Optimal Progressive Consumption Tax in an Economy with Consumption Tax Evasion

(Preliminary and Incomplete)

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Abstract

How can governments in developing countries design progressive taxes when informal incomes are unobserved? This study explores a consumption-based alternative to income-based redistribution. We use a structural heterogeneous life-cycle model calibrated to Thailand where large economic activities are in informal sectors, and evaluate a flat consumption tax (VAT) and incentive-compatible rebate system when two types of markets co-exist: formal (fully taxed) and informal (with embedded VAT). We find that the VAT level, the rebate design, and the extent of embedded taxation in informal goods are key to welfare outcomes, operating through direct resource redistribution and behavioral responses to relative price changes. Increasing the VAT rate from 7% to 10%, coupled with incentive-compatible progressive rebates, yields a 0.3% welfare gain—benefiting the elderly and informal workers the most.

1 Introduction

Progressive taxation is a key instrument in public finance to redistribute resources from the rich to the poor and mitigate uninsurable private income risk (Eaton and Rosen (1980) and Varian (1980)). In the context of advanced economies, the optimal income taxation has been extensively studied (Mirrlees (1971); Saez (2001); Heathcote et al. (2017)). However, the implications from these studies in less developed economies are limited. These economies often face high levels of income inequality (Alvaredo and Gasparini, 2015) and are typically characterized by large informal sectors. This presents a unique challenge: the informal economy not only narrows the income tax base but also

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makes it infeasible or costly to verify reported incomes, thereby undermining the government's ability to effectively target low-income households.

Our paper focuses on a consumption taxation which has a broad base in most countries. Specifically, we study progressive consumption taxes which are implemented through a combination of flat tax and a progressive consumption rebate. Our progressive consumption tax scheme explicitly accounts for consumers' incentive to truthfully self-report their total consumption (incentive-compatibility) and we examine its implications in a less developed economy where substitutable (tax-evasive) informal consumption is prevalent.

The consumption taxation has become a central revenue instrument worldwide due to its efficiency and ease of enforcement (Brockmeyer et al., 2024). Thank to its board base, consumption taxes constitute a larger proportion of tax revenue than income base taxation in most less developed countries. Despite its widespread adoption, existing consumption tax is often regarded as regressive, disproportionately burdening lower-income households (Blasco et al. (2023), Warren (2008)). Recent research, however, argues that consumption tax may, in fact, be progressive in emerging economies once taking into account the prevalent informal consumption (Bachas et al., 2024)). Since the budget share devoted to informal goods — characterized by a lower VAT pass-through — decline with income, the effective tax incidence is lower among lower-income households.

To address the concerns about non-progressivity of consumption taxes, a common approach is to use rates differentiation or tax-exemptions on specific goods consumed proportionally more among low income households, which can enhance social welfare relative to income taxation (Conesa et al., 2020). However, such measures may be inefficient, as high-income households also capture significant benefits. An alternative practice is through mean-tested consumption tax rebates, which are possibly linked to an existing welfare program.[1] Yet in many emerging economies, where informality is pervasive and household incomes are difficult to verify, welfare programs suffer from substantial inclusion and exclusion errors that undermine their targeting efficiency (Hanna and Olken, 2018).

Recent research has renewed interest in progressive consumption tax rates. Using a quantitative life cycle model, Da Costa and Santos (2023) find a large efficiency gain from lowering distortions in the US tax system when replacing progressive income taxes with progressive consumption taxes. While the implication of progressive consumption taxes is appealing, the main obstacle is its implementation feasibility, especially in the context of less developed countries. To overcome the problem we resort to a progressive consumption tax scheme which is implemented through a combination of flat consumption tax and (incentive-compatible) progressive consumption rebate schedule.

[1] Thailand offers an early example of this approach. In 2018, holders of State Welfare Card (SWC) who purchase goods and services at VAT-registered stores using Electronic Data Capture (EDC) machines have received a partial rebate of the 7 percent VAT: 5 percent is credited to their e-Money account via the government's "PaoTang" mobile application, while 1 percent is deposited into the National Saving Fund (NSF).

Unlike an existing flat consumption tax, progressive consumption taxes use monthly (or annual) aggregate consumption of each individual (or household) as the tax base, thus requiring individual consumption accounts tracking all transactions. However, establishing the complex accounting system is challenging, especially in lower income countries. Instead, we rely on individuals' self-reported total consumption and an incentive-compatible rebate schedule. More specifically, our consumption rebate schedule has two key properties: (i) rebate amount increases with total consumption, and (ii) marginal rebate is decreasing in total consumption or, equivalently, marginal rebate is always less than average rebate. In practice, any monotone-increasing concave rebate schedule satisfies both properties. Property (i) is to induce a truthful report. Property (ii) ensures that the average consumption tax after rebate is increasing in total consumption, thus our effective consumption tax is progressive.[2]

Besides the different strategy to obtain individuals' aggregate consumption, there are three additional aspects differentiating our proposed scheme from progressive consumption tax rates typically discussed in literature.

First, most countries adopt VAT system which collects consumption taxes at each stage of production.[3] Since final consumers are unknown during the production stage, any non-linear consumption tax schedule cannot be implemented in VAT system. In contrast, our scheme allows VAT system to collect a flat consumption tax at the production stages while rebates are redistributed after the final point of sale.

Second, while any progressive consumption tax schedule can be formulated as a combination of flat tax rate and progressive rebates, the resulting progressive rebates is not necessarily incentive-compatible. Due to the lagged period between the purchasing time and the time when the rebate is received, a high flat tax can cause a liquidy problem, especially amoung poor households. Thus, setting the flat tax at an arbitrarily high level is likely infeasible. If this is the case, a highly redistributive consumption tax schedule might not be implementable through our incentive-compatible scheme. More specifically, if the marginal taxes of progressive consumption taxes exceed the flat tax, its corresponding rebate schedule violates Property (i), thus no longer incentive-compatible.[4] This

[2] We can write the effective consumption tax under our flat tax and rebate scheme as $\tau_c c - R(c)$, where τ_c is a flat tax rate and $R(c)$ is a rebate function. Thus, the average consumption tax is $\tau_c - \frac{R(c)}{c}$. The effective tax schedule is progressive when the average tax is increasing in consumption c, or

$$\frac{R(c)}{c^2} - \frac{R'(c)}{c} > 0. \tag{1}$$

The above inequality is satisfied when $\frac{R(c)}{c} > R'(c)$.

[3] While consumption taxes are paid by the final consumers, in pratice, there are two different system to collect tax revenues, namely sales tax system and value-added system. Unlike VAT system, consumption tax is collected only at the final sale points to the consumers. As of 2025, the US is only major economy still using the sales tax system.

[4] Denote $f(c)$ as an increasing and convex function representing an arbitrary progressive consumption tax. Thus, a corresponding rebate function for a given flat tax τ_c is

$$\widehat{R}(c) = \tau_c c - f(c).$$

is likely the case when the inequality is high and a desirable consumption tax is highly progressive.

Third, a progressive consumption tax scheme requires special accounts recording all purchases of individuals. This can raise a privacy concern. Under our proposed scheme, while the government still requires valid receipts or records to verify individuals' consumption, it is not compulsory. Individuals do not need to report a particular transaction if monetary benefits from the marginal rebate is lower than their privacy concern, thus likely more politically acceptable.

An additional novel in our paper is to study the implication of our progressive consumption tax scheme in an emerging economy characterizing by a prevalence of (tax-evasive) informal consumption. The unique feature of consumption markets has two important implications. First, informal goods influence tax incidence because they incorporate inputs from formal sector, thereby embedding some degree of VAT passthrough (Blasco et al., 2023). Combined with a downward-sloping Engel curve for informality documented in Bachas et al. (2024) and corroborated in this study, this mechanism determines individuals' total VAT liability across consumption levels. Second, informal consumption introduces an additional behavioral margin, as consumers may substitute between formal and informal goods in response to rebate. Our analysis explicitly incorporates both of these dimensions.

We develop a heterogeneous life-cycle model that incorporates three challenges to the design of a progressive consumption tax. The framework captures salient features of emerging markets, including coexistence of dual labor sectors and their interactions. The model distinguishes between two categories of consumption goods — formal goods which are fully taxed, and informal goods, subject to partial VAT passthrough. The calibration aligns with the empirical observed downward-sloping Engel curve of informal consumption and the extent of VAT passthrough in Thailand. This structures enables us to analyze how tax progressivity arises from both the incidence of VAT and the substitution between formal and informal goods.

Our preliminary analysis shows that raising the VAT rate from 7 to 10 percent, when paired with an incentive-compatible progressive rebate, improves both equity and efficiency in Thailand's dual economy. Informal workers, who are typically disadvantaged under proportional rebates because much of their spending falls on informal goods with embedded but non-rebated VAT, become net beneficiaries under progressive rebate schedules. The model indicates that this reform not only redistributes resources toward low-consuming households—particularly retirees and informal workers—but also yields an overall welfare gain of approximately 0.3 percent. However, the results also highlight important trade-offs: while more progressive rebate schedules enhance redistribution, they introduce distortions to labor supply decisions, underscoring the

Note that the property (ii) is always satisfied. Property (i) is satisfied if $f'(c) < \tau_c$ for all possible c. In another word, the incentive-compatibility requirement imposes an upper bound on marginal consumption tax $f'(c)$, consequently limiting the degree of pregressivity of consumption taxes.

tension between equity and efficiency in policy design

Our contribution relates to three strands of literature. First, we build on optimal taxation literature (e.g., Mirrlees (1971), Diamond (1998),Heathcote et al. (2017), Saez (2001), Atkinson and Stiglitz (1976)), extending the logic of tax progressivity from income to consumption instruments, which may be more approrpirate in emerging economies characterized by widespread informality.

Second, we contribute to research on progressive consumption taxation and the equity implications of VAT in developing economies (e.g., Da Costa and Santos (2023), Swistak (2024), Kotlikoff et al. (2025)). We integrate evidence on VAT passthrough to informal goods (Brockmeyer et al. (2024), Brusco and Velayudhan (2024)) and evaluate a feasible policy tool — combining VAT and a rebate — while explicitly taking into account an incentive-compatibility constraint. We further provide a systematic analysis of channels through which such policy affect tax incidence: directly by redistributing across low- and high-consuming individuals, and indirectly, through policy-induced changes in the relative prices of formal and informal goods that generate substitution effects. We also highlight how the slope of the informality Engel curve and a degree of VAT passthrough shape the strength of each channel.

Third, we contribute to the literature on tax design in low-capacity setting and the structural modeling of emerging market economies (e.g.,Kudrna et al. (2025), Poonpolkul et al. (2024), Song et al. (2015), Esteban-Pretel and Kitao (2021), Li (2020)), by embedding dual labor markets and dual consumption goods in a heterogeneous-agent life-cycle model calibrated to Thailand.

This paper proceeds as follows. Section 2 presents empirical evidence from Thailand's Socio-Economic Survey, highlighting the distribution of formal and informal consumption across households. Section 3 develops a structural overlapping generations model with formal and informal labor markets, heterogeneous households, and old-age income programs, embedding a VAT rebate scheme into the fiscal framework. Section 4 details the calibration strategy, drawing on administrative, survey, and national accounts data. Section 5 establishes the theoretical underpinnings of the rebate function, its progressivity, and its implications for relative prices and fiscal balance. Section 6 reports the main results, including the effects of incentive-compatible rebates, welfare impacts, and the potential role of non-monotonic rebate schedules. Section 7 concludes.

2 Background

The coexistence of formal and informal consumption, extensively documented across emerging economies (Keen, 2008), generate distinctive implication for incidence and implication of VAT, as shown in Section 5.2. We define formal consumption as expenditures on goods and services purchased through official, regulated channels – such as registered businesses and retail outlets – where transactions are typically documented and subject to value-added tax (VAT). By contrast, informal consumption refers to purchases through unregulated and unofficial channels, including street vendors, fresh markets, and self-produced

goods. These transactions are generally untaxed at the point of sale, although VAT may remain embedded in prices through earlier stages of production and distribution from use of formal input (De Paula and Scheinkman, 2010).

We draw on microdata from Thailand's 2019 Socio-Economic Survey (SES), which reports household consumption expenditures alongside the retail outlets where purchases are made. We classify transactions conducted at general stores and fresh markets as informal, while those made through supermarkets, convenience stores, and other modern retail outlets are classified as formal (see Appendix D for details). Within each consumption category, we further distinguish between goods subject to VAT and those exempt under Thai law, notably unprocessed agricultural and animal products.

Figure 1 plots the shares of informal and formal consumption relative to total expenditure – an expenditure-based proxy for income, following Bachas et al. (2024) – across percentiles of expenditure. At a lower level of expenditure, informal consumption dominates: roughly 90 percent of spending in the lowest percentiles occurs through general stores and fresh markets. As total expenditure increases, however, the share of informal purchases declines steadily, with household increasingly shifting toward formal retail outlets.

The composition of purchases within informal markets also varies systematically in terms of VAT exemption. Among households in the lowest quartile, 38 percent of informal consumption is allocated to VAT-exempt goods. These shares diminish with rising expenditure, mirroring the broader decline in informal consumption. By contrast, formal consumption is concentrated in VAT-liable goods, with VAT-exempt purchases accounting for only a negligible fraction across all expenditure percentiles.

These patterns generate a downward-sloping Informality Engel Curve (IEC), which our dual-goods framework replicates closely.

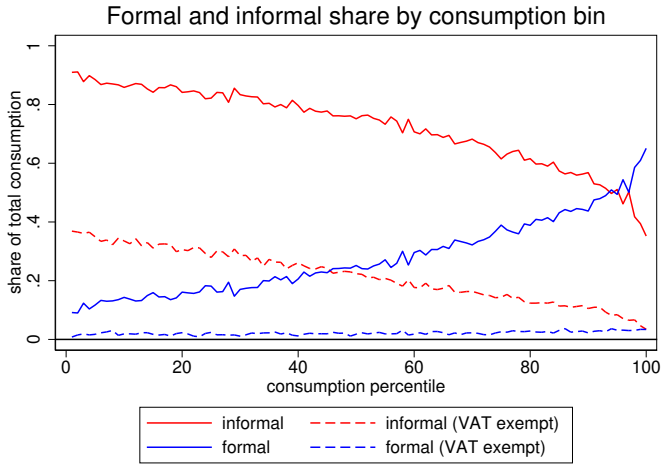


Figure 1: Formal and informal consumption relative to total expenditure

3 Model

We employ a partial-equilibrium overlapping generations (OLG) model to study the design of optimal tax progressivity through VAT and rebate mechanisms in emerging economies, using Thailand as a case study. This framework extends Poonpolkul et al. (2024). One model period corresponds to five years. The economy is calibrated to Thailand during 2015-2019, which we treat as stationary, and incorporates both dual labor market – formal and informal sectors – and the old-age income system.

The model features two types of consumption goods: formal and informal. These goods are imperfectly substitute, which allows us to analyze how households adjust their consumption bundles across sectors in respond to different VAT and rebate schemes.

Section 3.1 describes the structure of formal and households and their decision-makings, given their productivity, tax environment, and a rebate mechanism. Section 3.2 outlines the government's budgets in the baseline model under alternative rebate scenarios.

3.1 Households

Individuals enter the labor market at age group $j = 1$ (age 25-29) with no initial assets ($a_1 = 0$) and live up to $J = 15$ (age 95-99). Surviving probabilities of an individual age $j-1$ to age j is denoted by ξ_j, with $\xi_1 = 1$ and $\xi_{J+1} = 0$. Individuals are ex ante heterogeneous in their education level, $e \in \{L, H, C\}$, corresponding to less than high school, high school, and college. Education determine both individual productivity and the probability of employment in the formal labor market.

In each period, an individual is endowed with one unit of time, which can be allocated between labor supply (l) and leisure. Conditional on surviving to the end of period, individuals derive utility from consuming a bundle of goods – consisting of formal goods (c) and informal goods (n) – and from leisure. Preferences are represented by

$$u_e(n_j, c_j, l_j) = \frac{\left(\left(\omega \cdot c^{\phi_1} + (1-\omega) \cdot (n - \bar{n})^{\phi_2} \right)^{\frac{1-\nu_e}{\phi_1}} (1-l)^{\nu_e} \right)^{1-\rho}}{1-\rho} \tag{2}$$

where ρ denotes the coefficient of risk aversion, ν_e captures education-specific leisure weights, and ω governs the expenditure share on formal goods within the consumption bundle. The parameter $\bar{n}$ represents a subsistent level of informal consumption. Because consumption and leisure enter utility in a Cobb-Douglas form, the implied elasticity of substitution between the composite consumption and leisure is one.

Within the consumption bundle, we employ an aggregator that allows for distinct curvature parameters across goods, thereby relaxing the assumption of constant elasticity of substitution. Specifically, the curvature terms are calibrated

to match Informality Engel Curve (see Section 4.4), yielding $0 < \phi_2 < \phi_1 < 1$. This calibration implies diminishing marginal substitution that favors formal consumption as total consumption increases. This property is consistent with the empirical evidence, which indicate that individuals predominantly consume informal goods when the total consumption is low but increasingly shift to formal goods as the total consumption increases.

3.1.1 Formal and informal sectors

Let $o_j \in O = \{0, 1\}$ denote an individual's sectoral status in age j with $o_j = 1$ indicating formal employment and $o_j = 0$ indicating informal employment. Informal workers can freely adjust their hours of work, while formal workers choose only along the extensive margin: $l \in \{0, \bar{l}\}$ where $\bar{l} = 0.4$ which is equivalent to 45 hours per week.[5] This specification captures institutional frictions in emerging markets such as Thailand, where formal jobs are predominantly full-time.

The model incorporates transitions between formal and informal sectors using education- and age-specific probabilities $1 - \pi_j^o(e)$. Empirical evidence indicates that most individuals who exit formal employment remain in the informal sector. Accordingly, we assume that once workers leave the formal sector, they continue in the informal sector until retirement.

We impose mandatory retirement ages of 55 for high school-educated and 60 for college educated formal workers, consistent with the prevailing retirement practice in Thailand. By contrast, individuals who transition into the informal sector prior to reaching mandatory retirement age may continue working until age 70. After reaching the formal retirement age, formal workers are no longer permitted to switch into informal sector. This restriction aligns with administrative record from the Social Security (SS) system, which shows sharp increases in retirements precisely at ages 55 and 60.

Formal workers are subject to progressive income taxation and are mandated to contribute to the SS system. The earliest age at which SS benefits can be claimed is 55. Because benefits do not increase with delayed claiming, we assume that individuals who exit the formal sector and transition to the informal sector take their benefits at age 55, whereas those who remain in the formal sector collect benefits at the statutory retirement age, J_{SS}, of 60. At retirement, eligible contributors receive benefits either as a lump sum or as an annuity, depending on the duration of participation in the program (see Section 3.1.3 for details). By contrast, informal workers neither pay income tax nor make SS contributions and therefore do not have access to the formal pension system. However, both formal and informal workers are entitled to a non-contributory universal Old Age Allowance (OAA) beginning at age $J_{OAA} = 60$. Table 1 summarizes retirement ages across sectors and education groups, along with the timing of pension eligibility and OAA benefits.

[5] We assume 16 available hours per day.

	Retirement	SS benefit[a]	OAA benefit
All education in informal sector	70 $(J_R = 10)$	55 $(J_{ss} = 7)$	60 $(J_{OAA} = 8)$
High school in formal sector	55 $(J_R = 7)$	55 $(J_{ss} = 7)$	60 $(J_{OAA} = 8)$
College in formal sector	60 $(J_R = 8)$	60 $(J_{ss} = 8)$	60 $(J_{OAA} = 8)$

[a] For people ever paying the SS contribution.

Table 1: Retirement age and eligible age for SS benefit and OAA benefits

3.1.2 Labor productivity shock

In each period t, working-age individuals of aged j experience a labor productivity shock, $z_{jt}\left(e, o_j\right)$, which varies with age, educational attainment, and their current sector of employment. Once individuals retire, their productivity is assumed to be zero.

We parameterize the labor productivity shock as

$$z_{jt}(e, o_j) = \begin{cases} \lambda_j\left(e, o_j\right) \cdot exp\Big(\eta_j\left(e, o_j\right)\Big), & \text{if } \; j < J_R \\ 0 & \text{if } \; j \geq J_R, \end{cases} \tag{3}$$

where $\lambda_j\left(e, o_j\right)$ is the age-deterministic profiles which differ for each education and sector.

The persistent productivity shock, denoted by $\eta_j\left(e, o_j\right)$, evolves according to a first-order discrete Markov process. Conditional on the next period sector $o_{j'}$, the transition probability is given by $\pi_j^{\eta}\left(\eta_{j'} | \eta_j, o_j, o_{j'}, e\right)$. Combining this with the probability of remaining in the formal sector, $\pi_j^{o}\left(e\right)$, yields the overall the transition probability from the current state $\{\eta_j, o_j\}$ to the next-period state $\{\eta_{j'}, o_{j'}\}$.

3.1.3 Social security and Old-age allowance programs

The SS system is modeled after the SS program in Article 33. While employed in the formal sector, individuals are required to participate and contribute at a rate τ_{ss} of 3% of their SS taxable earnings y_{ss}, which can be expressed as

$$y_{ss} = \begin{cases} min\left(\widetilde{y}_{max}, \; l \cdot z_{jt}\left(e, o_j\right)\right) & \text{if } \; o_j = 1 \;\; \text{and} \;\; l = \bar{l} \\ 0 & \text{if otherwise,} \end{cases} \tag{4}$$

where $\widetilde{y}_{max}$ denotes the maximum earnings subject to SS payroll taxation, set at 15,000 THB. The individual SS contribution, or payroll tax, is therefore

$$Tax_{ss} = \tau_{ss} \cdot y_{ss} \tag{5}$$

Upon reaching the eligible age, J_{ss}, individuals who have contributed to the system qualify for pension benefits. For tractability, we simplify benefits formula to depend only on contribution years, (n_{ss}), and individuals' education

level and initial sector.[6] The dynamic of contribution year is defined as

$$n_{ss_{j'}} = \begin{cases} n_{ss_j} + 1 & \text{if } o_j = 1 \text{ and } l = \bar{l} \\ n_{ss_j} & \text{if otherwise} \end{cases} \tag{6}$$

Individuals with fewer than 15 years of contribution (equivalent to three model periods) receive a lump-sum benefits with the amount equal to the total accumulated contribution from both employers and employees. Let $\hat{ep}_{j'}(e, o_1)$ denote an average accumulated contributions up to age j for an individual with education level e and initial sector o_1, the dynamic of earnings points given by

$$\hat{ep}_{j'}(e, o_1) = \begin{cases} \hat{ep}_j(e, o_1) + 2 \cdot Tax_{ss} & \text{if } o_j = 1 \text{ and } l = \bar{l} \\ \hat{ep}_j(e, o_1) & \text{if otherwise.} \end{cases} \tag{7}$$

Individuals who have contributed for at least 15 years ($n_{ss} = 3$) receive annuity benefits equals 20 percent of their average earnings (i.e., replacement rate of 20 percent). For each additional year of contribution beyond 15 years, the replacement rate increases by 1.5 percentage points. Let $\hat{i}_{ss}(e, o_1)$ denote the average earnings during the last five years. The annuity benefits can be expressed as

$$pen_j(n_{ss_j}, o_1) = \begin{cases} \Big(20\% + 1.5\% \times \big(5n_{ss_j} - 15\big)\Big)\hat{i}_{ss}(e, o_1) & \text{if } j \geq J_{ss} \text{ and } n_{ss_j} \geq 3 \\ \hat{ep}_{j'}(e, o_1) & \text{if } j = J_{ss} \text{ and } n_{ss_j} < 3 \\ 0 & \text{if } j < J_{ss} \text{ or } n_{ss_j} = 0. \end{cases} \tag{8}$$

The pension benefits are scaled to balance the SS budget in Equation (17).

In addition, all individuals are entitled to non-contributory OAA benefits upon reaching age 60. The benefit schedule increases with age, as reported in Table 2.

age		monthly OAA
younger than 60	$j < J_{OAA} = 8$	-
60-69	$j = \{8, 9\}$	600 THB
70-79	$j = \{10, 11\}$	700 THB
80-89	$j = \{12, 13\}$	800 THB
90 or older	$j = \{14, 15\}$	1,000 THB

Table 2: OAA benefit schedule

[6] To reduce computational time, we simulate 100,000 individuals to obtain education- and and sector-specific average of final five years income and earnings points, rather than tracking these state variables for every model agent.

3.1.4 Taxation

Only formal workers are subject to income taxes. The tax base, y_{base}, consists of both earnings and interest income. Following Poonpolkul et al. (2024), we parameterize the progressive income tax function as

$$Tax_y = \begin{cases} 5 \cdot exp\Big(\lambda_1 + \lambda_2 \cdot ln(y_{base}/5)\Big) & \text{if } o_j = 1 \text{ and } l = \bar{l}, \\ 0 & \text{if otherwise,} \end{cases} \tag{9}$$

where the income tax base is defined as

$$y_{base} = r \cdot a + l \cdot z_{jt}\,(e, o_j)\,. \tag{10}$$

The parameters λ_1 and λ_2 are estimated using *annual* tax filing data from 2015-2017 from the Revenue Department. Accordingly, in Eq(9) we convert the five-year income tax base into an annualized measure to ensure consistency with the data.

All individuals pay value-added tax (VAT) on formal consumption at the rate $\tau_c = 7\%$.[7] We define informal consumption as purchases from stores operating outside the regulatory framework, which do not directly charge or remit VAT. Nevertheless, informal vendors incur VAT indirectly through formal suppliers or inputs such as utilities and transportation. Because they cannot credit the input VAT, unlike formal firms, these vendors internalize the VAT cost and pass it on to customers in the form of higher price.

We capture this pass-through by modeling informal consumption n as being subject to an implicit VAT payment of $\lambda_c \tau_c n$, where λ_c represents the share of statutory VAT rate embedded in informal-sector prices. The parameter λ_c is calibrated such that model-implied VAT revenue matches its empirical counterpart (see calibration details in Section 4.5).

3.1.5 VAT rebate function

Under a reform scenario with rebate, we assume that the government can verify everyone's reported formal consumption which is then used to determine the value of rebate. We assume a concave rebate function

$$R(c) = \alpha_0 c^{1-\alpha_1}. \tag{11}$$

The net consumption tax therefore becomes $T_c(c_j) = \tau_c c - \alpha_0 c^{1-\alpha_1}$, which follows the functional form in Heathcote et al. (2017). The parameter $0 < \alpha_1 \leq 1$

[7] We classify all VAT-exempted transactions as informal for simplicity. Section 81 of the Revenue Code specifies numerous exemptions, including sales of agricultural products, animals, fertilizers, and animal feed. However, these category account for a small share – less than 10 percents – across all formal consumption deciles. This reflects the fact that most exempt transactions occur through informal channels, which do not apply VAT in the first place. The pattern is consistent with Bachas et al. (2024) which document similar pattern in 32 developing countries.

captures the progressivity of net consumption tax, where larger value corresponding to greater progressivity. The parameter α_0 represents the generosity of the rebate, where higher value lower the effective tax burden. This functional form permits negative net taxes, implying transfers at low levels of consumption.

This choice of the rebate function offers two desirable properties. First, the first-order condition (FOC) is also sufficient for optimality. As shown in Appendix A, a concave rebate function – such as the one specified here – induces a convex budget set, ensuring that solving the FOC yields the global optimum. Second, the rebate scheme is incentive-compatible, as the rebate amount weakly increases with reported formal consumption (see Proof in Appendix B). This design mitigates the incentive to under-report formal purchases. Section 5.4 examine how this rebate function shapes overall tax progressivity and alters relative prices between formal and informal goods.

3.1.6 Households' optimization problems

Given the population structure and government tax policies, individuals choose how much to allocate to formal consumption, informal consumption, and leisure, as well as how much to save for the following period. The state vector for an individual of age j is

$$x_j = \{a_j, z_j, n_{ssj}, o_j, e\},$$

where a_j denotes asset holdings, z_j the idiosyncratic shock, n_{ssj} the accumulated years of SS contributions, o_j the employment sector, and e the education level. Denote the value function of an individual age j in the formal and the informal sector as V_j^F and V_j^I respectively. The recursive problem for formal-sector worker is given by

$$V_j^F(x_j) = \max_{a_{j'}, c_j, n_j, l_j} \left(u_e(c_j, n_j, l_j) + \beta_e \xi_{j'} \left(\pi_j^0 \mathbb{E}_j V_{j'}^F(x_{j'}) + (1 - \pi_j^0) \mathbb{E}_j V_{j'}^I(x_{j'}) \right) \right) \tag{12}$$

and the problem for an individual in an informal sector is

$$V_j^I(x_j) = \max_{a_{j'}, c_j, n_j, l_j} \left(u_e(c_j, n_j, l_j) + \beta_e \xi_{j'} \mathbb{E}_j V_{j'}^I(x_{j'}) \right) \tag{13}$$

Each individual faces the budget constraint:

$$\begin{aligned} a_{j'} = (1 + r) a_j + l_j z_j(e, o_j) + Beq(e) - (1 + \tau_c) c_j - (1 + \lambda_c \tau_c) n_j \\ - Tax_{ss} - Tax_{y_j} + pen_j(n_{ss}) + OAA_j + R(c) \end{aligned} \tag{14}$$

Utility function $u_e(c_j, n_j, l_j)$ is defined as in Equation (2). The conditional expectations on the right-hand side of Equation (12) and (13) are taken over the labor productivity process specified in Equation (3). If the individual survives to the next period, future utility is discounted by β_e. $Beq(e)$ is the bequest left behind by deceased individuals with the same education.

Only formal workers pay personal income tax, Tax_{y_j}, and SS contribution, Tax_{ss_j}, defined in Equations (9) and (5), respectively. Upon reaching the eligible age (J_{ss}), contributors receive pension benefits, pen_j, determined by Equation (8). All individuals aged 60 or older are entitled to the universal Old Age Allowance, OAA_j, based on the monthly schedule reported in Table 2. Under the reform scenario, individuals additionally receive consumption tax rebate, $R(c)$, as specified in Equation (11).

Retirees ($j \geq J_R$)

After retirement, individuals no longer supply labor and receive income solely from OAA and SS benefits. The state vector simplifies to

$$x_j = \{a_j, n_{ssj}, e\},$$

where $\{n_{ssj}\}$ is fixed at retirement. The recursive problem for a retiree is then

$$V_j^R(x_j^R) = \max_{a_{j'}, c_j, n_j} \quad u_e\left(c_j, n_j, 0\right) + \beta_e \left(\xi_{j'} V_{j'}^R(x_{j'}^R) \right) \tag{15}$$

subject to the budget constraint:

$$\begin{aligned}(1+\mu_w)\, a_{j'} =& (1+r)a_j + Beq\left(e\right) - (1+\tau_c)c_j - (1+\lambda_c\tau_c)n_j + pen_j(n_{ss}) \\ &+ OAA_j - (1+\tau_c)c_j + R(c_j).\end{aligned} \tag{16}$$

3.2 Government

The government operates under two balanced-budgets rules: one for the SS program and another for the general government budget. The SS program is assumed to have reached maturity in the stationary equilibrium.[8] Since our model is partial equilibrium, we supplement the SS budget with additional revenue and expenditure components to account for the broader fiscal position of the government.

3.2.1 SS budget

The social security budget is assumed to balance in the stationary equilibrium. Revenues are derived from two sources. First, private formal workers and their employers each contribute at the rate τ_{ss} of SS taxable earnings. Second, the government provide a subsidy equal to $\tau_g = 1\%$ of the SS taxable earnings of

[8]The Social Security program was introduced in 1999, initially covering firms with more then ten employees. Coverage was extended in 2002 to all firms with at least one employee. Because annuity benefits require a minimum contribution period of 15 years, the first annuity payments began in 2014. For analytical tractability, we assume that by the model's base year the program has already reached maturity.

private formal workers. Expenditures on SS benefits depends on individuals' contribution years and SS taxable earnings, as specified in Section 3.1.3.

Let x be the state variables of households in period t and $\Gamma(x)$ is its corresponding measure, of which total measure is normalized to one $\left(\int \Gamma(x) = 1\right)$. We can write the SS balancing condition as

$$(2\tau_{ss} + \tau_g) \int_{j<J_R} y_{ss}\ \Gamma(x) = \int_{j \geq J_{ss}} pen\ \ \Gamma(x). \tag{17}$$

We scale pension benefits such that the above relationship holds. Given population structure in our stationary state, benefits is scaled down to 34 percent of the original formula[9]

3.2.2 General fiscal budget

In each period, the government collects revenue from personal income and consumption taxes levied on both the private and the non-private sectors, the later denoted as NP_t. It also receives revenue from other sources, REV^{other}, which is fixed at 9 percent of GDP – the average share observed over 2000-2020. These revenues finance three components of expenditures: (i) the OAA transfers, (ii) SS subsidies at the rate of $\tau_g = 1\%$ of SS taxable earnings y_{ss}, and (iii) general government expenditure G which equals 13.5 percent of GDP, calculated to balance the fiscal budget in the base year.

The government's budget identity can therefore be written as

$$\begin{aligned} &\int_{o=1} Tax_y \Gamma(\mathbf{x}) + \tau_c \int (c_j + \lambda_c n_j)\Gamma(\mathbf{x}) + REV^{other} + NP_t \\ &= \int OAA\ \Gamma(\mathbf{x}) + \int_{o=1\ \cap\ l=\bar{l}} \tau_g \cdot y_{ss}\ \Gamma(\mathbf{x}) + G \end{aligned} \tag{18}$$

We assume that each individual in the non-private sector has the same level of income and consumption as those who start their career in the formal sector. This reflects the facts that the excluded group – civil servants, state enterprise workers, and employers – are likely in the upper income group. The income and consumption taxes from the non-private sector are defined as

$$NP_t = \theta_{NP} \int_{o=1\ \cap\ j<J_R} (Tax_y)\ \Gamma(\mathbf{x}) + \ \theta_{NP} \int_{o_{(j=1)}=1} (\tau_c c + \tau_c \lambda_c n_j)\ \Gamma(\mathbf{x}), \tag{19}$$

[9] The current SS benefit formula gives excessive benefits compared the required contribution rate. For example, a member with salary above SS taxable earnings contribute 450 THB per month to the old age benefits. If she contributes for 15 years, she will receive annuity of 3,000 THB per month after retirement. If life expectancy is at 80, the required rates of return for this person will be around 9% per year. This is much higher than the average rate of return between 2020-2024 which was at 2.59%.

where θ_{NP} is the relative size of non-private sector to private sector, which is set to the ratio of individuals in the non-private sector and the private sector in the LFS data: $\theta_{NP} = 9.76\%$.

3.2.3 General fiscal budget with consumption tax rebate

Under the VAT rebate scenario, the rebate function is incorporated into Equation (18). The mechanism operates in two stages: first, an initial increase in the VAT rate, and second, the introduction of a balancing rebate. The government chooses the combination of these two instruments to satisfy its budget constraint. By construction, the rebate schedule alone cannot achieve budget balance, since it must increase monotonically with consumption in order to remain incentive-compatible. The initial VAT increase therefore serves as a cap on the extent of progressivity that can be implemented through the net consumption tax.

Let REV^{total} denote total government revenue after the VAT increase, and let $GOV^{non-rebate}$ represent government expenditures other than consumption tax rebates.[10] The general fiscal budget becomes

$$REV^{total} = GOV^{non-rebate} + \alpha_0 \int c_j^{1-\alpha_1} \Gamma(\mathbf{x}) \tag{20}$$

A parameter α_0 in the rebate function is endogenously adjusted to ensure fiscal balance

$$\alpha_0 = \frac{REV^{total} - GOV^{non-rebate}}{\int c_j^{1-\alpha_1} \Gamma(\mathbf{x})} \tag{21}$$

A higher value of α_0 corresponds to greater tax progressivity, as demonstrated in Appendix 5.2. Moreover, Equation (21) shows that an increase in VAT rate permits a more progressive system. Intuitively, a higher VAT rate raises the government revenue, which can be redistributed more effectively towards individuals with lower consumption levels.

The government is assumed to maximizes utilitarian social welfare, represented by an aggregate of value functions across heterogeneous households of different ages. The government chooses the set of VAT rate and rebate parameters (α_0, α_1) – which jointly determine the generosity and curvature of the rebate schedule – to maximize ex-ante social welfare, accounting for behavioral responses to policy changes:

$$\max_{\tau_c, \alpha_0, \alpha_1} \int V_1(\Psi) m_1 \Gamma(\mathbf{x}), \tag{22}$$

subject to the government budget constraint (21). Here, Ψ denotes the government policy schedule.

[10] In the rebate scenario, government expenditure G is held constant at 13.5 percent of GDP.

4 Parameters Calibration

4.1 Population and labor market structures

Population structure is assumed to be stationary over the period 2015-2019. Age-specific survival probabilities, ξ_j, are taken from the United Nations estimates. The population growth rate is calibrated to be 1.3 percent to match a dependency ratio – defined as the share of individuals aged 60 and above relative to those below 60 – of 0.376 observed over the same year.

Educational attainment for individuals aged 25-29 is taken from the Labor Force Survey (LFS, 2016-2019), with 34 percent having less than high school education, 47 percent completing high school, and 19 percent attaining college education. Formal workers are assumed to face exogenous transition probabilities $\pi_j^0(e)$ into the informal sector as they age. These probabilities are estimated from the Social Security (SS) administration data (2005-2015), a monthly panel data that covers all participants contributing to the SS system in a given month.

Because the SS data do not record education, we impute individuals' education levels by combining it with the sample of workers in LFS, 2016-2019. Specifically, we estimate an ordered logit model of educational attainment using covariates observed in both datasets.[11] Each SS participants is then assigned to the most likely education level predicted by the model.

Given this imputation, formal-informal transition probabilities by education are computed as a fraction of workers who ceased contributing to the SS system conditional on being enrolled in the prior five-year period. Figure 2 presents the estimated transition probabilities by education. High school graduates are more likely to exit the formal sector than the college graduates, and in both groups exit probabilities decline with age.

[11] Covariates include wage at age 25, gender, firm size, urban/rural residence, and their interactions.

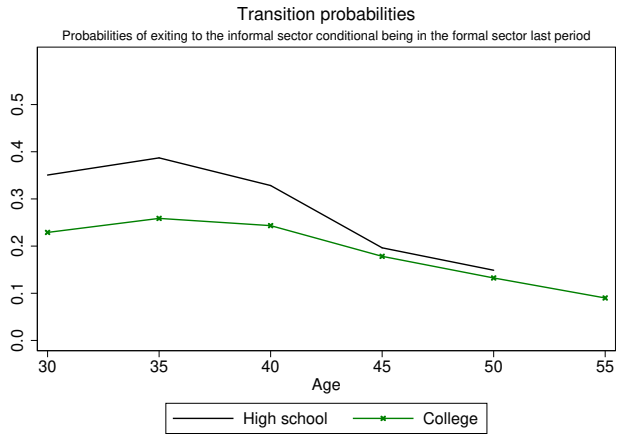


Figure 2: Transition probabilities from formal to informal sector π_j^o

4.2 Labor productivity

Labor productivity is characterized by two components that are education and sector specific: (i) the age-deterministic profiles $\lambda_j(e, o_j)$ and (ii) persistent productivity shocks that follow the first-order discrete Markow process.

Age-deterministic profiles $\lambda_j(e, o_j)$ are estimated for individuals aged 25 to 55 as a quadratic functions of age, separately by each education and sector, using LFS (2016-2019). To ensure consistency with observed earnings, the estimated profiles are scaled to match average earnings by education and sector in the LFS. For individuals above age 55, profiles are assumed to decline linearly, reaching zero at age 80.

The stochastic component $\eta_j(e, o_j)$ is also estimated from the LFS by education and sector. In the model, individuals draw a new hourly wage shock every five years, and the transition depends on whether they remain in the same sector or switch.

For those who remain in the same sector ($o_j = o_{j'}$), the shock follows an AR(1) process:

$$\eta_{j'} = \rho_\eta^o \eta_j + \epsilon_{j'}^o; \qquad \epsilon_j^o \sim N\left(0, \sigma_{\epsilon^o}^2\right). \tag{23}$$

The cross-sectional variance of η_j evolves recursively as

$$\sigma_{\eta_{j'}^o}^2 = \left(\rho_\eta^o\right)^2 \sigma_{\eta_j^o}^2 + \sigma_{\epsilon^o}^2. \tag{24}$$

We obtain the empirical counterpart of η_j by regressing log wages on a quadratic function of age and year dummies, separately for the formal and informal sectors:

$$log\left(wage_j\right) = f\left(age\right) + D_{year_j} + \eta_j.$$

Here, $wage_j$ is the individual's hourly wage, D_{year_j} is a year dummy, and $f(age)$ is a quadratic polynomial in age.

Assuming $\sigma^2_{\eta_1^o} = \sigma^2_{\epsilon^o}$, we estimate ρ^o_η and $\sigma^2_{\epsilon^o}$ by minimizing the sum square difference between the recursive variance in Equation (24) and the empirical variance from the LFS.[12] Estimates for each education and sector are reported in Table 3.[13]

Because the LFS is cross-sectional, we cannot directly estimate the hourly wage shock process for formal workers who transition into the informal sector ($o_j = 1, o_{j'} = 0$). We therefore assume that their discrete Markov process follows the same transition probabilities as those of workers who remain in the informal sector ($o_j = 0, o_{j'} = 0$).

	σ^2_ϵ	ρ
Less than high school	0.039	0.5119
High school in informal sector	0.044	0.5965
High school in formal sector	0.043	0.7088
College in informal sector	0.116	0.7111
College in formal sector	0.102	0.6401

Table 3: Estimated AR(1) process of hourly wage shock η_j (5-year period)

4.3 Preference parameters

The education-specific disutility of labor is calibrated to match the average hours worked by formal workers in the LFS.[14] Discount factors are calibrated to replicate the net worth of individuals aged 30-54 in the Household Socioeconomic Survey (SES). Table 4 reports calibrated parameters values by education group. The results indicate that individual with higher educational attainment place greater weight on leisure, consistent with the empirical finding that lower-educated workers supply more hours. Moreover, the high-education group exhibits greater patience, as reflected in their higher accumulated net worth.

	leisure weight (ν_e)	Discount factors (β_e)
Less than high school	0.48	0.84
High school	0.49	0.86
College	0.54	0.91

Table 4: Leisure weight and discount factor by education

4.4 Informality Engel Curve

To replicate the downward-sloping informality Engel curve, we calibrate four parameters: the subsistent level of informal consumption, $\bar{n} = 0.083$; the share of formal consumption in the composite bundle, $\omega = 0.37$; and the curvature

[12] $\sigma^2_{\epsilon^o}$ and ρ^o_η are identified by the intercept and curvature of the variance profile.
[13] Figure **??** in Appendix **??** compares the model-implied and empirical variances.
[14] Assume individual has 16 hours per day.

parameters for formal and informal consumption, $\phi_1 = 0.82, \phi_2 = 0.39$, respectively. The higher curvature of formal consumption relative to informal consumption reflects diminishing marginal substitution towards formality as total consumption rises. These calibrated values generate an informality Engel curve that closely matches the decile-level pattern observed in the data (Figure 3). The coefficient of risk aversion is set to $\rho = 2$, consistent with standard values in the literature.

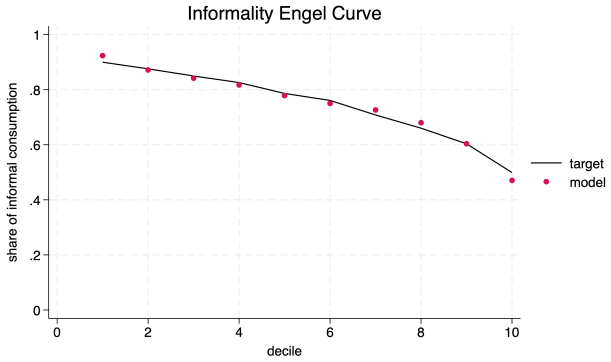


Figure 3: Informality Engel curve, target and model-generated values

4.5 VAT pass-through to informal consumption

To calibrate VAT pass-through to informal consumption, we draw on three complementary data sources.

First, we use macroeconomic aggregates from the national income accounts published by the Office of the National Economic and Social Development Council (NESDC). These data allow us to compute the total VAT base, $\mathcal{B}$, defined as private consumption, government investment, and general government consumption expenditure, let of compensation of employees. We assume that government investment and government consumption are fully taxed at a rate of 7 percent, with the residual VAT revenue attributed to private consumption. Private consumption, C^{dom}, includes expenditures by both residents and non-residents in the domestic market during 2015-2019, net of VAT refund to tourists in the corresponding years.

Second, we use administrative data on net VAT revenue, R_{vat}, reported by the Revenue Department for 2015-2019.

Finally, we rely on household-level evidence from the SES database to measure the relative shares of formal and informal goods in consumption. On average, formal goods account for $\bar{s} = 27.5\%$ of total household consumption, while informal goods account for $1 - \bar{s} = 72.5\%$. Informal goods are defined by goods purchased through general store, grocery store, fresh market, and flea market and include both in-cash and in-kind transactions.[15] Although some goods are

[15]The classification of informal goods is based on consultations with an expert from National

explicitly exempted from VAT – such as unprocessed agricultural products, basic food items and essentials – these are predominantly purchased through informal outlets and therefore effectively outside of VAT net. Moreover, VAT-exempted goods represent less than 10 percent of formal consumption. To tractability, we classify these exempted items as part of informal consumption.

The value of VAT pass-through to informal consumption is obtained from the following identity

$$(\tau_c \bar{s} + \lambda_c \tau_c (1 - \bar{s})) \cdot C^{dom} + \tau_c \mathcal{B}^{gov} = R_{vat}, \tag{25}$$

where $\mathcal{B}^{gov}$ denotes the VAT base from government consumption and investment. The implied VAT pass-through rate is 51.6 percent.[16]

5 Theoretical Underpinning

5.1 Rebate progressivity with respect to formal consumption

Net consumption tax progressivity in formal consumption can be illustrated by how the ratio of average net tax over formal consumption changes as people consume more formal goods. Average consumption tax rate of formal consumption is written as

$$\frac{\tau_c c - \alpha_0 c^{1-\alpha_1}}{c} = \tau_c - \alpha_0 c^{-\alpha_1}. \tag{26}$$

Differentiate with respect to c, we have

$$\frac{d(\tau_c - \alpha_0 c^{-\alpha_1})}{dc} = \alpha_0 \alpha_1 c^{-(1+\alpha_1)}. \tag{27}$$

Since $\alpha_0 > 0, c > 0, 0 < \alpha_1 < 1$ (incentive compatibility condition), the average consumption tax is strictly increasing in consumption and is therefore progressive.

The degree of progressivity in formal consumption rises with both the generosity parameter and progressivity measure. The generosity parameter shifts the level fo rebates, while the progressivity parameter governs the curvature of the rebate function. A higher curvature reduces the average rebate more rapidly as consumption increases, thereby strengthening progressivity in the tax system.

Statistical Office (NSO) responsible for the SES.

[16] This calculation is based on our model assumption of perfectly competitive firms. Empirical estimates of VAT pass-through vary substantially. For example, Bachas et al. (2024) estimate a 75 percent pass-through rate to formal stores and a 16% pass-through rate to conventional stores in Mexico. Other studies report full pass-through (e.g., Blasco et al., 2023; Lyssiotou and Savva, 2021) or even pass-through exceeding 100 percent (Frey and Haucap, 2024).

5.2 Rebate progressivity with respect to total consumption

Although a concave rebate is strictly progressive in formal consumption, it is not always the case when we consider total consumption that comprises both formal and informal goods. This complexity is due to two main reasons, namely: (i) the tendency to switch from consuming informal to formal goods as people consume more represented by a downward-sloping Informality Engel Curve (IEC) and (ii) the degree of embedded VAT in informal goods represented by λ_c.

A rebate makes consumption tax progressive if as people consume more, they pay higher share of consumption in net VAT. Average share of net consumption tax over total consumption can be written as

$$f(X) = \tau_c \left[s_i(1-\lambda_c) + \lambda_c \right] - \alpha_0 \cdot s_i^{1-\alpha_1} X_i^{-\alpha_1} \tag{28}$$

where share of formal consumption $s_i = s(X_i)$ is increasing in total consumption, i.e., $\frac{ds}{dX} > 0$. Net consumption tax is progressive when $df/dX > 0$ where

$$\frac{df}{dX_i} = \underbrace{\tau_c(1-\lambda_c) \cdot \frac{ds_i}{dX_i}}_{\text{IEC-driven progressivity}} + \underbrace{\underbrace{\alpha_0 \alpha_1 c^{-\alpha_1} \frac{s}{X}}_{\text{Declining average rebate}} \underbrace{- \alpha_0(1-\alpha_1) c^{-\alpha_1} \cdot \frac{ds}{dX_i}}_{\text{Marginal rebate effect}}}_{\text{Rebate-induced progressivity}}. \tag{29}$$

Tax progressivity can be decomposed into two broad components. The first component arises from the relationship between average consumption tax and the share of formal consumption, which increases monotonically due to a downward-sloping IEC. This mechanism is reinforced by two factors. First, a high VAT rate raises the effective tax burden on formal goods, amplifying the effect of $\frac{ds_i}{dX_i}$. Second, the extent to which formal goods are more heavily taxed than informal goods, captured by $(1-\lambda_c)$, further strengthens progressivity. Under conditions of low embedded VAT, households pay more VAT as total consumption rises, since higher-income households disproportionately consume more formal goods subject to full VAT rate. By contrast, when VAT is fully passed through to informal goods ($\lambda_c = 1$), substitution between formal and informal gods does not affect the tax burden. Overall, IEC-driven progressivity is strictly positive when $\frac{ds_i}{dX_i} > 0$ and $\lambda_c < 1$, both of which hold in our calibrated model. It is worth emphasizing, however, that high degree of embedded VAT in informal goods increases the effective VAT base and allows for a more generous rebate, as discussed in Section 5.4.

The second component arises from rebate on formal consumption. Rebates reduce net VAT burden, and whether they benefit lower- or higher-income individuals more strongly determines whether the overall system becomes more or less progressive. Rebate-driven changes can be further decomposed into two effects: marginal rebate effect and declining average rebate effect. The marginal rebate effect captures how incremental rebates change as formal consumption

increases. A higher progressivity parameter, α_1, implies a more concave rebate function that allocate disproportionately large rebates to people with low levels of consumption. As consumption rises, the incremental rebate diminishes, thereby favoring poorer household and increasing the overall progressivity of the net consumption tax. The second effect reflects mechanical decline in the average rebate as consumption rises, which inherently enhances the progressivity of the consumption tax.

Taken together, the rebate-driven progressivity will contribute to higher consumption tax progressivity when

$$\frac{ds_i}{dX_i} \cdot \frac{X_i}{s_i} < \frac{\alpha_1}{1-\alpha_1}, \tag{30}$$

where the left-hand side measures the elasticity of the formal consumption share with respect to total consumption and the right-hand side measures the degree of rebate concavity governed by the progressivity parameter α_1. Progressivity improves when the concavity of the rebate function – reflecting greater generosity toward low-consumption household – more than offsets the tendency of higher-income households to allocate a larger share of spending to formal goods and therefore receive larger rebate. Because the elasticity of the formal consumption varies with total consumption, an identical rebate schedule can generate different degrees of progressivity across the consumption distribution.

5.3 Relative price between formal and informal consumption

Relative prices play a central role in shaping individuals' consumption choices between formal and informal goods. When rebates are abstracted from the analysis, the relative price of formal and informal goods depends solely on the VAT rate and the degree of VAT pass-through to informal goods. Formally, let p_c and p_n denote the prices of formal an informal goods, respectively. The relative price is then given by

$$p_{rel} = \frac{p_c}{p_n} = \frac{1+\tau_c}{1+\lambda_c\tau_c}. \tag{31}$$

The interval $[1, 1+\tau_c]$ represents the lower and upper bounds of relative price prior to the introduction of rebate. The exact position within this range depends on the degree to which VAT is embedded in informal goods, as captured by λ_c which may vary across economies.

The rebate modifies the relative price by reducing the effective cost of an additional unit of formal goods by the marginal rebate, relative to the cost of additional unit of informal goods. The relative price with rebate is given by

$$\frac{1+\tau_c-(1-\alpha_1)\alpha_0 c^{-\alpha_1}}{1+\lambda_c\tau_c}. \tag{32}$$

Because incentive compatibility requires $0 < \alpha_1 < 1$, the marginal rebate is strictly decreasing in formal consumption and converge to zero as $c \to \infty$.

Consequently, as formal consumption increases, the relative price monotonically increases and asymptotically approaches $\frac{1+\tau_c}{1+\lambda_c\tau_c}$.

The rebate makes formal goods cheaper than informal goods whenever

$$(1-\alpha_1)\alpha_0 c^{-\alpha_1} > (1-\lambda_c)\tau_c, \tag{33}$$

illustrating that rebates tilt relative prices in favor of formal goods when they are sufficiently large (high α_0), when formal consumption is low (typically among poorer households), or when the VAT advantage of informal goods, measured by $(1-\lambda_c)$, is limited.

Equation (33) makes clear that a greater VAT advantage for informal goods reduces the likelihood that rebate will render formal goods cheaper, thereby limiting the scope for behavioral adjustment in the consumption bundle. There is, however, a second channel. The degree of embedded VAT also influences the government revenue (see Equation (35)), which in turns determines the size of the VAT base available to finance rebates. Put differently, a low degree of embedded VAT not only lowers the relative prices of informal goods but also constrains the additional revenue that can be raised from increasing VAT rates. This dual effect limits the government's capacity to provide sufficiently generous rebates that would encourage a shift toward formal consumption.

5.4 Government budget constraint in a static setting

We have shown how tax progressivity and relative prices depend on the degree of VAT pass-through and on policy instruments such as the VAT rate and the rebate progressivity parameter, both of which can be directly chosen by the government. By contrast, the generosity of rebate is endogenous. Its determination can be understood by examining the government budget constraint in a static framework without behavioral responses.

Let τ_c be a VAT rate under reform and $\tilde{\tau}_c$ be a VAT rate under the baseline scenario. In this setting, the government must satisfy the following budget constraint:

$$(\tau_c - \tilde{\tau}_c)\sum_i [(s_i + \lambda_c(1-s_i))X_i] = \alpha_0 \sum_i (s_i X_i)^{1-\alpha_1} \tag{34}$$

To balance the budget under a static setting, the government sets α_o such that

$$\alpha_0 = \frac{(\tau_c - \tilde{\tau}_c)\sum_i [(s_i + \lambda_c(1-s_i))X_i]}{\sum_i (s_i X_i)^{1-\alpha_1}} \tag{35}$$

Equation (35) shows that the generosity of rebate α_0 increases with (i) the degree of VAT pass-through to informal goods λ_c (ii) the VAT rate τ_c and (iii) the degree of progressivity, governed by α_1

6 Results

In this section, we employ our calibrated model, which embeds a 52 percent VAT pass-through to informal sector, to evaluate the impact of a consumption

tax rebate. We set a statutory rate at 10 percent – its current level before temporary reduction – and examine how a rebate scheme can be designed to both balance the government budget and maximize social welfare. The analysis proceeds in three steps.

First, we assess the direct effects of a budget-neutral VAT increase and alternative rebate schemes on the progressivity of taxation, holding consumption bundles fixed. Second, we incorporate behavioral responses to relative price changes and show how varying rebate progressivity shapes the allocation between formal and informal goods. This step also highlights the heterogeneous impacts across labor market segments (formal versus informal employment) and across age groups. Finally, we evaluate the welfare implications of alternative rebate designs. We explain the tradeoffs between redistributive gains and efficiency costs along different progressivity, and identify the welfare-maximizing rebate scheme in the context of Thailand.

6.1 Distributional Effects of VAT Rebate Under Fixed Consumption Bundles

We choose three levels fo rebate progressivity to illustrate is impacts: a welfare optimal rebate ($\alpha_1 = 0.65$), a lump-sum rebate ($\alpha_1 = 1.0$), and a rebate with low progressivity ($\alpha_1 = 0.4$). Each level of progressivity corresponds to different level of rebate generosity (α_0), reflecting the tradeoff between generosity and coverage (Figure 4). In our scenario, rebate generosity balance the additional VAT revenue from 7% to 10%[17].

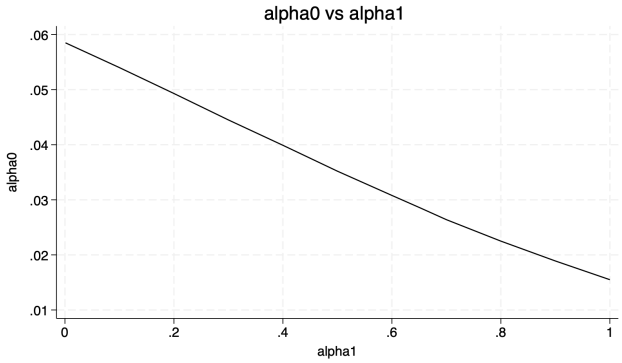


Figure 4: Relationship between rebate generosity and progressivity

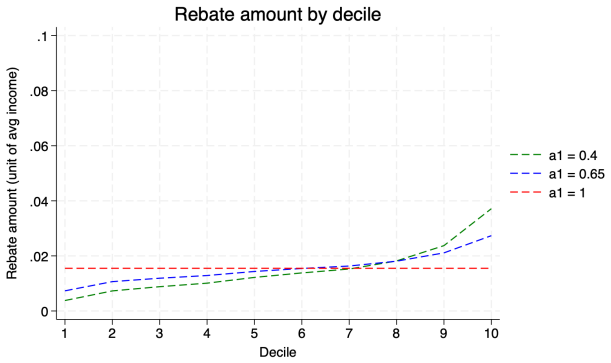
Figure 5 illustrates consumption tax progressivity using three complementary indicators: (i) the rebate amount, (ii) the rebate amount relative to total

[17]Using higher VAT rates allow for higher values of rebate as well as higher degree of progressivity. Scenarios with rebate and the government budget surplus follow the same mechanisms in this section, only with the surplus subtracting from available resources used for rebate.

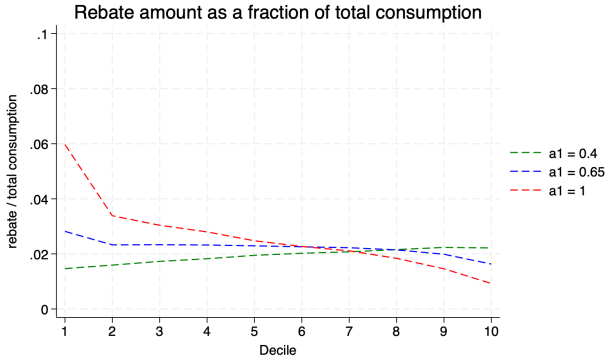
consumption, and (iii) net VAT relative to total consumption. Each panel illustrates these measures across consumption deciles under three alternative rebate schedules that differ in their degree of progressivity.

In the lump-sum scenario, a fixed rebate is provided to all individuals consuming at least one unit of formal goods. Becuase the rebate is constant in absolute terms, its value relative to total consumption declines monotonically as consumption rises (Figure 5b). This declining share share mechanically generates an increasing effective tax rate (Figure 5c). As discussed in Section 5.2, the lump-sum rebate therefore produces the most progressive tax schedule: average tax burdens decrease with consumption, while marginal rebate effects are absent.

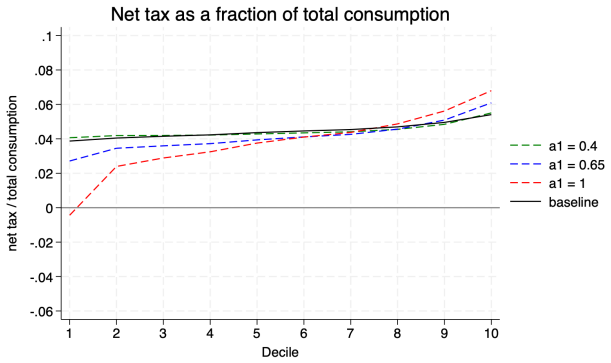
The same mechanisms extend to the cases of optimal and lower progressivity. Compared to the lump-sum rebate, these scenarios yield less progressivity because rebate schedule is more concave. In particular, lower value of the progressivity parameters allocate relatively larger marginal rebates to higher-consuming individuals, therefore flattening the effective tax profile across the consumption distribution.



(a) Rebate amount



(b) Rebate amount as a fraction of total consumption



(c) Net VAT as a fraction of total consumption

Figure 5: Illustration of rebate progressivity across deciles of total consumption

6.2 Behavioral Responses and VAT Rebate Progressivity

Changes in relative prices induced by the VAT and rebate system shape individuals' allocation between formal or informal goods across consumption distribution. Before the introduction of rebate, relative prices remain constant across consumption levels, and their magnitudes is determined entirely by the VAT rate and VAT pass-through to informal goods.

In the baseline specification, the relative price of formal to informal goods is $(1 + \tau_c)/(1 + \lambda_c\tau_c) = 1.032$, implying that formal goods are 3.2 percent more expensive than informal goods (black horizontal line in Figure 6). When the VAT rate increases to 10 percent, the price wedge widens: formal goods becomes 4.6% more expansive, since only a fraction of VAT is embedded in informal goods. This higher relative price reduces the share of total consumption allocated to formal goods(dotted black line in Figure 7).

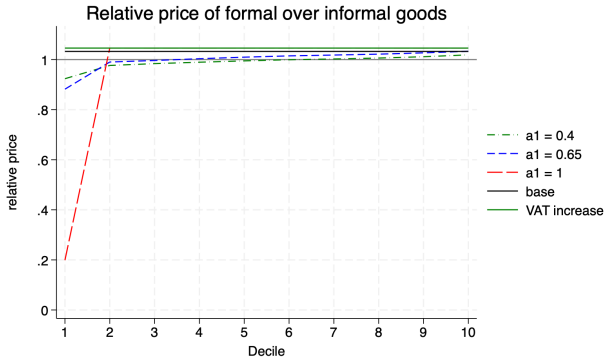


Figure 6: Relative prices between formal and informal consumption across deciles of total consumption

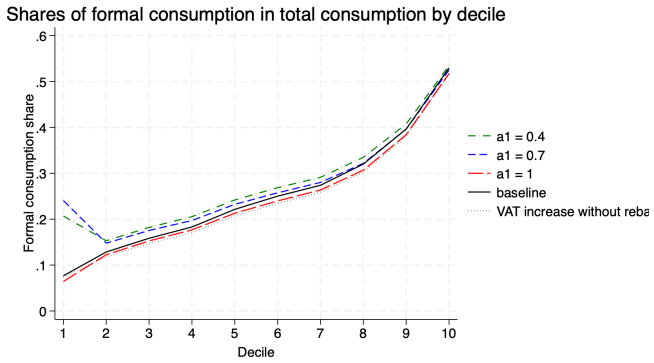


Figure 7: Relative prices between formal and informal consumption across deciles of total consumption

Following an introduction of VAT rebate, the relative price of additional unit of formal consumption is altered by the marginal rebate amount, as detailed in Section 5.3. The effects depend critically on rebate structure. For instance, a lump-sum rebate influences only the relative price of the first unit of formal goods, as shown in the first decile of total consumption (Figure 6). Because most individuals already consume some formal goods, the substantially lower price of the first unit – while subsequent units remain unaffected – does not alter their overall consumption bundle (Figure 7). The resulting wealth effect is too small to induce significant formalization of consumption, particularly when the rebate is modest and distributed universally.

By contrast, rebates with lower progressivity affect relative prices over a broader range of consumption. Figure 6 illustrate that the optimal rebate drives the price of formal goods below that of informal goods for the bottom three deciles. A less progressive rebate, while not reducing the price of formal goods as sharply at very low consumption levels, generates a more gradual relative price increase across higher consumption.

This capacity to sustain lower formal-goods prices arises from two structural features of the economy. First, informal goods embody substantial VAT – 52 percent in our calibrated model – which both enlarges the effective tax base and raises their consumer price. Second, informal goods account for roughly three-quarters of total consumption, creating ample resources to finance the rebate. Together, these factors enable rebates to compress the relative price gap between formal and informal goods across a wide span of consumption.

When behavioral responses are incorporated, lower effective prices for formal goods induce low-consuming individuals to shift toward formality. This adjustment generates a more progressive tax schedule than in the counterfactual with fixed consumption bundle (Figure 8).

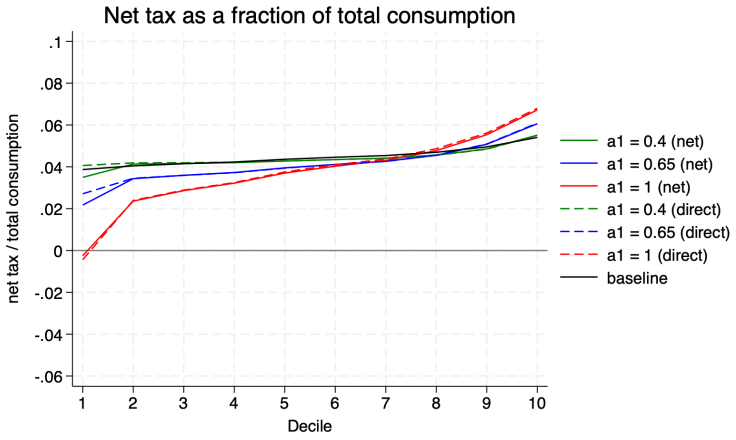
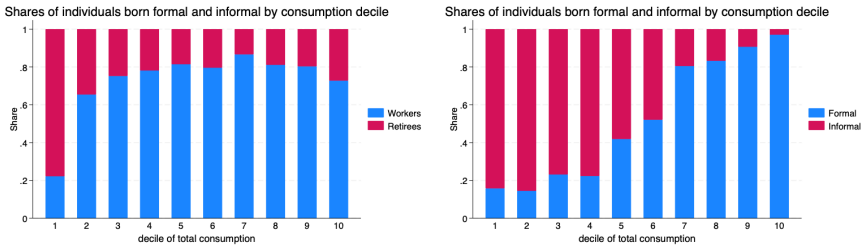


Figure 8: Net tax relative to total consumption, with and without behavioral responses

Rebate transfers disproportionately benefit specific population groups. As shown in Figure 9, individuals with low levels of consumption – particularly those who enter the labor market in the informal sector and retirees – receive relatively larger rebates. For these groups, the rebate substantially reduces their net tax burden as a share of total consumption. In fact, individuals in the lowest decile often receive a net transfer, with rebates exceeding their gross tax liability.



(a) Share of workers and retirees (b) Share of born formal and informal

Figure 9: Illustration of redistribution by sector and age cohort by decile of total consumption

6.3 Welfare Evaluation

We measure ex-ante welfare using the Hicksian Equivalent Variation (HEV). Specifically, we compute the additional consumption – comprising both formal and informal goods – that an individual in the baseline would require to attain the same utility level achieved under the reform. Let Δ denote the percentage

change in the composite consumption bundle, and let $V_0(e), V_{RS}(e)$ represent the value functions in the the baseline and reform scenarios, respectively, for an individual with education level e. The welfare change is then given by

$$\begin{aligned} V_{RS}(e) &= \mathbb{E}\left(\sum_{j=1}^{J}\beta_e^{j-1}\prod_{k=1}^{j}\xi^k\frac{\left(\left((1+\Delta)\left(\omega\cdot c^{\phi_1}+(1-\omega)\cdot(n-\bar{n})^{\phi_2}\right)\right)^{\frac{1-\nu_e}{\phi_1}}(1-l)^{\nu_e}\right)^{1-\rho}}{1-\rho}\right) \\ &= (1+\Delta)^{\frac{1-\nu_e}{\phi_1}\cdot(1-\rho)}\cdot V_0(e) \\ \Delta &= \left(\frac{V_{RS}(e)}{V_0(e)}\right)^{\frac{\phi_1}{(1-\nu_e)\cdot(1-\rho)}}-1 \end{aligned} \tag{36}$$

Figure 10 reports ex-ante welfare effects of introducing a 10% VAT combined with a budget-neutral rebate of varying levels of progressivity. Individuals who enter the labor market as formal workers prefer rebate with relatively low progressivity. This preference arise because, under more progressive rebate schedules, formal workers effectively finance the program: they purchase a larger share of formal goods (Figure 9b) yet receive small transfers.

Notably, even under a lump-sum rebate, the welfare loss of formal workers remain limited. Two factors account for this outcome. First, a nontrivial subset of formal workers have low consumption levels and therefore benefit from the rebate. Second, among high-consuming individuals, the marginal disutility of reducing consumption is relatively small, which dampen the welfare cost.

Proportion rebate worsen welfare of informal workers as it is regressive. Most informal workers has relatively low consumption, and a large share of their expenditure is devoted to informal good that embed VAT but do not qualify for rebates. A higher statutory VAT rate therefore raises the price of informal goods that dominate their consumption basket, while providing them little or no offsetting transfer. In effect, informal workers finance the rebate system, the benefits of which accrue primarily to high-consuming formal workers.

By contrast, a progressive rebate schedule directs greater benefits toward low-consuming individuals, making informal workers net recipients of transfers. This design reduce the effective burden on those most disadvantaged by informality and increases the overall progressivity of the system. However, steeply progressive rebate distort labor supply decisions by weakening incentives at the margin.

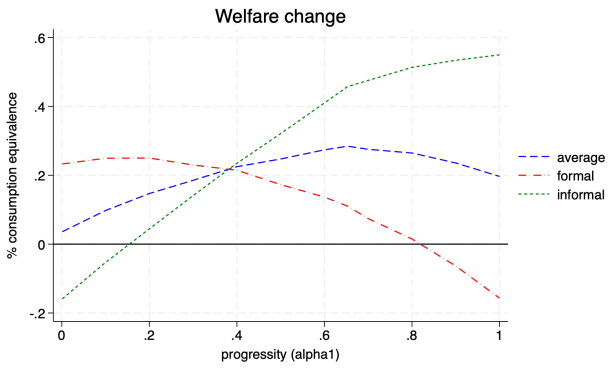


Figure 10: Welfare change from rebate program with 10% VAT rate

7 Conclusion

Future research will extend the analysis to incorporate income taxation and evaluate the model's implications using data on formal income.

References

Alvaredo, F., and Gasparini, L. (2015). Recent trends in inequality and poverty in developing countries. *Handbook of income distribution*, *2*, 697–805.

Atkinson, A., and Stiglitz, J. (1976, July). The design of tax structure: Direct versus indirect taxation. *Journal of Public Economics*, *6*(1-2), 55–75. Retrieved 2025-08-22, from https://linkinghub.elsevier.com/retrieve/pii/0047272776900414 doi: 10.1016/0047-2727(76)90041-4

Bachas, P., Gadenne, L., and Jensen, A. (2024). Informality, consumption taxes, and redistribution. *Review of Economic Studies*, *91*(5), 2604–2634.

Blasco, J., Guillaud, E., and Zemmour, M. (2023, June). The inequality impact of consumption taxes: An international comparison. *Journal of Public Economics*, *222*, 104897. Retrieved 2025-08-19, from https://linkinghub.elsevier.com/retrieve/pii/S0047272723000798 doi: 10.1016/j.jpubeco.2023.104897

Brockmeyer, A., Mascagni, G., Nair, V., Waseem, M., and Almunia, M. (2024, February). Does the Value-Added Tax Add Value? Lessons Using Administrative Data from a Diverse Set of Countries. *Journal of Economic Perspectives*, *38*(1), 107–132. Retrieved 2025-08-08, from https://pubs.aeaweb.org/doi/10.1257/jep.38.1.107 doi: 10.1257/jep.38.1.107

Brusco, G., and Velayudhan, T. (2024). *Vat Incidence in Real Vat Systems.* Retrieved 2025-08-13, from https://www.ssrn.com/abstract=4876625 doi: 10.2139/ssrn.4876625

Conesa, J. C., Li, B., and Li, Q. (2020, November). Welfare implications of switching to consumption taxation. *Journal of Economic Dynamics and Control*, *120*, 103991. Retrieved 2025-08-13, from https://linkinghub.elsevier.com/retrieve/pii/S0165188920301597 doi: 10.1016/j.jedc.2020.103991

Da Costa, C. E., and Santos, M. R. (2023, April). Progressive consumption taxes. *Journal of Public Economics*, *220*, 104854. Retrieved 2025-08-13, from https://linkinghub.elsevier.com/retrieve/pii/S0047272723000361 doi: 10.1016/j.jpubeco.2023.104854

De Paula, A., and Scheinkman, J. A. (2010). Value-added taxes, chain effects, and informality. *American Economic Journal: Macroeconomics*, *2*(4), 195–221.

Diamond, P. A. (1998). Optimal income taxation: an example with a u-shaped pattern of optimal marginal tax rates. *American Economic Review*, 83–95.

Eaton, J., and Rosen, H. S. (1980). Taxation, human capital, and uncertainty. *The American Economic Review*, *70*(4), 705–715.

Esteban-Pretel, J., and Kitao, S. (2021, January). Labor Market Policies in a Dual Economy. *Labour Economics*, *68*, 101956. Retrieved 2025-08-22, from https://linkinghub.elsevier.com/retrieve/pii/S0927537120301603 doi: 10.1016/j.labeco.2020.101956

Frey, A., and Haucap, J. (2024). Vat pass-through: the case of a large and permanent reduction in the market for menstrual hygiene products. *In-*

ternational Tax and Public Finance, *31*(1), 160–202.

Hanna, R., and Olken, B. A. (2018). Universal basic incomes versus targeted transfers: Anti-poverty programs in developing countries. *Journal of Economic Perspectives*, *32*(4), 201–226.

Heathcote, J., Storesletten, K., and Violante, G. L. (2017). Optimal tax progressivity: An analytical framework. *The Quarterly Journal of Economics*, *132*(4), 1693–1754.

Keen, M. (2008). Vat, tariffs, and withholding: Border taxes and informality in developing countries. *Journal of Public Economics*, *92*(10-11), 1892–1906.

Kotlikoff, L. J., Lagarda, G., and Marin, G. (2025). A personalized vat with capital transfers: a reform to protect low-income households in mexico. *International Tax and Public Finance*, 1–61.

Kudrna, G., Piggott, J., and Poonpolkul, P. (2025). Sustainable and equitable pension reform for emerging economies: An application to indonesia. *Economic Modelling*, *148*, 107080.

Li, Q. (2020). Dynamic effects of consumption tax reforms with durable consumption. *The BE Journal of Macroeconomics*, *20*(2), 20190026.

Lyssiotou, P., and Savva, E. (2021). Who pays taxes on basic foodstuffs? evidence from broadening the vat base. *International Tax and Public Finance*, *28*(1), 212–247.

Mirrlees, J. A. (1971). An exploration in the theory of optimum income taxation. *The review of economic studies*, *38*(2), 175–208.

Poonpolkul, P., Porapakkarm, P., and Wasi, N. (2024). Aging, inadequacy, and fiscal constraint: The case of thailand. *International Studies of Economics*, *19*(1), 35–67.

Saez, E. (2001). Using elasticities to derive optimal income tax rates. *The review of economic studies*, *68*(1), 205–229.

Song, Z., Storesletten, K., Wang, Y., and Zilibotti, F. (2015, April). Sharing High Growth across Generations: Pensions and Demographic Transition in China. *American Economic Journal: Macroeconomics*, *7*(2), 1–39. Retrieved 2025-08-22, from https://pubs.aeaweb.org/doi/10.1257/mac.20130322 doi: 10.1257/mac.20130322

Swistak, A. (2024, April). Designing a Progressive VAT. *IMF Working Papers*, *2024*(078), 1. Retrieved 2025-08-14, from https://elibrary.imf.org/openurl?genre=journal&issn=1018-5941&volume=2024&issue=078&cid=546923-com-dsp-crossref doi: 10.5089/9798400271830.001

Varian, H. R. (1980). Redistributive taxation as social insurance. *Journal of public Economics*, *14*(1), 49–68.

Warren, N. (2008). A review of studies on the distributional impact of consumption taxes in oecd countries. *OECD Social, Employment, and Migration Working Papers*(64), 1.

A Conditions ensuring a convex budget set

Let R(c) be the rebate amount, which is a function of formal consumption. The budget constraint can now be written as

$$W \geq n + (1+\tau)c - R(c)$$

where W represents income.

For a budget set $A = \{(n,c) \in \mathbb{R}^2 | W \geq n + (1+\tau)c - R(c)\}$, the budget set is a convex set if for any convex combination $\lambda \in [0,1]$[18], the points n_λ, c_λ are still in set A. That is, the following budget constraint still holds for any affordable bundles (n_1, c_1) and (n_2, c_2),

$$W \geq n_\lambda + (1+\tau)c_\lambda - R(c_\lambda) \tag{39}$$

$R(c)$ introduces nonlinearity into the budget constraint. We require a property of $R(c)$ that satisfies (39). Substituting (37) and (38) into (39) and rewrite, we have

$$0 \leq W - (\lambda n_1 + (1-\lambda)n_2) - (1+\tau)(\lambda c_1 + (1-\lambda)c_2) + R(\lambda c_1 + (1-\lambda)c_2) \tag{40}$$

Add and subtract the terms $\lambda R(c_1) + (1-\lambda)R(c_2)$ to the above equation and rearrange gives

$$\begin{aligned} 0 \quad \leq \quad & \lambda W - \lambda n_1 - (1+\tau)\lambda c_1 + \lambda R(c_1) + \\ & (1-\lambda)W - (1-\lambda)n_2 - (1+\tau)(1-\lambda)c_2 + (1-\lambda)R(c_2) - \\ & \lambda R(c_1) - (1-\lambda)R(c_2) + R(\lambda c_1 + (1-\lambda)c_2) \end{aligned} \tag{41}$$

Regrouping by taking out the λ terms,

$$\begin{aligned} 0 \quad \leq \quad & \lambda\left(W - n_1 - (1+\tau)c_1 + R(c_1)\right) + \\ & (1-\lambda)\left(W - n_2 - (1+\tau)c_2 + R(c_2)\right) - \\ & \lambda R(c_1) - (1-\lambda)R(c_2) + R(\lambda c_1 + (1-\lambda)c_2) \end{aligned} \tag{42}$$

From (42), we can see that the terms on the right hand side of the first and the second line are greater than or equal to zero due to the fact that the bundles (n_1, c_1) and (n_2, c_2) are both in budget set A. For the relationship (42) to hold, this requires the third line to also be greater than or equal to zero, specifically

$$\lambda R(c_1) + (1-\lambda)R(c_2) \leq R(\lambda c_1 + (1-\lambda)c_2). \tag{43}$$

Equation 43 is a reverse Jensen's inequality, requiring that a secant line of function $R(\cdot)$ lies on or below the graph of the function. Hence, the rebate function $R(\cdot)$ needs to be quasi-concave in c for the budget set to be convex.

[18] i.e.,

$$n_\lambda = \lambda n_1 + (1-\lambda)n_2 \tag{37}$$

$$c_\lambda = \lambda c_1 + (1-\lambda)c_2 \tag{38}$$

Additionally, assuming a concave rebate function is quite intuitive as it suggest a progressive rebate. If this condition does not hold (i.e., as in the case of convex rebate function), the average rebate $(R(c)/c)$ will be increasing in the amount of formal consumption, which implies a regressive rebate.

B Rebate and Consumption Tax Progressivity

We want to show that average consumption tax rate is increasing in consumption. Average consumption tax rate is written as

$$\frac{\tau_c c - \alpha_0 c^{1-\alpha_1}}{c} = \tau_c - \alpha_0 c^{-\alpha_1}. \tag{44}$$

Differentiate with respect to c, we have

$$\frac{c(\tau_c - \alpha c^{-\alpha_1})}{\partial c} = \alpha_0 \alpha_1 c^{-\alpha_1 - 1}. \tag{45}$$

Since $\alpha_0 > 0, \alpha_1 > 0, c > 0$, it follows that this average consumption tax rate is increasing in consumption and therefore progressive.

A higher rate of change in Equation 45 corresponds to greater consumption tax progressivity. A parameter α_0 enters the equation linearly, implying that higher an increase in α_0 directly raises the degree of progressivity. Additionally, a higher value of α_1 increases the curvature of the rebate function, rendering it more concave. As a result, the average rebate decline more rapidly with rising consumption, making the system more progressive.

C Derivation of First-Order Conditions with Flexible CES Utility

Given the following utility function

$$u_e(n_j, c_j, l_j) = \frac{\left(\left(\omega \cdot c^{\phi_1} + (1-\omega)\cdot(n-\bar{n})^{\phi_2}\right)^{\frac{1-\nu_e}{\phi_1}}(1-l)^{\nu_e}\right)^{1-\rho}}{1-\rho},$$

we can simplify the notations by letting

$$\begin{aligned} C_{\text{agg}} &= \left(\omega \cdot c^{\phi_1} + (1-\omega)\cdot(n-\bar{n})^{\phi_2}\right)^{1/\phi_1} \\ Z &= C_{\text{agg}}^{1-\nu}(1-l)^{\nu} \end{aligned}$$

which simplify the utility function to

$$u_e = \frac{1}{1-\rho} Z^{1-\rho}.$$

We can write the Lagrangian as

$$\mathcal{L} = u_e + \lambda \cdot [\text{budget constraint}]$$

where budget constraint is given in Equation (14). FOCs with respect to formal consumption, informal consumption, and hours worked are

$$\frac{\partial u_j}{\partial c} - \lambda(1+\tau_c) + \lambda R'(c) = 0$$
$$\frac{\partial u_j}{\partial n} - \lambda(1+\lambda_c\tau_c) = 0$$
$$\frac{\partial u_j}{\partial l} + \lambda z_j = 0$$

Derivatives terms can be expressed as

(i) With respect to c:

$$\frac{\partial u_j}{\partial c} = Z^{-\rho} \cdot \frac{\partial Z}{\partial c}$$
$$\frac{\partial Z}{\partial c} = (1-\nu)C_{\text{agg}}^{-\nu} \cdot \frac{\partial C_{\text{agg}}}{\partial c} \cdot (1-l)^{\nu}$$
$$\frac{\partial C_{\text{agg}}}{\partial c} = \left(\omega c^{\phi_1} + (1-\omega)n^{\phi_2}\right)^{\frac{1-\phi_1}{\phi_1}} \omega c^{\phi_1 - 1}$$
$$\Rightarrow \frac{\partial u_j}{\partial c} = Z^{-\rho}(1-\nu)C_{\text{agg}}^{-\nu}(1-l)^{\nu}\omega c^{\phi_1-1}\left(\omega c^{\phi_1} + (1-\omega)n^{\phi_2}\right)^{\frac{1-\phi_1}{\phi_1}}$$

(ii) With respect to n:

$$\frac{\partial u_j}{\partial c} = Z^{-\rho} \cdot \frac{\partial Z}{\partial n}$$
$$\frac{\partial Z}{\partial c} = (1-\nu)C_{\text{agg}}^{-\nu} \cdot \frac{\partial C_{\text{agg}}}{\partial n} \cdot (1-l)^{\nu}$$
$$\frac{\partial C_{\text{agg}}}{\partial n} = \left(\omega c^{\phi_1} + (1-\omega)n^{\phi_2}\right)^{\frac{1-\phi_1}{\phi_1}} (1-\omega)\frac{\phi_2}{\phi_1}(n-\bar{n})^{\phi_2-1}$$
$$\Rightarrow \frac{\partial u_j}{\partial c} = Z^{-\rho}(1-\nu)C_{\text{agg}}^{-\nu}(1-l)^{\nu}(1-\omega)\frac{\phi_2}{\phi_1}(n-\bar{n})^{\phi_2-1}\left(\omega c^{\phi_1} + (1-\omega)n^{\phi_2}\right)^{\frac{1-\phi_1}{\phi_1}}$$

(iii) With respect to l:

$$\frac{\partial u_j}{\partial l} = -Z^{-\rho}\nu C_{\text{agg}}^{1-\nu}(1-l)^{\nu-1}$$

Take the ratio of the first two FOCs, we have

$$\frac{\frac{\partial u_j}{\partial c}}{\frac{\partial u_j}{\partial n}} = \frac{\omega\phi_1 c^{\phi_1-1}}{(1-\omega)\phi_2(n-\bar{n})^{\phi_2-1}} = \frac{(1+\tau_c) - R'(c)}{1+\lambda_c\tau_c}.$$

We can then express n in terms of c as

$$n(c) = \left[\frac{\omega\phi_1}{(1-\omega)\phi_2} \cdot \frac{c^{\phi_1-1}(1+\lambda_c\tau_c)}{(1+\tau_c) - R'(c)}\right]^{\frac{1}{\phi_2-1}} + \bar{n}$$

The solution to household's problem can then be expressed as a function of only c and l.

D Classification of Formal and Informal Consumptions in the SES

We use microdata from 2019 round of Thailand's Socio-Economic Survey (SES), which records both households' expenditures and the outlets through which goods are purchased. This information allows us to construct the shares of formal and informal goods in total household consumption and trace how these share evolve along the expenditure distribution.

The SES distinguishes between multiple outlet types, including:

1. General Stores / Grocery Stores
2. Fresh / Dry Markets, Flea Markets

Types of Malls / Supermarkets

3. General Stores / Grocery Stores
4. Fresh / Dry Markets, Flea Markets
5. Discount Stores (e.g., Tesco Lotus, Big C, Makro, etc.)
6. Other Supermarkets (e.g., Tops, MaxValu, Home Fresh Mart, etc.)
7. Convenience Stores (e.g., 7-Eleven, V-Shop, Family Mart, 108-Shop, etc.)
8. Department Stores (e.g., Central, Robinson, Banglamphu, Tang Hua Seng, etc.)
9. Specialty Stores and Other Malls (e.g., Watsons, CP Fresh Mart, Home-Pro, Index Living Mall, etc.)
10. Traditional Malls Established by Local Entrepreneurs
11. Catalogs / Stores / Mobile Shops (Mobile Vehicles)
12. Internet / Online Stores

In consultation with a staff from National Statistical Office (NSO), we classify outlets (1) and (2) as informal, and outlets (3)-(12) as formal. Purchases made through informal outlets are treated as informal consumption, while those from formal outlets are treated as formal consumption.

The survey also record, for each of twelve major consumption categories (e.g., clothing, shoes, electrical devices, food), the types of outlets used and the relative ranking from one (most frequent) to four (least frequent). Because the data do not report the distribution of purchases across all ranks, we classify each category based on the first-ranked outlet type.

Finally, within each category, we distinguish between VAT-liable and VAT-exempt goods, with exemption primarily cover unprocessed agricultural and animal product as specified under Thailand's Revenue code.