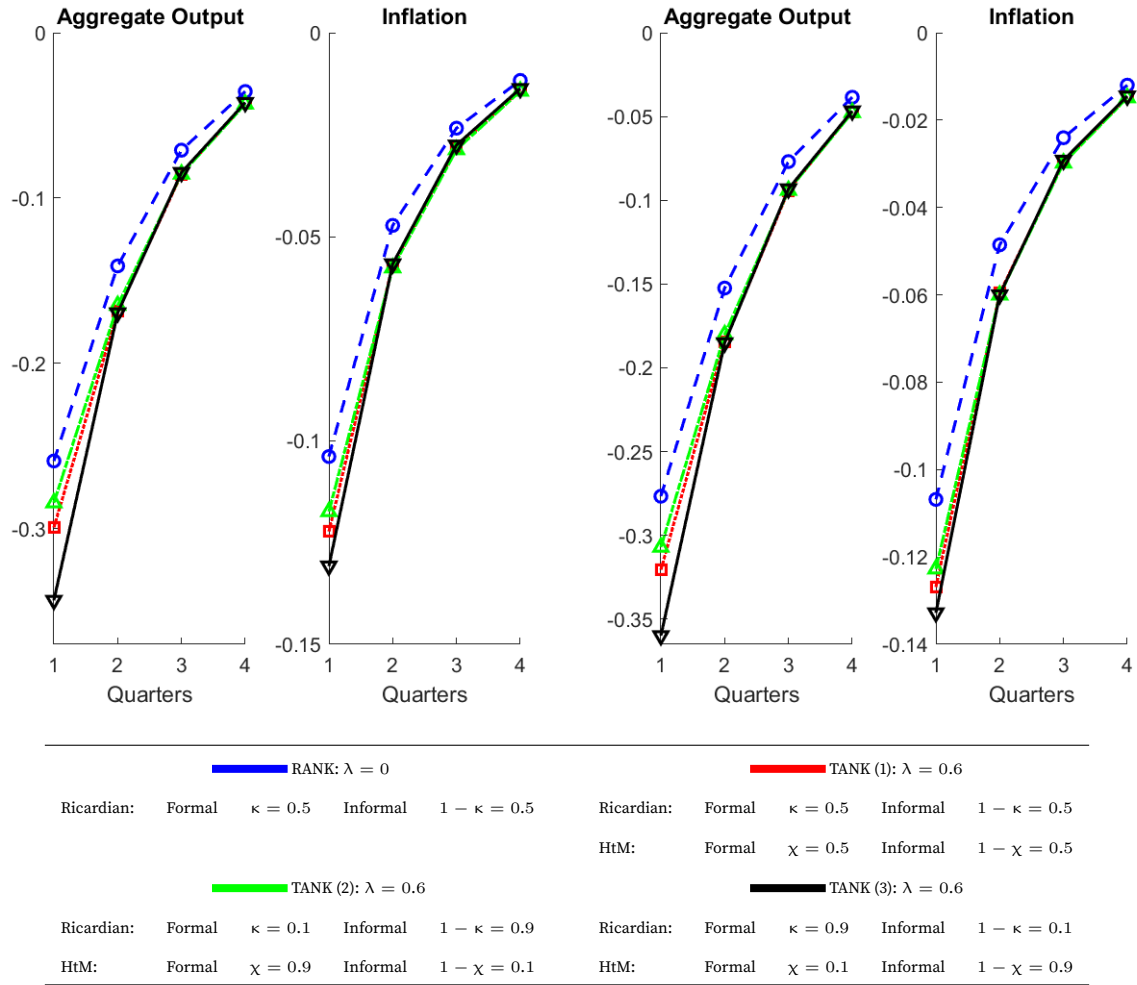
Table A12: Calibrated Parameters for GHH utility function

Parameter		Interpretation
Phillips Curve Parameters		
β	0.99	Discounting factor
θ	0.75	% of firms who do not update prices
Monetary Policy Parameters		
ϕ_π	1.5	Inflation coefficient in interest rate rule
ϕ_y	0.5	Output coefficient in interest rate rule
ρ	0.5	Persistence of shock of MP
σ_ρ	0.03	S.D of shock of MP
Firms		
α	1	Parameter in production function
ε	6	Elasticity of substitution among differentiated goods
Households		
γ	2	Inverse of Frisch elasticity (HtM HHs)
φ	2	Inverse of Frisch elasticity (Ricardian HHs)
ψ	0.067	Relative risk aversion
ϑ	1	Preference parameter

Figure A22: Unexpected rise on interest rate: output and inflation

(a) CRRA utility function

(b) GHH utility function

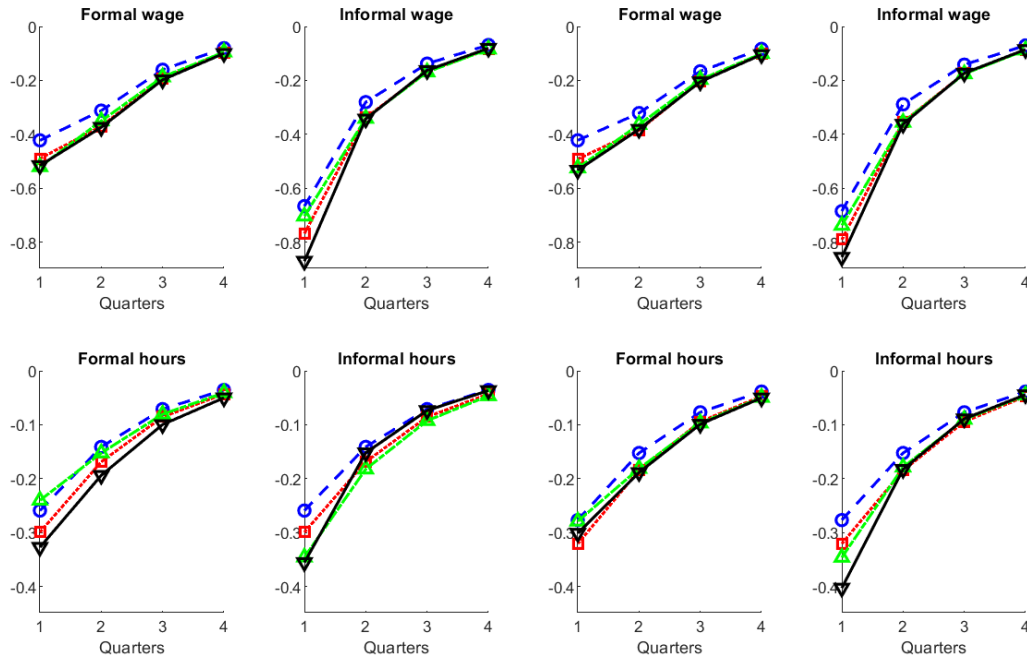


Note: The graphs show the dynamics of total output and inflation over four quarters under different economic models (RANK and three variants of TANK) and utility functions (CRRA and GHH). The RANK (Representative Agent New Keynesian model), represented by the blue dashed line, assumes no hand-to-mouth (HtM) households ($\lambda = 0$) and an equal split of Ricardian households between formal ($\kappa = 0.5$) and informal jobs ($1 - \kappa = 0.5$). The TANK (Two-Agent New Keynesian) models include three variants, each with different allocations: TANK (1), shown by the red line, assumes that HtM households make up 60% ($\lambda = 0.6$) of the total, with both Ricardian and HtM households equally split between formal ($\kappa = 0.5, \chi = 0.5$) and informal jobs ($1 - \kappa = 0.5, 1 - \chi = 0.5$). TANK (2), depicted by the green line, also assumes that HtM households constitute 60% ($\lambda = 0.6$) of the total, but with most Ricardian households in informal jobs ($\kappa = 0.1$) and most HtM households in formal jobs ($\chi = 0.9$). TANK (3), represented by the black line, maintains the same proportion of HtM households ($\lambda = 0.6$) but assumes most Ricardian households have formal jobs ($\kappa = 0.9$) while most HtM households have informal jobs ($\chi = 0.1$). On the other hand, for the GHH utility function, we use $\psi = 0.067$, which is the maximum value of ψ that ensures stability given the same parameters as in the case of the CRRA utility function.

Figure A23: Unexpected rise on interest rate: labor market

(a) CRRA utility function

(b) GHH utility function



<div style="display: flex; align-items: center;"> <div style="width: 20px; height: 5px; background-color: blue; margin-right: 5px;"></div> RANK: $\lambda = 0$ </div>					<div style="display: flex; align-items: center;"> <div style="width: 20px; height: 5px; background-color: red; margin-right: 5px;"></div> TANK (1): $\lambda = 0.6$ </div>				
Ricardian:	Formal	$\kappa = 0.5$	Informal	$1 - \kappa = 0.5$	Ricardian:	Formal	$\kappa = 0.5$	Informal	$1 - \kappa = 0.5$
HtM:	Formal	$\chi = 0.5$	Informal	$1 - \chi = 0.5$	HtM:	Formal	$\chi = 0.5$	Informal	$1 - \chi = 0.5$
<div style="display: flex; align-items: center;"> <div style="width: 20px; height: 5px; background-color: green; margin-right: 5px;"></div> TANK (2): $\lambda = 0.6$ </div>					<div style="display: flex; align-items: center;"> <div style="width: 20px; height: 5px; background-color: black; margin-right: 5px;"></div> TANK (3): $\lambda = 0.6$ </div>				
Ricardian:	Formal	$\kappa = 0.1$	Informal	$1 - \kappa = 0.9$	Ricardian:	Formal	$\kappa = 0.9$	Informal	$1 - \kappa = 0.1$
HtM:	Formal	$\chi = 0.9$	Informal	$1 - \chi = 0.1$	HtM:	Formal	$\chi = 0.1$	Informal	$1 - \chi = 0.9$

Note: The graphs show the dynamics of formal and informal wages and hours over four quarters under different economic models (RANK and three variants of TANK) and utility functions (CRRA and GHH). The RANK (Representative Agent New Keynesian model), represented by the blue dashed line, assumes no hand-to-mouth (HtM) households ($\lambda = 0$) and an equal split of Ricardian households between formal ($\kappa = 0.5$) and informal jobs ($1 - \kappa = 0.5$). The TANK (Two-Agent New Keynesian) models include three variants, each with different allocations: TANK (1), shown by the red line, assumes that HtM households make up 60% ($\lambda = 0.6$) of the total, with both Ricardian and HtM households equally split between formal ($\kappa = 0.5, \chi = 0.5$) and informal jobs ($1 - \kappa = 0.5, 1 - \chi = 0.5$). TANK (2), depicted by the green line, also assumes that HtM households constitute 60% ($\lambda = 0.6$) of the total, but with most Ricardian households in informal jobs ($\kappa = 0.1$) and most HtM households in formal jobs ($\chi = 0.9$). TANK (3), represented by the black line, maintains the same proportion of HtM households ($\lambda = 0.6$) but assumes most Ricardian households have formal jobs ($\kappa = 0.9$) while most HtM households have informal jobs ($\chi = 0.1$). On the other hand, for the GHH utility function, we use $\psi = 0.067$, which is the maximum value of ψ that ensures stability given the same parameters as in the case of the CRRA utility function.

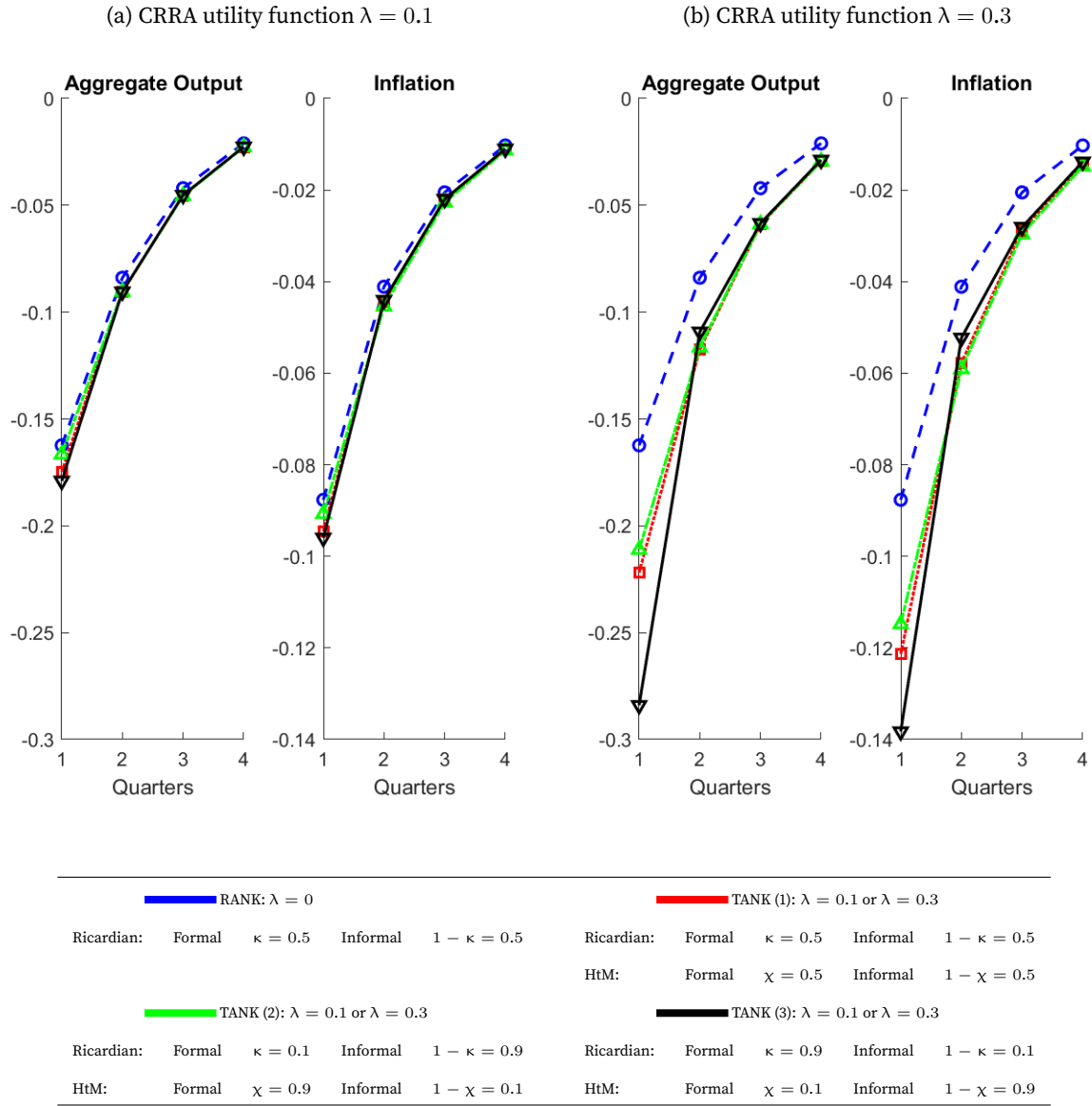
G.3. The U.S. Labor Market

Table A13: Calibrated Parameters for the US economy

Parameter		Interpretation
Phillips Curve Parameters		
β	0.99	Discounting factor
θ	0.75	% of firms who do not update prices
Monetary Policy Parameters		
ϕ_π	1.5	Inflation coefficient in interest rate rule
ϕ_y	0.5	Output coefficient in interest rate rule
ρ	0.5	Persistence of shock of MP
σ_ρ	0.03	S.D of shock of MP
Firms		
α	1	Parameter in production function
ε	6	Elasticity of substitution among differentiated goods
Households		
γ	2	Inverse of Frisch elasticity (HtM HHs)
φ	2	Inverse of Frisch elasticity (Ricardian HHs)
ψ	1	Relative risk aversion

Baseline $\kappa = 0.5$ and $\chi = 0.5$.

Figure A24: Unexpected rise on interest rate: output and inflation

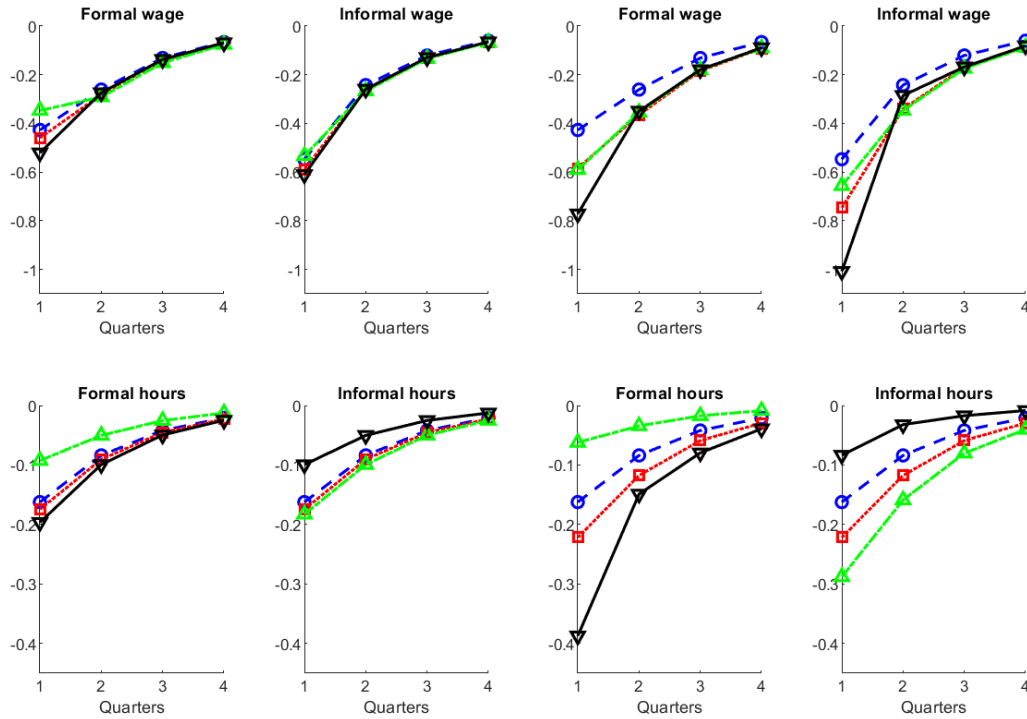


Note: The graphs show the dynamics of total output and inflation over four quarters under different economic models (RANK and three variants of TANK) and different proportions of hand-to-mouth households (λ). The RANK (Representative Agent New Keynesian model), represented by the blue dashed line, assumes no HtM households, and Ricardian households are divided between formal ($\kappa = 0.5$) and informal jobs ($\chi = 0.5$). The TANK (Two-Agent New Keynesian) models include three variants with different allocations: TANK (1), shown by the red line, assumes that both Ricardian and HtM households are divided between formal ($\kappa = 0.5, \chi = 0.5$) and informal jobs ($1 - \kappa = 0.5, 1 - \chi = 0.5$). TANK (2), depicted by the green line, assumes that most Ricardian households have informal jobs ($\kappa = 0.1$) while most HtM households have formal jobs ($\kappa = 0.9$). TANK (3), represented by the black line, assumes most Ricardian households have formal jobs ($\kappa = 0.9$) while most HtM households have informal jobs ($\chi = 0.1$).

Figure A25: Unexpected rise on interest rate: labor market

(a) CRRA utility function $\lambda = 0.1$

(b) CRRA utility function $\lambda = 0.3$

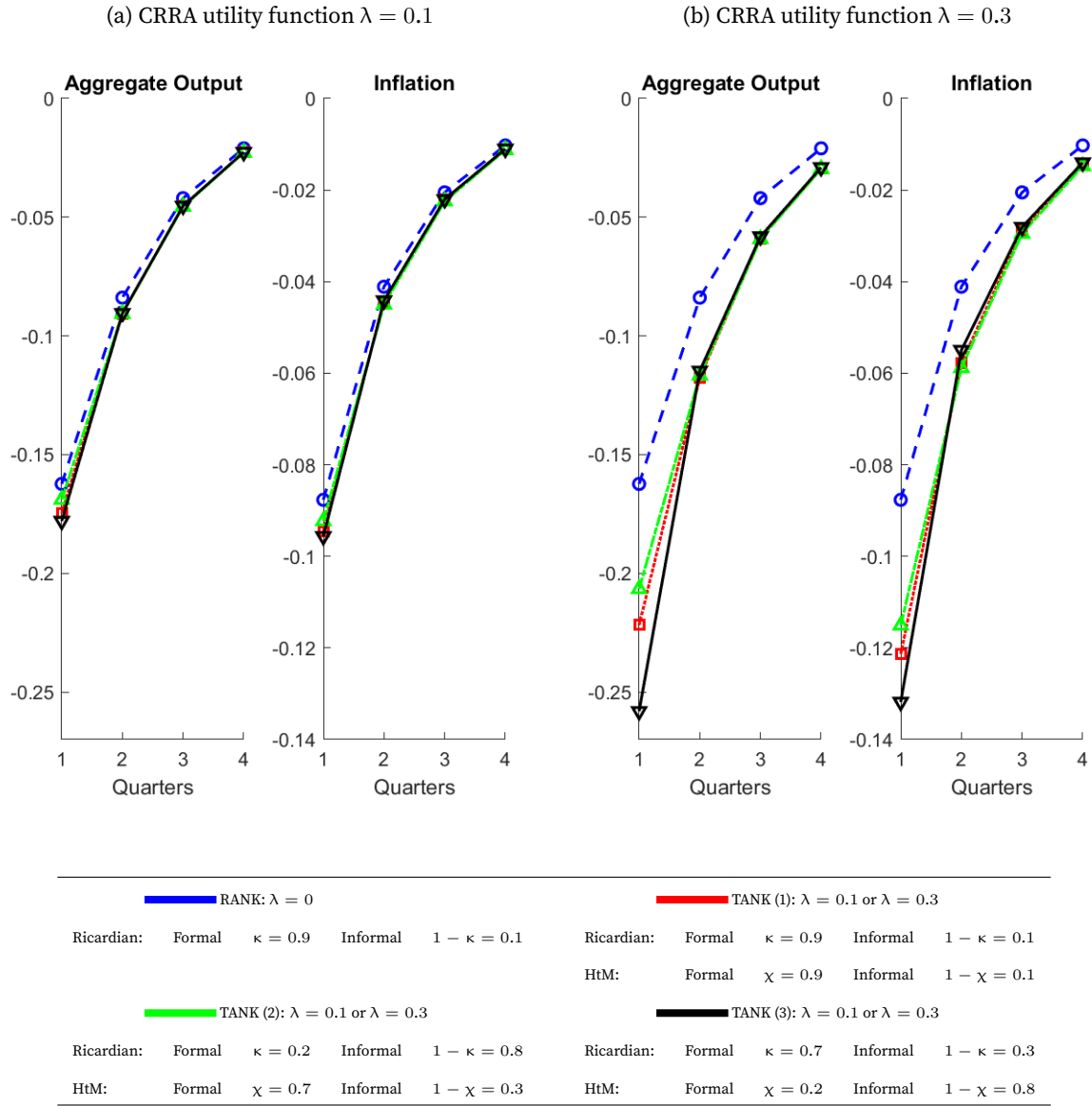


RANK: $\lambda = 0$					TANK (1): $\lambda = 0.1$ or $\lambda = 0.3$				
Ricardian:	Formal	$\kappa = 0.5$	Informal	$1 - \kappa = 0.5$	Ricardian:	Formal	$\kappa = 0.5$	Informal	$1 - \kappa = 0.5$
HtM:	Formal	$\chi = 0.5$	Informal	$1 - \chi = 0.5$	HtM:	Formal	$\chi = 0.5$	Informal	$1 - \chi = 0.5$
TANK (2): $\lambda = 0.1$ or $\lambda = 0.3$					TANK (3): $\lambda = 0.1$ or $\lambda = 0.3$				
Ricardian:	Formal	$\kappa = 0.1$	Informal	$1 - \kappa = 0.9$	Ricardian:	Formal	$\kappa = 0.9$	Informal	$1 - \kappa = 0.1$
HtM:	Formal	$\chi = 0.9$	Informal	$1 - \chi = 0.1$	HtM:	Formal	$\chi = 0.1$	Informal	$1 - \chi = 0.9$

Note: The graphs show the dynamics of total output and inflation over four quarters under different economic models (RANK and three variants of TANK) and different proportions of hand-to-mouth households (λ). The RANK (Representative Agent New Keynesian model), represented by the blue dashed line, assumes no HtM households, and Ricardian households are divided between formal ($\kappa = 0.5$) and informal jobs ($\chi = 0.5$). The TANK (Two-Agent New Keynesian) models include three variants with different allocations: TANK (1), shown by the red line, assumes that both Ricardian and HtM households are divided between formal ($\kappa = 0.5, \chi = 0.5$) and informal jobs ($1 - \kappa = 0.5, 1 - \chi = 0.5$). TANK (2), depicted by the green line, assumes that most Ricardian households have informal jobs ($\kappa = 0.1$) while most HtM households have formal jobs ($\kappa = 0.9$). TANK (3), represented by the black line, assumes most Ricardian households have formal jobs ($\kappa = 0.9$) while most HtM households have informal jobs ($\chi = 0.1$).

Baseline $\kappa = 0.9$ and $\chi = 0.9$.

Figure A26: Unexpected rise on interest rate: output and inflation

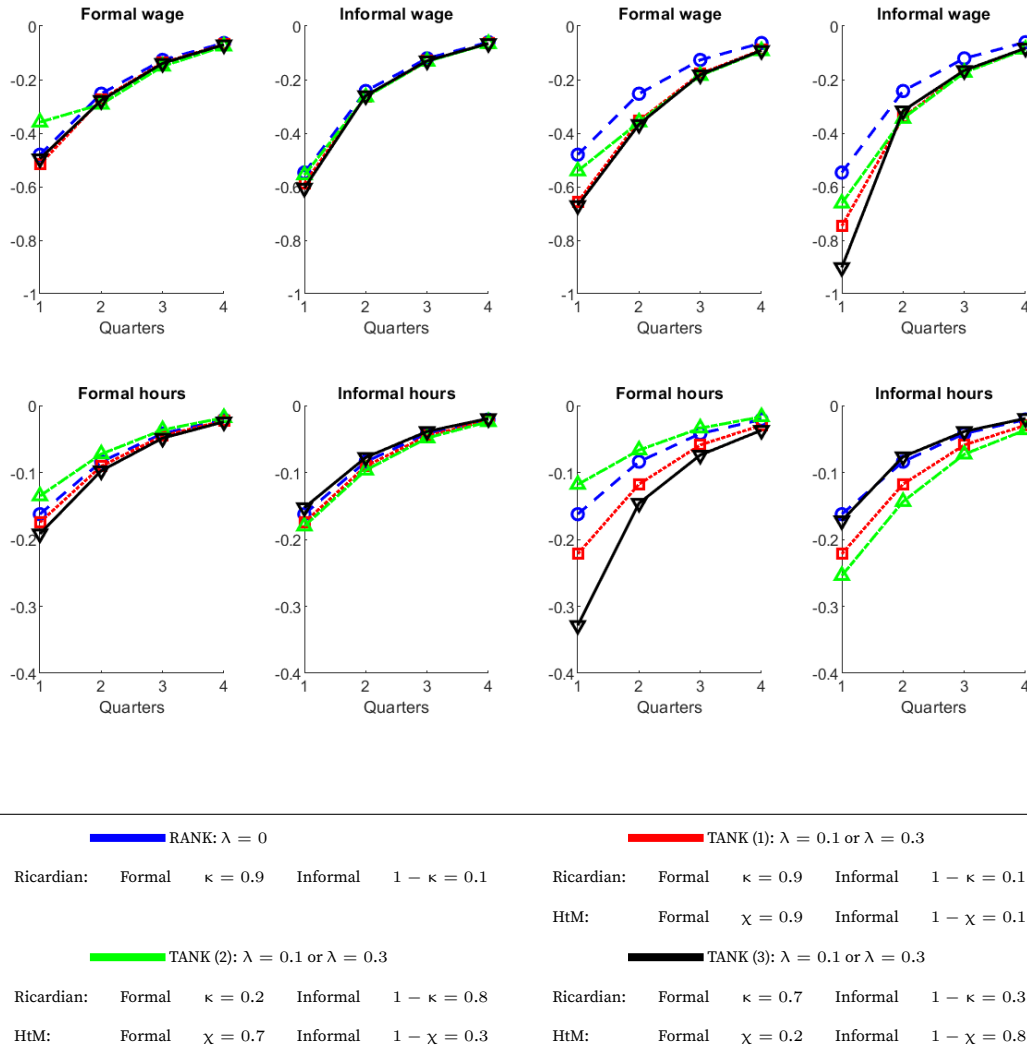


Note: The graphs show the dynamics of total output and inflation over four quarters under different economic models (RANK and three variants of TANK) and different proportions of hand-to-mouth households (λ). The RANK (Representative Agent New Keynesian model), represented by the blue dashed line, assumes no HtM households, and Ricardian households are divided between formal ($\kappa = 0.9$) and informal jobs ($\chi = 0.9$). The TANK (Two-Agent New Keynesian) models include three variants with different allocations: TANK (1), shown by the red line, assumes that both Ricardian and HtM households are divided between formal ($\kappa = 0.9, \chi = 0.9$) and informal jobs ($1 - \kappa = 0.1, 1 - \chi = 0.1$). TANK (2), depicted by the green line, assumes that most Ricardian households have informal jobs ($\kappa = 0.2$) while most HtM households have formal jobs ($\kappa = 0.7$). TANK (3), represented by the black line, assumes most Ricardian households have formal jobs ($\kappa = 0.7$) while most HtM households have informal jobs ($\chi = 0.2$).

Figure A27: Unexpected rise on interest rate: labor market

(a) CRRA utility function $\lambda = 0.1$

(b) CRRA utility function $\lambda = 0.3$



Note: The graphs show the dynamics of formal and informal wages and hours over four quarters under different economic models (RANK and three variants of TANK) and different proportions of hand-to-mouth households (λ). The RANK (Representative Agent New Keynesian model), represented by the blue dashed line, assumes no HtM households, and Ricardian households are divided between formal ($\kappa = 0.9$) and informal jobs ($\chi = 0.9$). The TANK (Two-Agent New Keynesian) models include three variants with different allocations: TANK (1), shown by the red line, assumes that both Ricardian and HtM households are divided between formal ($\kappa = 0.9, \chi = 0.9$) and informal jobs ($1 - \kappa = 0.1, 1 - \chi = 0.1$). TANK (2), depicted by the green line, assumes that most Ricardian households have informal jobs ($\kappa = 0.2$) while most HtM households have formal jobs ($\kappa = 0.7$). TANK (3), represented by the black line, assumes most Ricardian households have formal jobs ($\kappa = 0.7$) while most HtM households have informal jobs ($\chi = 0.2$).

G.4. Local Projection estimations

In this section, we evaluate the main conclusions of our TANK model, as discussed in Section 5. The model suggests that monetary policy is more effective under two key conditions: (1) a high proportion of "hand-to-mouth" individuals, and (2) a significant level of labor informality. Based on this, we hypothesize that countries with both high informality and a large

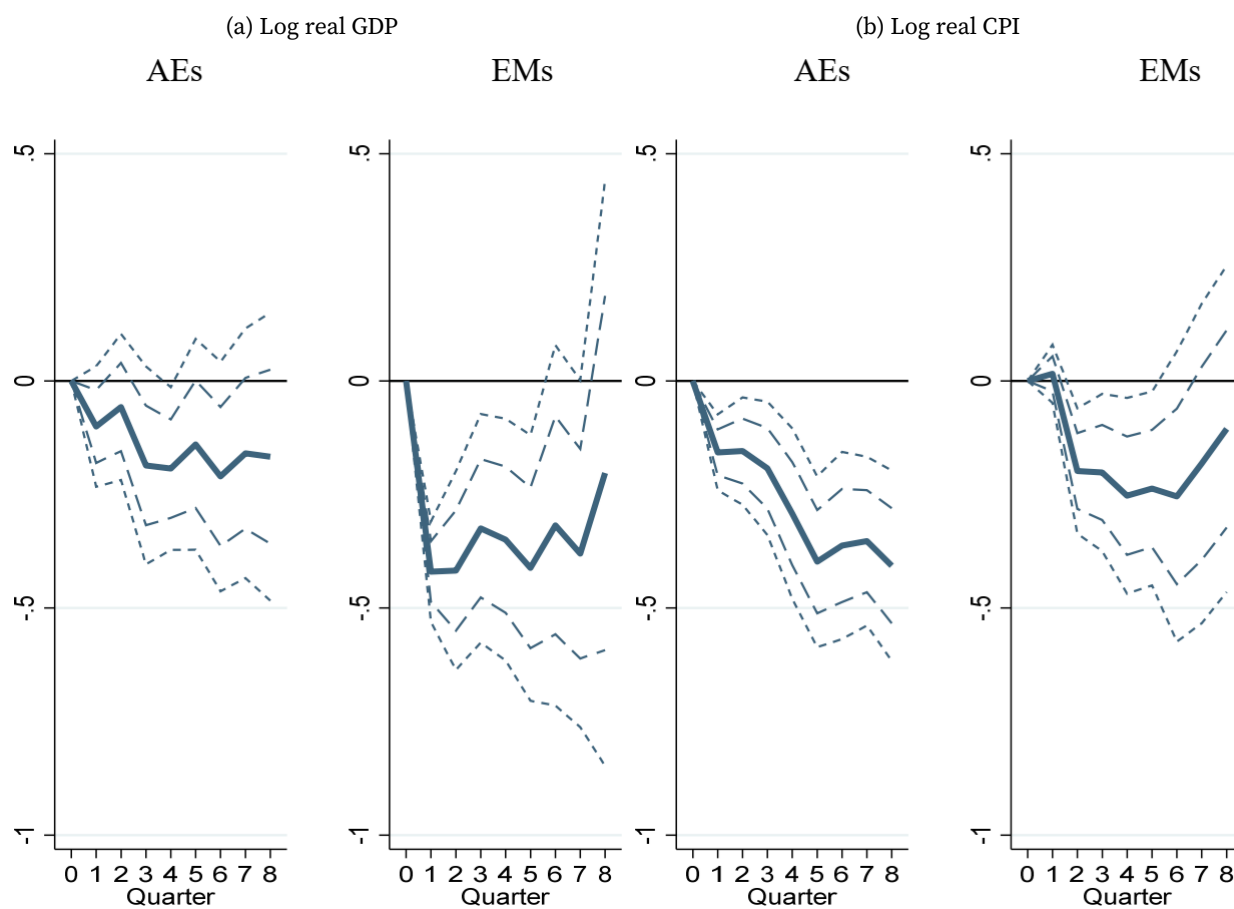
share of hand-to-mouth individuals should exhibit a stronger response to monetary policy interventions. Emerging economies are natural candidates for these characteristics, and thus we expect to observe a greater output response to monetary shocks in emerging economies compared to advanced economies.

To test this hypothesis, we draw on estimates from [Deb et al. \(2023\)](#), who construct monetary policy shocks for 33 countries spanning from 1991Q2 to 2023Q2. This study is well-suited for testing our model's predictions for several reasons. First, it includes both advanced and emerging markets. Second, the identification strategy used by [Deb et al. \(2023\)](#) follows the methods of [Romer and Romer \(2004\)](#) and [Cloyne and Hürtgen \(2016\)](#), aligning with established approaches for isolating exogenous monetary shocks^{A2} like [Miranda-Agrippino and Ricco \(2021\)](#). Third, the consistent use of this methodology across the entire sample ensures uniform construction of monetary shocks, which is crucial for comparing advanced and emerging economies. Fourth, [Deb et al. \(2023\)](#) utilize a local projection framework to assess the impact of monetary policy on GDP and inflation, a method recognized for its robustness ([Montiel Olea and Plagborg-Møller, 2021](#)). Finally, they evaluate the effects of a 100 basis point (bps) monetary policy shock, directly in line with our own analysis.

The findings are presented in figure 19, with Panel (a) illustrating the response of log real GDP and Panel (b) showing changes in the log Consumer Price Index (CPI). In Panel (a), the impulse response functions indicate that GDP responses in emerging economies are significantly stronger than those in advanced economies. In contrast, Panel B shows a slightly stronger inflation response in advanced economies, though these differences are not statistically significant at 90%. These results are consistent with the predictions of our TANK model. We attribute the stronger output response in emerging economies to higher levels of informality and limited access to financial services—both common characteristics of these markets. In contrast, advanced economies, with lower informality and broader financial access, exhibit smaller output responses to monetary policy shocks. The local projection estimations and identification strategy thus align well with our model's predictions.

^{A2}As described by [Deb et al. \(2023\)](#): “First, we calculate forecast errors in short-term rates by subtracting interest rate forecasts from realized interest rates. Next, we extract the part of these forecast errors that is orthogonal to the state of the economy by regressing the forecast errors on changes and forecasts of growth, inflation, and other predetermined macroeconomic variables.”

Figure A28: IRFs to an unexpected monetary shock of 100 bps



Note: AEs: Advanced Economies. EMs: Emerging Economies. The solid line represents the point estimate, the dashed line the 68% confidence interval, and the short-dashed line the 90% confidence interval. IRFs based on local projection methods following [Jordà \(2005\)](#) using an unbalanced panel of quarterly data for 33 countries from 1990 to 2019. Source: [Deb et al. \(2023\)](#).