Large Devaluations, Heterogeneous Consumption Adjustments, and Macroeconomic Implications*

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November 1, 2023

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Abstract

This paper studies massive drops in consumption across households during large devaluations associated with sudden stops. Using cross-country comparison and the Mexican 1994 peso crisis as a case study provides evidence that, unexpectedly, non-tradable consumption decreased considerably, as much as tradable. Employing micro-data, we show that non-tradable consumption falls more for higher-income households. Moreover, expenditure share in non-tradable increases with income level, reflecting non-homotheticicities. As a result, higher-income households concentrate expenditure on non-tradable and motivate the aggregate result. Based on this evidence, we build a new open economy framework that combines a Heterogeneous Agent New Keynesian structure and non-homothetic CES preferences. The results show this framework allows to reconcile micro and macro evidence of the Mexican 1994-peso crisis. I show a novel result: The propagation of disturbances across economic sectors through household consumption decisions is asymmetric, depressing production more when it starts from the tradable sector. Finally, through sufficient statistics, we provide evidence of the economic significance of the interaction between heterogeneous consumption bundles and MPCs.

*I am very grateful to my advisors Andy Atkeson, Ariel Burstein, Sebastian Edwards, and Oleg Itskhoki for their invaluable guidance, support, and advice throughout this project. I also thank Lee Ohanian and Joao Guerreiro for their insightful discussions and suggestions. I also thank Andres Blanco and Federico Mandelman for their great support and sharp comments during my Dissertation Fellowship at the Federal Reserve Bank of Atlanta. This paper also benefited from long discussions with Alvaro Boitier, Bernardo Candia, Fatih Ozturk, and Mariano Palleja, to whom I am grateful. I finally thank David Baqaee, Paula Beltran, Salomé Baslandze, Saki Bigio, Anton Braun, Simon Fuchs, Matteo Maggiori, Indrajit Mitra, Veronika Penciakova, Pierre-Olivier Weill, Jon Willis, and participants in the UCLA Macroeconomics Proseminar, UCLA Trade Proseminar, FED of Atlanta Seminar, Central Bank of Chile Seminar, CSULB Seminar, and SOCAE 2023 for their useful comments and suggestions. This paper was supported by the Lewis L. Clarke Graduate Fellowship Fund.

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1 Introduction

Large contractionary devaluations during episodes of sudden stops are associated with a massive decline in consumption (Bianchi and Mendoza , 2020). Salient examples are Mexico in 1994, Thailand in 1998, and Iceland in 2008. Although theory prediction for those episodes is a more substantial decrease in tradable than non-tradable consumption due to a relative increase in tradable prices, in previously mentioned episodes, it is observed that non-tradable consumption can decline as much as tradable.

This paper studies the dynamics of tradable and non-tradable consumption during large contractionary devaluations. Using micro-data for Mexico's 1994 peso crisis as a case study and a new framework that combines household heterogeneity and non-homothetic CES preferences, I show that household consumption decisions are an essential factor in the domestic cross-sector propagation and help to explain the aggregate macroeconomic response after the devaluation.

Our analysis starts from the novel empirical finding that non-tradable consumption can fall as much as tradable during large devaluations. This finding, combined with the empirical result that expenditure share in tradable increases after large devaluation, implies that the tight connection between relative consumption and relative prices predicted by homothetic preferences is broken. This result is mainly explained by high-income households that experience a significant non-tradable consumption decline. Moreover, expenditure share in non-tradable increases with income level, reflecting the presence of non-linear Engel curves, so higher income households concentrate expenditure on non-tradable, which explains the aggregate result on non-tradable consumption. Then, we build a new open economy framework that combines a Heterogenous Agent New Keynesian structure and non-homothetic CES preferences. We show that non-homothetic CES preferences are essential to explain the propagation of shocks to non-tradable sectors originating from tradable sectors. Moreover, we provide evidence through a sufficient statistic of amplification in consumption decline produced by the interaction between heterogeneous expenditure share across households distribution and MPCs.

On the empirical side, first, we provide evidence at the aggregate level of consumption dynamics and expenditure shares during three large devaluation episodes. We focus on three sudden stop episodes, well-known by the literature, that are characterized by a large contractionary devaluation: Mexico in 1994, Thailand in 1998, and Iceland in 2008.[1] Those episodes also exhibit total household consumption and income decline and current account reversals. We show that in those three episodes, the consumption of non-tradables falls as much as that of tradables. This is unexpected, as theory prediction for homothetic preferences is a tight connection with relative prices.[2] Moreover, we found that in those episodes, expenditure share in tradable increases, which is, in fact, consistent with the theory. Consequently, theory predictions under homothetic CES preferences in these episodes tend to be characterized by a disconnect between both empirical findings.

[1]Usually, a sudden stop is accompanied by devaluation, but only a smaller set has a large devaluation (Korinek and Mendoza , 2014).

[2]During a devaluation, exchange rate pass-through is higher to tradable prices (Burstein et al. , 2007). It implies that tradable prices increase more than non-tradable.

Next, we investigate the micro-level dynamics of consumption and expenditure adjustment using household-level expenditure data from the 1994 Mexican peso crisis.[3] First, we investigate how consumption changes in tradable and non-tradable evolve along households' income deciles. We provide evidence that the above patterns do not consistently hold along all income deciles simultaneously. The finding that consumption of non-tradables falls as much as that of tradables is driven by high-income households that significantly decrease non-tradable consumption. Then, we move to study expenditure share in tradables. We show that it decreases as income level increases. Exactly the opposite is observed for non-tradable: It increases as income level increases. This provides strong evidence for non-linear Engel curves, i.e., non-homothetic preferences in consumption allocation decisions. A notable implication is that higher-income households concentrate relatively more on non-tradable consumption. Moreover, after the devaluation, households of every income decile increased their expenditure share in tradable, which is more augmented in those with higher incomes due to a relative decline in non-tradable expenditure. Finally, the combination of higher consumption decline and concentration of non-tradable observed by high-income households explains the considerable aggregate decline in non-tradable.

Motivated by previous findings, we develop a new framework to study the propagation of a tradable sector disturbance to non-tradable and how macroeconomic aggregates respond. We start from the canonical two-sector tradable and non-tradable representative agent model, and we extend it into two dimensions.[4] First, we extend the representative agent model to heterogeneous agents by incorporating idiosyncratic income risk and borrowing constraints in incomplete markets. This element is fundamental to size up the income effect and produce contractionary devaluations.[5] This heterogeneous agent model is complemented with nominal wage and non-tradable price rigidities to transmit nominal shocks to the real sector and to account for relative prices. Second, non-homothetic CES preferences are incorporated to account for heterogeneous expenditure share in tradable and non-tradable across households and to deal with the disconnect discussed for homothetic CES preferences between relative consumption and relative prices. With these elements, we aim to build an economy with the main mechanisms observed in the Mexican peso crisis in 1994 that allow us to replicate the empirical findings at the micro-level, i.e., expenditure share in tradable heterogeneity and household consumption distribution, and at the aggregate level, i.e., the dynamics for consumption of tradable and non-tradable.

Our results reveal that the combination of a heterogeneous agent structure and non-homothetic CES preferences is essential to replicate expenditure share in tradable and the relative consumption concentration across households. The main exercise compares our benchmark model with non-homothetic CES to a heterogeneous agent model with homothetic CES preferences. In steady state, our benchmark model provides a close ap-

[3]This data was recently used by Cravino and Levchenko (2017) to study the household-level price index, and Guntin et al. (2023) to study how total consumption changes inform micro-patterns of traditional theories of aggregate consumption adjustment.

[4]The departure point is the canonical open economy model with two sectors in Schmitt-Grohé and Uribe (2016).

[5]Auclert, Rognlie, Souchier and Straub (2021) demonstrate that in a heterogeneous agent version of canonical open economies Gali and Monacelli (2005) model, heterogeneity size-up a new channel during devaluations that they call real income channel, producing a contractionary devaluation.

proximation to household expenditure share in tradable and total consumption share allocation across households to Mexico in 1994.[6] In comparison, homothetic CES preferences underperform in both aspects, as expenditure share in tradable does not change with income and can not replicate the high consumption concentration of high-income households.

Then, we move to simulate the 1994 Mexican peso crisis in our model. The simulations assume that a 15% increase in the foreign interest rate from the steady-state level triggers the devaluation.[7] The simulations in our benchmark model replicate the phenomenon observed in this episode, i.e., a non-tradable consumption decrease as considerable as in the tradable. In contrast, under homothetic preferences, although the consumption of tradable decreases in a similar magnitude to that in the non-homothetic case, non-tradable consumption does not decrease. This is in contrast to the observed empirical phenomenon documented in this paper. Moreover, our stylized model is still able to reproduce the current account reversal. Consequently, the heterogeneous agent open economy model, in combination with non-homothetic CES, is a powerful device that allows the reproduction of key aggregate and micro-level characteristics of this large devaluation episode. But what are the macroeconomic implications of the interaction between non-homothetic preferences and heterogeneous agents operating in this large devaluation episode? We move to investigate the impact of non-homotheticities and then the interaction with heterogeneity.

Non-homothetic CES preferences amplify the relative consumption decline of non-tradable and produce asymmetric propagation of shocks, raising the impact on the non-tradable sector if this starts from the tradable sector when income elasticity is relatively higher on non-tradable. From the household perspective, those results explain why the devaluation was so devastating in Mexico in 1994. The intuition is the following. When devaluation started, relatively higher non-tradable than tradable income elasticity produced a relatively higher non-tradable demand decrease and relative price response than if income elasticities were equal to one. Under flexible exchange rates and nominal wages, supply can accommodate this disturbance. However, the Mexican economy in 1994 had a fixed exchange rate regime with rigid labor markets, so an adjustment of that sort was difficult. Consequently, under nominal rigidities, involuntary unemployment in non-tradable was the equilibrium response. In equilibrium, non-tradable production and consumption were strongly depressed, which our model explains is mainly due to higher income elasticity under non-homothetic CES preferences, as homothetic CES preferences have equal income elasticities. Therefore, relatively higher non-tradable income elasticities observed in the data were a critical intersectoral propagation mechanism that amplified the aggregate economic response during this episode of large devaluation.

[6]A key element of our calibration of non-homothetic CES preferences is estimating a demand system to recover parameters associated with income elasticities. We take two complementary approaches, using instrumental variables to estimate income elasticities consistently. Our results show that non-tradable income elasticities are higher than tradable (Comin et al. (2021) finds that the elasticity of services is higher than manufacturing goods and food).

[7]The literature that studies the causes of the Mexican peso crises identifies the sudden increase in 75 bps in the US in November 1994 as one of the main triggers for the devaluation. However, at that point, the Mexican economy suffered other problems (see Calvo and Mendoza (1996) and Edwards (2010) chapter 6). For a recent analysis, see Davis et al. (2022).

Finally, we study the implications for aggregate consumption decrease of the interaction between household heterogeneity and non-homotheticities. We show that sector-level MPCs, sector intertemporal substitution, and a new sufficient statistic of the interaction between expenditure shares and MPCs modify sector-level consumption. This new interactive term is positive in the data and in our model for tradable and non-tradable. We show it amplifies consumption decline. Quantitatively, we show that this term is positive and economically significant as in our model, it is about 80% of the price substitution effect. Therefore, the quantitative relevance of those elements explains the importance of considering heterogeneity and non-homotheticities simultaneously to study the aggregate consumption decline in Mexico in 1994.

Related literature. Our paper relates to several strands of literature. First, there is a large literature in international macroeconomics that studies business cycles in emerging markets and sudden stops. This is associated with different theories to explain the sources of macroeconomic fluctuations and key mechanisms interacting. A leading explanation for the former is changes in foreign interest rates (see, for instance, Neumeyer and Perri (2005), Uribe and Yue (2006), Dedola et al. (2017), and Iacoviello and Navarro (2019)). For the latter, one of the most important mechanisms is associated with financial frictions, among them, balance sheet effects with agency problems (Céspedes et al. , 2004), working capital (Neumeyer and Perri (2005), Uribe and Yue (2006), and Chang and Fernandez (2013)), and Fisherian models.[8] Closer to our research are Rojas and Saffie (2022) and Arce and Tran-Xuan (2022) that introduce non-homothetic preferences in Fisherian models.[9] Our contribution to this literature is empirical and theoretical. Empirically, we provide evidence that non-tradable consumption, excluding housing, can fall as much as tradable during large devaluations in sudden stops, which is mainly due to high-income households.[10] Theoretically, we show that non-homothetic CES preferences with relatively higher non-tradable income elasticities are essential to propagate shocks across sectors asymmetrically. Finally, our framework also shows that the interaction between household heterogeneity and non-homothetic preferences is critical to explaining observed stylized facts at the micro and aggregate levels.

Our paper is also associated with the literature on consumption response to exchange rates, particularly with the literature that emphasizes the role of income effect.[11] Gyongyosi et al. (2022) find that quantity and quality of consumption are affected by debt revaluation after a large depreciation, which is consistent with non-homothetic preferences. Bems and Di Giovanni (2016) find that during a balance of payment cri-

[8]Fisherian models are models with credit constraints linked to market prices that have been proposed to explain sudden stops. For complete summaries of this literature, see Korinek and Mendoza (2014), and Bianchi and Mendoza (2020).

[9]Rojas and Saffie (2022) based on differences in income elasticities and credit booms in the housing sector, introduce non-homothetic preferences in Fisherian models to account for credit and consumption booms that precede sudden stops. Arce and Tran-Xuan (2022) extend the analysis in Rojas and Saffie (2022) to a two-agent model.

[10]As we show, even without considering expenditure in housing, non-tradable consumption can be considerably affected during large devaluations. So, our framework does not require collateral constraints as Fisherian models.

[11]Another important strand of literature is welfare effects associated with price changes caused by exchange rate changes (see Cravino and Levchenko (2017)).

sis, even in the absence of a devaluation, expenditure switching can induce substitution between imported and domestic goods. Additionally, Auer et al. (2022) shows that lower-income households substitute between imported and domestic goods when the exchange rate changes. Similar to our research, Guntin et al. (2023) use Mexico's 1994 large devaluation as a case study, among others, and find that high-income households have higher than average consumption-income elasticities, and Cugat (2018) emphasizes the relevance of idiosyncratic income shocks. Our contribution to this literature is to provide evidence that, even at the aggregate level, homothetic CES preferences can be inconsistent with relative consumption and expenditure shares during large devaluations. We also show that the income effect in large devaluations is associated with a higher drop in non-tradable. Moreover, we present evidence that the non-homothetic pattern in non-tradable consumption implies that inequality in non-tradable consumption is relatively higher, a key driver of aggregate fall in non-tradable. Finally, we expand the results in Guntin et al. (2023) by showing that studying consumption dynamics and expenditure share simultaneously is essential to account for aggregate dynamics of consumption in multiple sector economies.[12]

Finally, our research is associated with an increasing literature that analyzes the role of Heterogeneous Agents New Keynesian models to study foreign shocks and monetary and fiscal policies in open economies. Auclert, Bardóczy, Rognlie and Straub (2021) show conditions for the importance of heterogeneity and the relevance of income effect in those models. De Ferra et al. (2020) and Zhou (2022) show the relevance of borrowing in foreign currency for household balance sheets, and Ferrante and Gornemann (2022) shows the connection between currency mismatch in the banking sector is partly associated with household savings in dollars. Other important contributions are associated with studying financial integration (Guo et al. , 2023), exchange rate regimes (Oskolkov , 2023), fiscal devaluations (Giagheddu , 2020), and the business cycle (Hong , 2020). Our contribution to this literature is to provide evidence of the importance of the interaction of non-homotheticities and household heterogeneity to study the impact on consumption of shocks that start in the tradable sector. Moreover, we show that non-homothetic CES preferences amplify consumption decline more than homothetic CES associated with shocks starting in the tradable sector and the asymmetric propagation of shocks across economic sectors due to differences in income elasticity.[13] Finally, we also show that non-homothetic CES preferences are essential to reconcile expenditure share and consumption distribution across households in HANK open economy models.[14]

This paper is organized as follows. In Section 2, we study consumption and expenditure share dynamics during large devaluations at the aggregate and micro-level. Then,

[12] Cugat (2018) first reported changes in aggregate consumption of tradable and non-tradable with micro-data for Mexico in 1994, then Guntin et al. (2023) expanded this result to compare the average with high-income households. However, in both cases, there is no discussion about the relative consumption difference between tradable and non-tradable, the relationship with relative prices, expenditure shares, or non-homotheticities.

[13] Non-homothetic CES has been extensively used by structural transformation literature (see, e.g., Comin et al. (2021), Cravino and Sotelo (2019), and Fujiwara and Matsuyama (2022)). For a review of non-homothetic CES, and several classes of non-CES aggregators, see Matsuyama (2023).

[14] In contrast, incorporating non-homotheticities as Stone-Geary preferences produces a scarce difference with homothetic CES (Zhou , 2022).

in Section 3, we describe the model to embed the empirical findings and explain how we calibrate it. In Section 4, we simulate our model to replicate the main aspects of the Mexican 1994 peso crisis. Section 5 studies how foreign shocks propagate through the economy, the relevance of heterogeneity and non-homotheticities to study large devaluations, and implications for fear of floating. Finally, Section 6 discusses Conclusions.

2 Data and Background

This section describes the stylized facts that guide the analysis in this research. First, the focus is on an international comparison of consumption and expenditure share dynamics using aggregate data of Sudden Stop episodes characterized by large devaluations. Then, microdata is used to study the household-level consumption and expenditure share dynamics during the 1994 Mexican devaluation.

2.1 Cross country comparison

2.1.1 Data description

Cross-country data corresponds to national account data provided by domestic central banks or OECD statistics. Goods and services under this framework are classified according to COICOP international classification, and for the exercise in this paper, they are split between tradable and non-tradable goods. The episodes considered are those in Burstein and Gopinath (2013), with a devaluation of US dollars and nominal effective exchange rate higher than 40% in 12 months when they have available consumption data disaggregated, according to COICOP. Countries with data available that we consider in this research are Iceland, Mexico, and Thailand.[15] In those cases, devaluation in terms of the bilateral exchange rate with the US and nominal effective exchange rate (NEER) is more than 40%.[16] According to national account data, consumption in Mexico and Iceland are at 2015 constant prices, and for Thailand, it is chain volume with the reference year 2002.

Figure 1 shows the evolution of aggregate total household consumption growth rate, GDP growth rate, and nominal exchange rate for Mexico, Iceland, and Thailand. It is remarkable that although the three countries are quite different, among others, in terms of size, location, and development stage, those three episodes exhibit similar characteristics. The consumption growth rate and GDP growth rate plummet. Moreover, the nominal exchange rate suddenly jumps for two years.[17] As will be shown below, the

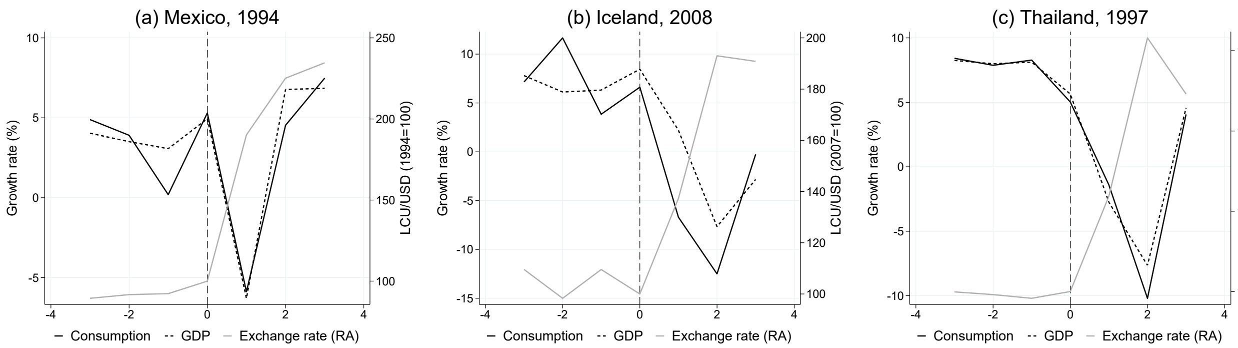
[15] See more details related to aggregate data and selection of these countries in Appendix A.1.1.

[16] According to Burstein and Gopinath (2013) after 12 months devaluation in nominal terms for Iceland, Mexico, and Thailand was NEER 94.4%, 123.3%, and 43.1% and for the bilateral exchange rate with the US 122.6%, 122.5%, and 64.3%.

[17] Another critical characteristic in episodes of large contractionary devaluation associated with sudden stops is the current account reversal, called external adjustments. A leading example of external adjustment has been recently documented for the U.S. during the Great Depression. After abandoning the Gold Standard, the dollar devaluation was a critical driver of economic recovery in cities more exposed to exports (Candia and Pedemonte , 2023).

combination of large devaluation and a contraction of GDP can be associated with an important decline not only in the consumption of tradable but also in non-tradable.

Figure 1: Main characteristics of sudden stops associated with large devaluations



Note: This figure shows the dynamics of real aggregate household consumption growth rate (solid black line), real GDP growth rate (dotted black line), and nominal exchange rate index (solid gray line in right axis) for Mexico in 1994, Iceland in 2008, and Thailand in 1997 in annual frequency. The nominal exchange rate index is the local currency unit (LCU) per US dollar equal to 100 in the year before the devaluation. The vertical segmented black line equals zero in the year of the devaluation.
Sources: WDI World Bank.

2.1.2 Stylized Facts

Stylized fact 1. Consumption of non-tradable can fall as much as tradable goods after a large devaluation. Theory prediction from sudden stop literature using homothetic cobb-douglas preferences is that a change in relative consumption is tightly connected with a change in relative prices. A devaluation provokes a movement in relative prices with a higher increase in tradable prices. Under cobb-douglas preferences, the intratemporal household consumption allocation problem requires that:

$$d\ln C_t^T - d\ln C_t^N = d\ln P_t^N - d\ln P_t^T \tag{1}$$

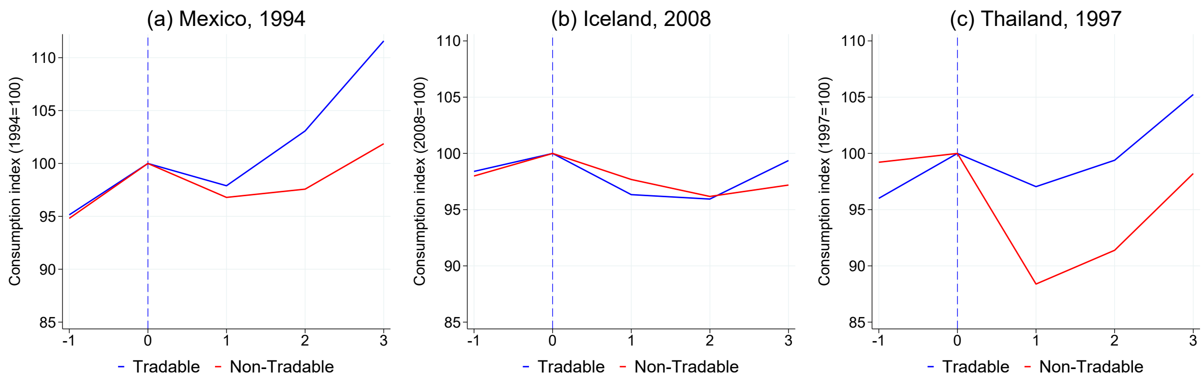
Where $d\ln C_t^T$ ($d\ln C_t^N$) corresponds to log change in tradable (non-tradable) consumption, and $d\ln P_t^T$ ($d\ln P_t^N$) is log change in tradable (non-tradable) prices. The more general case with homothetic CES preferences is similar, as the difference is associated with the elasticity of substitution that mediates prices.[18]

Figure 2 shows a consumption index for tradable and non-tradable equal to 100 in the period previous to the devaluation for Mexico, Iceland, and Thailand. The Mexican case in 1994, which will be analyzed in more detail below, is our benchmark to compare. Due to the exchange rate pass-through, after the 12-month, tradable prices increased by 57.8% and non-tradable by 37.2%.[19] In this case, according to equation (1), almost a 20% higher tradable consumption fall than non-tradable is expected.

[18] Appendix B.1 derives the household problem with CES preferences.
[19] Data from Burstein and Gopinath (2013).

Figure 2 panel (a) shows that for Mexico in 1994, the opposite is observed. Although there are about 2% differences between relative consumption change in tradable and non-tradable after one year of the devaluation, the magnitude order is at least one level below, and the sign is opposite the expected. Under homothetic preferences, this empirical observation is inconsistent with cobb-douglas preferences. Even assuming the

Figure 2: Consumption of tradable and non-tradable during sudden stops associated with large devaluations



Note: This figure shows the real aggregate household consumption index for tradable and non-tradable for Mexico in 1994, Iceland in 2008, and Thailand in 1997 in annual frequency. The real aggregate household consumption index equals 100 in the year of the devaluation. The vertical segmented blue line equals zero in the year of the devaluation.
Sources: OECD and Thailand Central Bank.

most general case of homothetic CES, the elasticity of substitution close to zero or negative can reconcile this data, which is not the empirically relevant case as theoretical literature usually uses 0.5.[20]

Figure 2 panel (b) and (c) shows the same exercise for Iceland in 2008 and Thailand in 1997. After one year of the devaluation, Iceland shows a very tight path between tradable and non-tradable consumption. Thailand is the most disturbing case, as non-tradable consumption decreased by almost 10% more than tradable, which is inconsistent with a positive elasticity of substitution under the assumption of homothetic CES preferences.

Stylized fact 2. Expenditure share in tradable goods increases after a large devaluation. In the Cobb-Douglas preferences case, just discussed expenditure shares are independent of prices and depend only on the weight assigned to each consumption good, i.e., they do not change over time which is a too extreme assumption. In the case of homothetic CES preferences, we have that the expenditure share of tradables depends on relative prices and elasticity of substitution as follows:

$$d \ln b_{T,t} = (1 - \sigma)(d \ln P_t^T - d \ln P_t) \tag{2}$$

[20] Appendix A.5 discusses in detail change in consumption of tradable and non-tradable in alternative economic crises in Mexico with a lower devaluation close to 30% as it was the case for the Global Financial Crisis 2008 and the most recent COVID-19 crisis.

where $d \ln b_{T,t}$ is log change in expenditure share of tradable goods, $d \ln P_t^T$ is log change in price of tradable goods and $d \ln P_t$ is log change of aggregate price. Notice that when the elasticity of substitution σ equals one, we return to the Cobb-Douglas case $d \ln b_{T,t} = 0$. As was previously discussed, under a large devaluation, exchange rate pass-through implies that tradable prices increase by more than non-tradable prices. As a result, a higher increase in the relative price of tradable goods is observed. As an alternative to

Figure 3: Expenditure share of tradable during sudden stops associated with large devaluations

Note: This figure shows the expenditure share in the tradable index for Mexico in 1994, Iceland in 2008, and Thailand in 1997 in annual frequency. The expenditure share in the tradable index equals 100 in the year of the devaluation. The vertical segmented green line equals zero in the year of the devaluation.
Sources: OECD and Thailand Central Bank.

the Cobb-Douglas case, we can assume, as standard in the sudden stop literature, an elasticity of substitution 0.5. Then, it is expected that the expenditure share in tradable goods will increase after the large devaluation.

Again, first, we focus on Mexico in 1994, at the aggregate level, and the results are in Figure 3 Panel (a). The results show an increase in the expenditure share of tradable goods and are aligned with what is expected when relative prices of tradable goods increase more than non-tradable under homothetic CES preferences. We highlight that this observation is not compatible with cobb-douglas preferences as under those preferences, expenditure share does not change with relative prices.[21] In Panel (b) and (c), we can observe similar patterns for Iceland in 2008 and Thailand in 1997, as in both cases, expenditure share in tradable goods increased.

Putting together the evidence of stylized facts 1 and 2, we can compare them to predictions under Cobb-Douglas preferences. In this case, we observed that it is impossible to match either stylized facts 1 or 2. To match stylized fact 1, we require a small negative change in relative tradable and non-tradable prices, while for stylized fact 2, we require relative prices fixed, i.e., exchange rate pass-through to tradable and non-tradable are the same, which was not observed.

[21] Appendix A.5 discusses in detail expenditure share in tradable in alternative economic crises in Mexico with lower 30% devaluation as was the case for the Global Financial Crisis 2008 and the most recent COVID-19 crisis.

Next, we evaluate stylized facts 1 and 2 under the more general case of homothetic CES preferences. Stylized fact 1 is not reconciled for this type of preference because, given a higher exchange rate pass-through to tradable, we require an elasticity of substitution close to zero or negative to reconcile the data. Stylized fact 2 can be explained under this environment. As a result, together, those stylized facts imply a disconnection between relative consumption and expenditure share for homothetic CES preferences. To reconcile both stylized facts 1 and 2, we require an additional degree of freedom. Below, we will argue that non-homothetic CES preferences are an ideal candidate to reconcile both stylized facts.

2.2 Case Study: Mexico 1994 Peso Crisis

The 1994 Mexican Peso Crisis was a massive event that plummeted output by 6.2%, starting with a small devaluation that became huge after a couple of days. This subsection describes the data and gives an overview of the main characteristics of this event. Then, it describes the stylized facts at a household level across household income distribution to complement those at the aggregate level described in the previous section.

2.2.1 Data description

To study this event, household-level data is used to build consumption and expenditure shares. The household survey data for Mexico corresponds to *Encuesta Nacional de Ingresos y Gastos de los Hogares* (ENIGH) and is a cross-section of data that is collected and reported biannually by Instituto Nacional de Estadística y Geografía (INEGI).[22] This survey has been run continuously since 1992 until 2020. It is a representative sample of urban and rural areas, and we consider households with heads aged 25-60 as it is standard in consumption literature. Given the high level of expenditure disaggregation in this survey, it is possible to study good-level expenditures. This survey also contains data related to labor income, monetary transfers, savings flows, and debt flows. Moreover, in the case of food and beverages, which are almost 50% of the consumption basket, the household survey asks for the total value of expenditures and total quantity, so it is possible to recover unit values that are informative to the household level.[23]

We consider the entire basket of goods and services consumed by Mexican households over 1994-1996. The exercises described in the next section make products homogeneous across time and re-classify them into 247 products split into tradable and non-tradable goods using the Bank of Mexico classification.[24] An important characteristic of this survey is the timing of implementation between September and December 1994; then, the survey was applied again in August and November 1996. The devaluation was in December 1994, so the survey reflects the economic condition before and after. Finally, to construct the consumption index, expenditures in each good or service

[22] This survey has been used by related literature, for instance, Cravino and Levchenko (2017), and Guntin et al. (2023).

[23] See Appendix A.1.2 for a detailed description of this survey data.

[24] See Appendix A.1.2 for details. Durable goods are not considered due to highly volatile behavior during this episode, which is similar to investment. Consumption literature uses a similar approach. See Aguiar and Bils (2015).

are deflated by October of the same year's product-level price index.[25]

2.2.2 Episode overview and identification strategy

In December 1994, a small devaluation announced by the Mexican government quickly became a huge event that affected Mexican output, consumption, and the economic performance of other emerging markets. At the beginning of December 1994, the new Mexican government, headed by President Zedillo, took office and decided to devaluate the peso by 15% to stop an incipient foreign capital outflow. Foreign investors left the country massively, and a few days later exchange rate was allowed to float freely, amounting to 50% devaluation after a couple of months. The effect on the economy was a GDP drop of 6.2% in 1995, unemployment was from 3.7% in 1994 to 6.2% in 1995, and inflation peaked from 7% in 1994 to 35.1% in 1995. The effect on private consumption was devastating, as prices and unemployment generated a 30% drop in real wages and an increase of extreme poverty from 21% in 1994 to 37% in 1996. Foreign investors not only left Mexico but emerging markets in general, and the crisis led to financial contagion in other emerging markets, such as Brazil.

To understand how households were affected overall, we start analyzing total consumption. We order households according to monetary income in deciles and sum up the entire consumption bundle for each household income group. Particularly, total consumption per income decile $c_{d,t}$ is equal to $c_{d,t} \equiv \sum_{h \in \mathcal{I}_{d,t}} \sum_{k \in \mathcal{K}} c_{kh,t}$, where $c_{kh,t}$ is consumption for good or service k in total consumption bundle $\mathcal{K}$, for household h pertaining to income decile d. Then, we compute consumption change for each income level between 1994 and 1996.

Figure 4 shows that consumption declined for every group of households across the income distribution. Moreover, change was unstable across the income distribution. For the first income decile, consumption falls by 13%, and for the last one, it decreases by 25%. Although there is heterogeneity across other income deciles, a negative trend is observed and reflects that this economic crisis affected households with different income profiles.[26]

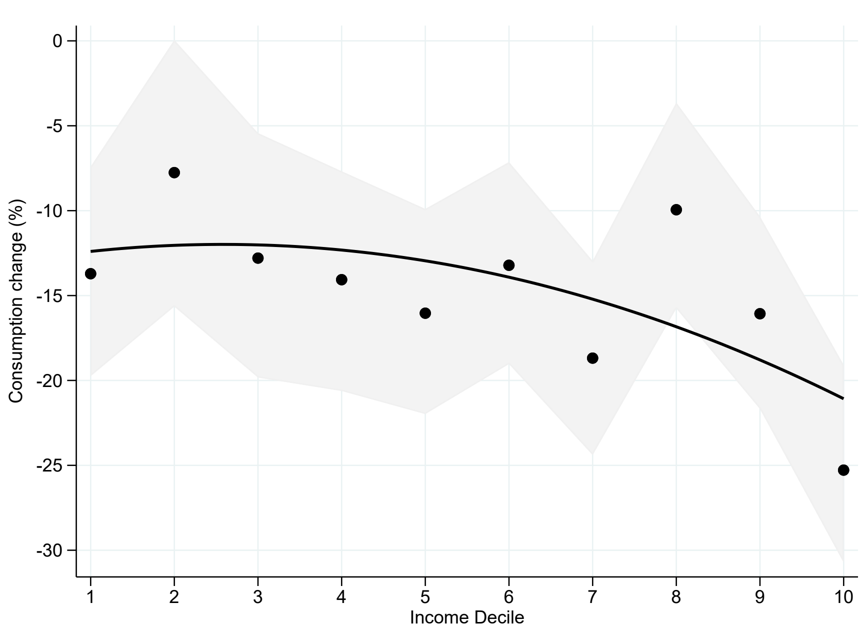
The Mexican 1994 contractionary devaluation episode is particularly interesting because it combines changes in relative prices across goods due to the devaluation and the income decline across households with different income levels. Our identification strategy relies on this double difference. As it is well known, prices and quantities respond simultaneously, so in this case, changes in relative prices and relative income allow us to tackle this endogeneity problem. So, let's review changes in monetary income and relative prices.

During the Mexican peso crisis, households' monetary income was severely affected. Total output increased by 4.9% in 1994, and then it declined by 6.3% in 1995. It generated a spike in unemployment of 6.2% in 1995, starting at 3.7% in 1994. As a result, monetary

[25] Regarding prices to normalize expenditure data, it is possible to identify and match the price level for every 247 products in the household survey. INEGI uses this data to construct the national consumer price index in Mexico. This data comes from replication data in Cravino and Levchenko (2017). Gagnon (2009) also has a replication package with Mexican price data at a product level.

[26] This declining pattern for total consumption has also been observed in other episodes of economic crises. See Guntin et al. (2023).

Figure 4: Total aggregate consumption change by household income decile in Mexico, 1994-1996



Note: This figure shows the total aggregate household consumption growth between 1994 and 1996 per household income decile. The shaded gray area corresponds to 90% confidence intervals, estimated using bootstrap with 1000 replications.
Source: ENIGH-INEGI.

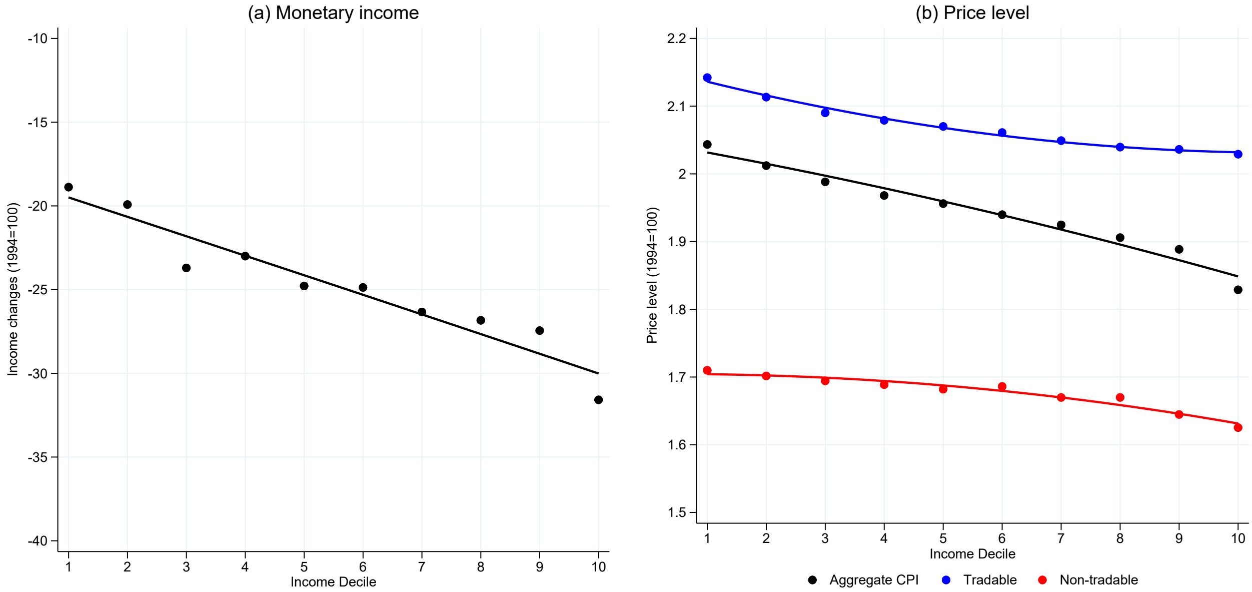
income was severely damaged. Figure 5 Panel (a) shows real monetary income across income deciles.[27] The first two deciles decreased monetary income by close to 20%, but then the last two deciles decreased by 27% and 32%. Those results reveal that monetary income for high-income households was more affected in this episode. This result implies that income inequality decreased. This decline in inequality has been observed in other episodes across emerging markets (Blanco et al. , 2019) or in other economic crises in advanced economies (Aguiar and Bils , 2015).

The high level of exchange rate pass-through in this devaluation episode provoked a considerable spike in inflation of 52% in December 1995 and 28% in December 1996 compared to 7% in December 1994, the month of the devaluation. The inflation in consumer prices affected different low- and high-income households as their consumer baskets were distinct. To evaluate this statement, we replicate the exercise in Cravino and Levchenko (2017) of constructing price indices base 100 in October 1994 for household income deciles splitting between tradable and non-tradable goods.

Figure 5 Panel (b) shows the price results. There is a sharp difference in the relative level of tradable and non-tradable prices. Across income deciles, the price difference after 24 months is about 40%, so the exchange rate pass-through was higher for tradable as expected (Burstein et al. , 2007). If we pick the first decile, tradable inflation is about 115% in two years in comparison to the tenth decile, 104%. Similar behavior is observed for non-tradable goods. As a result, total inflation also follows a declining

[27] Nominal monetary income is deflated with the aggregate price index.

Figure 5: Monetary income change and price level by household income decile in Mexico, 1994-1996



Note: Panel (a) shows monetary income change between 1994 and 1996 by income decile. Panel (b) shows tradable and non-tradable price indexes equal to 100 in 1994 by income decile.
Source: ENIGH-INEGI, and prices from Cravino and Levchenko (2017).

pattern across households' income decile. These results confirm the initial hypothesis that inflation affected more low-income households in this event, mainly due to tradable goods. Moreover, it confirms a high difference in relative prices after 24 months.

In this section, we have shown a massive decline in monetary income and price increases. The decline in monetary income was more important for high-income households, and prices increased more in tradable, especially for low-income. Together, both results point to a significant decrease in consumption. However, the combination of changes in relative prices impacts tradable and non-tradable consumption differently. Moreover, when income elasticities across tradable and non-tradable are different, a heterogeneous monetary income decrease will also have a differential impact on consumption patterns. This is investigated next in stylized facts 3 and 4.

2.2.3 Stylized Facts

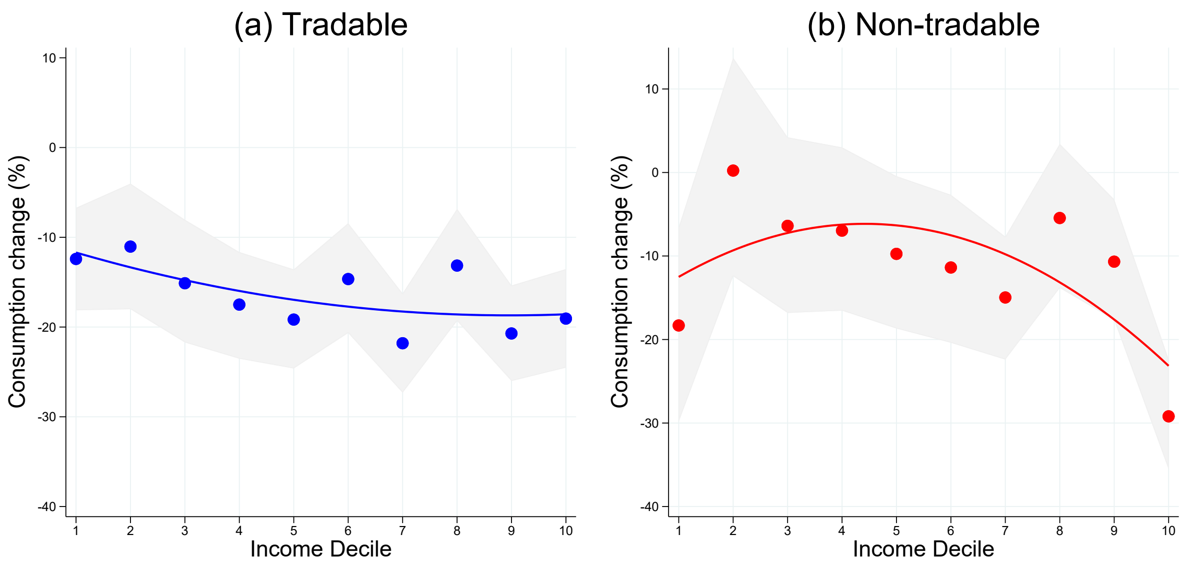
Stylized fact 3. The relative decline in tradable and non-tradable goods changes across the income distribution. We are interested in studying consumption changes across the income distribution for different types of goods and services. We split the household income distribution across income deciles and then sum up consumption across households per each good $c_{jd,t} \equiv \sum_{h \in \mathcal{I}_{d,t}} c_{jh,t}$, where $c_{jh,t}$ is the consumption for tradable and non-tradable j, for household h of income decile d.[28] Then, we compare

[28] In the baseline scenario, we focus on tradable and non-tradable goods. As robustness, we split tradable and non-tradable goods between food or non-food and utilities or non-utilities. See Appendix A.2

the synthetic cohorts across time, before and after the devaluation episode.

Figure 6 shows the consumption of tradable and non-tradable goods across the income deciles. Panel (a) reveals a declining pattern for tradable consumption across the income distribution. Comparing the first income decile with the last one, the difference

Figure 6: Household consumption change for tradable and non-tradable per household income decile in Mexico, 1994-1996



Note: This figure shows the percentage change for household consumption of tradable and non-tradable between 1994 and 1996 per household income decile. The shaded gray area corresponds to 90% confidence intervals, estimated using bootstrap with 1000 replications.
Source: ENIGH-INEGI.

is about 8% consumption decline. Although there is heterogeneity, it shows that tradable consumption for higher-income households declined by more.[29]

Non-tradable consumption change is in Figure 6 panel (b). In this case, the first income decile shows an important decline of 18%, while the last one is 29%. If we consider the third to tenth income decile, we observe a declining pattern in consumption, as was the case for tradable goods. However, the results are similar to U-shape behavior across the income distribution. [30] It implies that the results observed at the aggregate level, i.e., non-tradable consumption can fall as much as tradable is mainly motivated by high-income households.

Another characteristic that reveals Figure 6 is that non-tradable consumption presents

for an additional discussion.

[29]In appendix A.2, we additionally explore if this declining pattern across income distribution comes from food or non-food components of tradable goods. We find that both components share the same negative slope, although, in level, non-food consumption falls in a higher magnitude.

[30]When we split non-tradable consumption between consumption associated with utilities and non-utilities, the former has the same declining pattern as tradable, and the last one conducts the U-shaped pattern. For additional details, see Appendix A.2.

more significant skewness. In terms of total expenditure, the first income quintile represents 7.2% of total expenditure, while the fifth quintile was 42.5% in 1994. This difference is more dramatic when considering only non-tradable. The first income quintile represents 4.4% of total expenditure, while the fifth quintile is 53.5% in 1994. That is the reason when we compare decile by decile, we can not reconcile the aggregate stylized fact 1 that consumption of non-tradable can fall as much as tradable. However, as shown below, even in this case of high skewness in the expenditure distribution, we observe that stylized fact 2 holds at income decile level.[31]

Those results show that when we split consumption between tradable and non-tradable across the income distribution, then not only relative prices explain differences. For instance, the higher decline in non-tradable consumption of the first and last income deciles is not explained only by relative prices. However, income drops and higher non-tradable than tradable income elasticity are better candidates.

Stylized fact 4. Expenditure share in tradable decreases across the income distribution. Moreover, expenditure share in tradable increases, which changes more for higher-income households. Expenditure shares are estimated as the portion of total expenditures dedicated to tradable goods. In this case, the denominator is tradable plus non-tradable expenditure.[32] The expenditure share is grouped by household income group. Total expenditure in good j per each household income decile is $e_{jd,t} \equiv \sum_{h \in \mathcal{I}_{d,t}} e_{jh,t}$, where $e_{jh,t}$ is expenditure in good or service j, per household h of income decile d in period t.

Figure 7 shows the expenditure share in tradable goods per income deciles. Panel (a) presents the level of expenditure shares in tradable for 1994 and 1996. A striking fact that appears is that low-income households hold a larger portion of expenditure on tradable goods. Moreover, this difference is considerable. In 1994, the first income decile destinated close to 76% expenditure on tradable goods, and it declined monotonously until the highest income decile spent about 42%. Moreover, this negative relationship was maintained after the devaluation in 1996.[33] It implies that Engel curves are non-linear across households with different income levels and reveals the presence of non-homotheticities in this economy.[34]

Panel (b) of Figure 7 shows the change in expenditure share in tradable goods after the 1996 devaluation. Notably, Stylized fact 2 is maintained at a household level as for any income decile expenditure share in tradable goods increases. We can observe in Panel (b) that the first and last deciles present a higher increase than other deciles.

[31] Consumption inequality is explored in more detail in Appendix A.3.

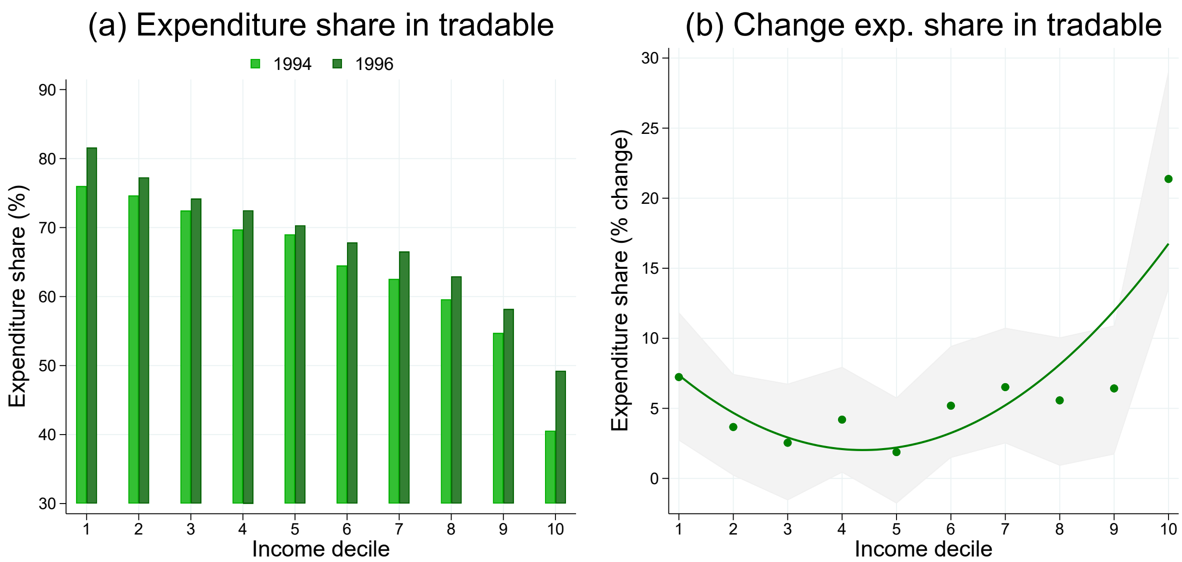
[32] It implies that expenditure share in tradable directly reflects patterns in expenditure share in non-tradable.

[33] Appendix A.5 discusses expenditure share in tradable in alternative economic crises in Mexico with a devaluation lower than 30% as was the case for the Global Financial Crisis 2008 and the most recent COVID-19 crisis for each income quintile. Consistently across time, low-income households spend more on tradable goods than high-income households. Moreover, in every crisis episode, expenditure share in tradable increases.

[34] Engel curves can be traced as how consumption of certain goods changes when income changes or expenditure share changes when income changes. In this economy, both cases hold, as it is revealed by stylized facts 3 and 4.

The underlying factor that motivates this decline is a higher drop in consumption of non-tradable. Then, between deciles 2 and 9, the expenditure share in tradable changes between 1994 and 1996 differs across the income distribution, and high-income households increase by more.

Figure 7: Expenditure share in tradable per household income decile in Mexico, 1994-1996



Note: Panel (a) shows expenditure share in tradable per household income decile in 1994 and 1996. Panel (b) shows the percentage change between 1994 and 1996 in expenditure share in tradable per household income decile. The shaded gray area in Panel (b) corresponds to 90% confidence intervals, estimated using bootstrap with 1000 replications.
Source: ENIGH-INEGI.

Then, we take a formal analysis of the change in expenditure share in tradable goods across household income. First, we evaluate if the expenditure share increases after the devaluation, i.e., we evaluate stylized fact 2 at the household level. Then, we test if, across different income levels, we observe a different level of change.

We measure the effect of the devaluation on expenditure share by doing a diff-in-diff analysis, and we compare this result across households with different income levels. Our baseline specification is the following regression,

$$ExpShare_{Th,t} = \beta_0 Post_t + \beta_1 Income_{q,t} + \beta_2 Post_t \times Income_{q,t} + \Gamma X_{h,t} + \epsilon_{hj,t} \tag{3}$$

Where $ExpShare_{Th,t}$ is expenditure share in tradable goods for household h in period t, $Post_t$ denotes a dummy variable to identify the devaluation, and $X_{h,t}$ are household-level characteristics that include, age, gender, education, household size, and employment sector. $Income_{q,t}$ corresponds to household income quintile dummies, and the first quintile is skipped, so results are compared to that income group. The identification assumption is that absent the devaluation, we should not observe a significant increase in expenditure shares in tradable goods. Then, controlling by household level characteristics, income level reflects exposure to shock.

Table 1 shows the regression results. Column (1) evaluates if the expenditure share in tradable goods increases after the devaluation, so income level is not considered. The results confirm Figure 7 and stylized fact 2 at the household level, i.e., after the devaluation, expenditure share in tradable goods increases, and it is statistically significant. Column (2) evaluates the hypothesis that expenditure share changes across different income quintiles. The results confirm the observation in Figure 7 Panel (a) that expenditure share in tradable goods decreases as the income level increases.

Then, columns (3) and (4) evaluate the hypothesis that expenditure share in tradable changes differs across households' income quintiles. The results in column (3) do not control for the income quintile, and they reveal that higher-income households had lower expenditure shares in 1996 than income quintile 1, and this difference broadens monotonically. Then, column (4) shows how the expenditure share changes by income quintile compared to low-income households. The results exhibit the same pattern as Figure 7 Panel (b) as expenditure share for the fifth income quintile is not significantly different from the first quintile. In the case of quintiles 2, 3, and 4, the increases in expenditure shares are significantly lower than quintile 1, with a U-shape trend. The minimum increase in expenditure share is in quintile 3.[35]

Previous results reveal a fundamental identification problem in economic models with heterogeneous households in multisector economies. If we want to reconcile the decreasing expenditure share in the tradable observed across income deciles, homothetic CES preferences underdetermine the system of equations. Moreover, as we showed, if expenditure shares change over time, we require even more information to determine the system of equations.[36]

To reconcile the stylized fact 4 we will use non-homothetic CES preferences. The idea is that we require that expenditure share in tradable changes across income deciles, and these preferences go over that direction.[37] Even better, they can also help obtain changes in expenditure share across time at the decile level. In addition, non-homothetic CES gives the additional freedom we require to reconcile the inconsistency between stylized facts 1 and 2, as we discussed previously.[38]

[35] As robustness, we tried with income decile, and it reveals the same patterns as the income quintile.

[36] To make a sharp difference, we can think about low b_L^T versus high-income households b_H^T. Under CES preferences, in level $b_L^T = b_H^T = \omega_T^\sigma \left(\frac{P^T}{P}\right)^{1-\sigma}$, or in differences $d\ln b_L^T = d\ln b_H^T = (1-\sigma)(d\ln P^T - d\ln P)$. So, in a model with two sectors and two households, we can not identify the observed stylized fact 4 in level or differences unless we account for additional parameters to incorporate income changes.

[37] An additional extension comes from assuming an elasticity of substitution changing across the income distribution. In this case, we recover a similar result. See Auer et al. (2022).

[38] Note that the implication of stylized fact 4 differs from cross-sector findings in the literature on structural change. In that case, the aggregate economy under a representative agent is assumed, and expenditure shares change smoothly over the decades (Comin et al. , 2021). In our case, considerable shocks changing relative prices and relative income across households over business cycle frequencies produce changes in expenditure shares differently across households, and that produces the identification problem in multisector economies with heterogeneous households.

Table 1: Expenditure share across household income group

	(1)	(2)	(3)	(4)
$Post_t$	0.0398***	0.0375***	0.1474***	0.0558***
	(0.0040)	(0.0037)	(0.0062)	(0.0095)
Quintile 2		-0.0449***		-0.0324***
		(0.0062)		(0.0103)
Quintile 3		-0.0860***		-0.0684***
		(0.0062)		(0.0099)
Quintile 4		-0.1351***		-0.1235***
		(0.0063)		(0.0102)
Quintile 5		-0.2290***		-0.2258***
		(0.0068)		(0.0109)
Quintile 2 $\times$ $Post_t$			-0.0525***	-0.0242*
			(0.0072)	(0.0124)
Quintile 3 $\times$ $Post_t$			-0.0977***	-0.0339***
			(0.0074)	(0.0122)
Quintile 4 $\times$ $Post_t$			-0.1384***	-0.0223*
			(0.0072)	(0.0123)
Quintile 5 $\times$ $Post_t$			-0.2229***	-0.0061
			(0.0075)	(0.0128)
Observations	18,917	18,917	18,917	18,917
Adj. R-squared	0.114	0.257	0.184	0.258

Note: This table shows the regression for equation (3) for expenditure share in tradable as dependent variable. It includes household-level control variables and population weights.

3 Model setup

This section presents a two-sector, tradable and non-tradable, small open economy Heterogeneous Agent New Keynesian model augmented with generalized non-homothetic CES preferences. This economy is an infinite horizon with incomplete markets that include households, firms, the financial sector, and the rest of the world. The model includes production in the non-tradable sector, and tradable is an endowment sector; this simplification is intended to keep the model as simple as possible and focus on the non-tradable sector. The model simulates the Mexican peso crisis in 1994, and the calibration is intended to match key elements of this episode.

3.1 Households

Households consume two types of goods: tradable and non-tradable. They save on domestic assets and assume the existence of borrowing constraints. Household heterogeneity comes from the uninsurable labor-income risk (see Auclert, Bardóczy, Rognlie and Straub (2021) for open economies and Kaplan et al. (2018) for closed economies). Household offers inelastically their labor force to the non-tradable sector and receive endowments from the tradable sector. A key assumption of this model is the existence of preferences characterized by generalized non-homothetic CES, where tradable and non-tradable goods and services are identified with a parameter that identifies income elasticity.

Consider an infinite horizon economy populated by a continuum of households with preferences over streams of consumption who face uninsurable labor-income risk in the form of productivity shocks e_{ht}, which follow a first-order Markov chain. The following function describes preferences,

$$\mathbb{E}_t \sum_t \beta^t v\big(\mathcal{C}_t(E_t; \mathbb{P}_t)\big) \tag{4}$$

where $\mathcal{C}$ is an increasing function of expenditure E_t given a vector $\mathbb{P}_t$ of prices, and function v is a standard CRRA function with parameter θ. Parameter β is a subjective discount factor within the interval $(0, 1)$.

It is assumed that the consumer divides expenditures between tradable $c_{hT,t}$ and non-tradable $c_{hN,t}$ consumption and has access to a domestically traded one-period, state non-contingent bond $a_{h,t+1}$ denominated in domestic currency, and are subject to borrowing limits $a' \geq \underline{\text{a}}$.

Then, consumer budget constraint is,

$$P_t^N c_{hN,t} + P_t^T c_{hT,t} + a_{h,t+1} = \big(1 + r_t\big)a_{h,t} + W_t n_{h,t} e_{h,t} + P_t^T Q_{h,t}^T e_{h,t} \tag{5}$$

where P_t^N is the price of non-tradable goods, P_t^T is the price of tradable goods. Households receive income from labor where W_t is the nominal wage in the non-tradable sector, $n_{i,t}$ hours worked that are supplied inelastically.

We assume that the Law of One Price holds at a good level so that $P^T = \mathcal{E}P^{T*}$, where $\mathcal{E}$ is the nominal exchange rate, and P^{T*} is foreign tradable price. Moreover, we assume that $P^{T*} = 1$, then $P^T = \mathcal{E}$. An additional assumption is that the tradable sector is endowment Q^T, and those are received for households as an additional income source proportional to labor income productivity.

Generalized Non-homothetic CES preferences are defined by,

$$1 = \omega_T^{\frac{1}{\sigma}} \mathcal{C}^{\frac{\gamma_T - \sigma}{\sigma}} c_T^{\frac{\sigma-1}{\sigma}} + \omega_N^{\frac{1}{\sigma}} \mathcal{C}^{\frac{\gamma_N - \sigma}{\sigma}} c_N^{\frac{\sigma-1}{\sigma}} \tag{6}$$

where it is assumed that $\omega_T + \omega_N = 1$ and both are weight parameters, and σ is elasticity of substitution. γ_T and γ_N are parameters that govern income elasticity in this economy. If both parameters equal one $\gamma_T = \gamma_T = 1$ then we are back to homothetic CES preferences. Associated expenditure function $E(.)$ for this preference is:

$$E_t(\mathbb{P}_t, \mathcal{C}_t) = \left[\sum_j \omega_j \mathcal{C}_t^{\gamma_j - \sigma} P_{jt}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{7}$$

This expenditure function satisfies that $E_t = P_t^N c_{N,t} + P_t^T c_{T,t}$. Therefore, the problem that solves household in this economy corresponds to

$$V_t(a, e) = \max_{\{c_T, c_N, a'\}} v(\mathcal{C}) + \beta \mathbb{E}_t V_{t+1}(a', e')$$

$$\text{s.t.} \quad P^N c_N + P^T c_T + a' \leq (1 + r)a + Wne + P^T Q^T$$

$$1 = \omega^{\frac{1}{\sigma}} \mathcal{C}^{\frac{\gamma_T - \sigma}{\sigma}} c_T^{\frac{\sigma-1}{\sigma}} + (1 - \omega)^{\frac{1}{\sigma}} \mathcal{C}^{\frac{\gamma_N - \sigma}{\sigma}} c_N^{\frac{\sigma-1}{\sigma}}$$

$$E = P^N c_N + P^T c_T$$

$$a' \geq 0$$

The solution to this problem implies that households differ in their level of spending, and they have heterogeneous consumption baskets. Moreover, optimality conditions imply that a household in the state (a, e) splits expenditure between tradable and non-tradable according to relative prices and an increasing transformation of income given for indirect utility $\mathcal{C}$.

3.2 Non-homothetic CES versus homothetic CES preferences

Expenditure share of good j for non-homothetic CES is:

$$b_{hjt} = \frac{P_{jt} c_{hjt}}{E_{ht}} = \frac{\omega_j \mathcal{C}_{ht}^{\gamma_j - \sigma} (P_{jt})^{1-\sigma}}{\sum_{j'} \omega_{j'} \mathcal{C}_{ht}^{\gamma_{j'} - \sigma} (P_{j't})^{1-\sigma}} = \frac{\omega_j \mathcal{C}_{ht}^{\gamma_j - \sigma} (P_{jt})^{1-\sigma}}{E_{ht}^{1-\sigma}} \tag{8}$$

We can linearize equation (8) such that a change in expenditure share for good j is:[39]

$$d \log b_{hj} = (1 - \sigma) \Bigg[\underbrace{\Big(d \log P_j - \mathbb{E}_b(d \log P_j) \Big)}_{\text{Price effect}} + \underbrace{\Big(\frac{\gamma_j - \sigma}{\mathbb{E}_b(\gamma - \sigma)} - 1 \Big) \Big(d \log E_h - \mathbb{E}_b(d \log P_j) \Big)}_{\text{Real income effect}} \Bigg] \tag{9}$$

[39]See Appendix B.2 for derivation.

Where for a given variable x_h, $\mathbb{E}_b(x_j) = \sum_j b_{hj} x_{hj}$. Now, we can compare it to the expenditure share of good j in standard homothetic CES:

$$b_{hjt} = \frac{P_{jt} c_{hjt}}{E_{ht}} = \frac{\alpha_j P_{jt}^{1-\sigma}}{\sum_{j'} \omega_j'^{\sigma} P_{j't}^{1-\sigma}} = \frac{\alpha_j P_{jt}^{1-\sigma}}{P_t^{1-\sigma}} \tag{10}$$

We can linearize equation (10) such that a change in expenditure share for good j is:

$$d \log b_{hj} = (1-\sigma) \underbrace{\Big(d \log P_j - d \log P \Big)}_{\text{Price effect}} \tag{11}$$

Three key differences arise from comparing homothetic and non-homothetic CES: First, there are no differences across households in standard homothetic CES.[40] So, we do not expect differences in expenditure shares across households. Second, no income-expenditure switching across goods ($\mathcal{C}^{\gamma_j - \sigma}$) or real income effect. This difference between non-homothetic and homothetic CES preferences produces an endogenous response across households, goods, and time.[41] Third, price effect changes across households in non-homothetic cases.[42]

3.3 Wage rigidities

The union sets a nominal wage W_{kt} to maximize the aggregate real utility with quadratic adjustment costs as in Rotemberg (1982). The problem of the union written recursively is:

$$V_t^L(W_{kt-1}) = \max_{W_{kt}, n_{kt}} \Big\{ \int u(\mathcal{C}_{ht}) - \nu(n_{ht}) d\Psi_{ht} - \frac{\mu_w}{\mu_w - 1} \frac{1}{2\kappa_w} \big[\log(1 + \pi_{kt}^w) \big]^2 N_t + \beta V_{t+1}^L(W_{kt}) \Big\}$$

It is assumed that each household produces a differentiated variety of labor services with productivity e_{ht}. Moreover, it is supposed that labor differentiated services n_{kt} are aggregated through a CES aggregator where μ_w is the elasticity of substitution across differentiated labor:

$$N_t = \left(\int_0^1 n_{kt}^{\frac{\mu_w - 1}{\mu_w}} dk \right)^{\frac{\mu_w}{\mu_w - 1}}$$

[40] Homothetic CES preferences can be modified to incorporate a set of household level taste shocks to recover heterogeneity such that α_{hj}. However, those estimated parameters do not endogenously change with income, and for differences across time, we require estimating additional sets of parameters.

[41] Instead of decomposing expenditure share changes, the same decomposition is possible for consumption c_{hjt} given in expenditure share. In this last case, as it is standard in microeconomic literature, price and income effect appears under homothetic CES preferences. However, in this case, under homothetic CES, every good j has the same real income effect equal to $d \log E - d \log P$, compared to non-homothetic CES that changes across goods.

[42] Note that elasticity of substitution is fixed across households. Auer et al. (2022) considers the most general case with the elasticity of substitution depending on the indirect utility.

The recruiting firm minimizes costs, given the aggregate level of labor to produce the demand for labor services:

$$n_{kt} = \left(\frac{W_{kt}}{W_t}\right)^{-\frac{\mu_w}{\mu_w - 1}} N_t$$

It is defined labor wage inflation and aggregate adjustment costs as:

$$\pi_{kt}^w = (1+\pi_t)\frac{W_{kt}}{W_{kt-1}} - 1$$
$$\phi_t^w = \frac{\mu_w}{\mu_w - 1}\frac{1}{2\kappa_w}\left[\log(1+\pi_{kt}^w)\right]^2 N_t$$

Finally, given the demand for labor services n_{kt}, symmetry of labor and wages, $n_{kt} = N_t = 1$, $W_{kt} = W_t$, and $U' = \int u(\mathcal{C}_{it})d\Psi_{it}$, then the New-keynesian Phillips curve for wages is:

$$\log(1+\pi_t^w) = \kappa_w\left(\varphi - W_t U_t'/\mu_w\right) + \beta\log(1+\pi_{t+1}^w)$$

3.4 Firms

3.4.1 Final good producer's firm

A representative final good firm aggregates a continuum of domestic intermediate goods y_{jt} with prices P_{jt}^N through a CES technology:

$$Y_t = \left(\int_0^1 y_{jt}^{\frac{\mu-1}{\mu}} dj\right)^{\frac{\mu}{\mu-1}} Y_t$$

Cost minimization implies that given aggregate demand Y_t for intermediate good j, then y_{jt} and the aggregate price P_{Nt} correspond to:

$$y_{jt} = \left(\frac{P_{jt}^N}{P_t^N}\right)^{-\mu} Y_t$$
$$P_t^N = \left(\int_0^1 (P_{jt}^N)^{1-\mu} dj\right)^{\frac{1}{1-\mu}}$$

3.4.2 Intermediate good's firm

It is assumed that intermediate good producers in the non-tradable sector set prices subject to adjustment costs, as Rotemberg (1982). The problem of the firm can be written recursively:

$$V_t^F(P_{jt-1}^N) = \max_{y_{jt}, P_{jt}^N, n_{jt}} \left\{\frac{P_{jt}^N}{P_t^N} y_{jt} - \frac{W_t}{P_t^N} n_{jt} - \frac{\mu}{\mu-1}\frac{1}{2\kappa}\left[\log(1+\pi_{Nt})\right]^2 Y_t + \frac{V_{t+1}^F(P_{jt}^N)}{1+r_{t+1}}\right\}$$
$$\text{s.t.} \quad y_{jt} = Z_t n_{jt}$$
$$y_{jt} = \left(\frac{P_{jt}^N}{P_t^N}\right)^{-\frac{\mu}{\mu-1}} Y_t$$
$$\phi_t^F = \frac{\mu}{\mu-1}\frac{1}{2\kappa}\left[\log(1+\pi_{Nt})\right]^2 Y_t$$

Notice that the production function of the firm is set as $y_{jt} = Z_t n_{jt}$, and it is subject to the demand from final good producers. The adjustment cost parameter is κ and scaled up with μ. The problem of the firm is solved by choosing prices P^N_{jt}, and it produces the New-Keynesian Phillips curve:

$$\log(1+\pi_{Nt}) = \kappa\Big(\frac{W_t}{P^N_t Z_t} - \frac{1}{\mu}\Big) + \frac{1}{1+r_t}\frac{Y_{t+1}}{Y_t}\log(1+\pi_{Nt+1})$$

Notice that the aggregate dividend (d_t), given aggregate labor demand (N_t) of the firm is:

$$d_t = Y_t - \frac{W_t}{P^N_t}N_t - \frac{\mu}{\mu-1}\frac{1}{2\kappa}\big[\log(1+\pi_{Njt})\big]^2 Y_t \tag{12}$$

3.4.3 Financial sector

The financial sector closely follows across the lines of Auclert, Bardóczy, Rognlie and Straub (2021) and assumes complete capital flow mobility across countries. A risk-neutral domestic mutual fund issues claims to households with aggregate value A_t and can invest in four types of financial assets non-tradable firms, domestic and foreign shares, nominal domestic and foreign bonds.

Non-tradable domestic firms' shares are in positive supply in this economy. Real dividends were defined by equation (12), and firms have a unit mass of outstanding shares with end-of-period price p_t. Firms' objective is to maximize firm value $d_t + p_t$, and the return is $(p_{t+1}+d_{t+1})/p_t$. Domestic nominal bonds have an interest rate equal to i_t. Foreign nominal bonds have interest rates equal to i^*_t, and it is assumed to be exogenous. It will be perturbed to simulate the exchange rate devaluation in our simulation exercise.

The mutual fund objective is maximizing the (expected) real rate of return r^p_{t+1}. It implies a portfolio choice indeterminacy, as the four assets should have the same expected return. Free capital mobility also implies that the Uncovered Interest Parity condition holds:

$$1 + i_t = (1 + i^*_t)\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \tag{13}$$

Moreover, ex-ante real interest rate in the spirit of the Fisher equation is:

$$1 + r_t = (1 + i_t)\frac{P_t}{P_{t+1}} \tag{14}$$

Finally, domestic return on firm shares and ex-post return on the mutual fund are related by

$$1 + r_t = 1 + r^p_{t+1} = \frac{p_{t+1} + d_{t+1}}{p_t} \tag{15}$$

Net foreign asset position (NFA_t) is defined as the difference between assets accumulated domestically A_t, and the value of domestic assets in positive net supply p_t, so that $NFA_t = A_t - p_t$.

3.5 Monetary policy

The central bank sets the nominal rate i_t with a standard Taylor rule based on producer prices,

$$i_t = r_{ss} + \alpha_\pi \pi_t + \epsilon_t$$

As it is standard $\alpha_\pi > 1$ with $\pi_t = \frac{P_t}{P_{t-1}} - 1$

3.6 Equilibrium

Given exogenous processes for foreign interest rate, supply of foreign bonds, external demand, initial distribution of households Ψ_0, and an initial allocation of the mutual fund portfolio, a competitive equilibrium in the small open economy is given by a sequence of prices $\{P_{Nt}, P_{Tt}, \mathcal{E}_t, P_t, W_t, i_t, r_t, r_t^p, p_t\}$, and aggregate allocations $\{A_t, Y_t, C_t, C_{Nt}, C_{Tt}\}$, distribution Ψ_t and a path of policies for households $\{c_{Tt}(a,e), c_{Nt}(a,e), c_t(a,e), a_{t+1}(a,e)\}$ such that: Given prices, wages, and interest rates households optimize. Given prices, wages, and interest rates firms optimize. Distribution Ψ_t is consistent with consumption, labor supply, and bond demand policies. Labor, asset, and non-tradable markets are in equilibrium. The law of one price and uncovered interest parity condition holds. Notice that aggregate policy functions and distribution correspond to the following:

$$\mathcal{C}_t = \int \mathcal{C}_t(a,e) d\Psi_t(a,e) \tag{16}$$

$$\mathcal{A}_t = \int a_t(a,e) d\Psi_t(a,e) \tag{17}$$

$$\mathcal{N}_t = \int e n_t(a,e) d\Psi_t(a,e) \tag{18}$$

$$\Psi_{t+1}(\mathcal{A}, e') = \int \Pi(e,e') \Psi_t(a,e) \tag{19}$$

The appendix B.3 shows that the balance of payment gives the equilibrium in the external sector:

$$NFA_{t+1} = \frac{P_t^T}{P_t}(Q_t^T - C_{T,t}) + (1+r_t) NFA_t$$

where we define net exports as $NX_t = \frac{P_t^T}{P_t}(Q_t^T - C_{T,t})$.

Equilibrium in the domestic non-tradable market is given by:

$$Y_t = C_{N,t} + \phi_t^F \tag{20}$$

3.7 Assumptions discussion

As shown in the empirical section, according to the Mexican economy and during large contractionary devaluations, the economy presents characteristics associated with non-homotheticities. Three empirical observations allow us to understand why this type of preference is required in this economy. First, the empirical observation that relative changes in consumption of tradable and non-tradable are not closely connected to relative prices as expected with homothetic CES preferences leads to require an additional underlying factor affecting relative consumption that we associate with income elasticities different for tradable and non-tradable. Second, expenditure share in tradable goods decreases monotonically across households as income level increases. Under homothetic preferences and given a price level, we expect to observe the same level of expenditure share in tradable goods independently of the income level. Finally, after the devaluation, the expenditure share in tradable increases for every income decile, and this change varies across households' income distribution. This observation provides stronger identification for non-homotheticities as it implies the existence of non-homotheticities at the household level.

The model does not incorporate production in the tradable sector. The objective of this assumption is to isolate potential compensation or amplification of the effects of the tradable on the non-tradable sector. It is well-known that external adjustment during sudden stops produces a faster recovery in this sector related to increased sales from the devaluation. Moreover, by incorporating production in the tradable sector, we need to account for access to foreign funding (Neumeyer and Perri , 2005) or imported inputs (Blaum , 2022) on the production side. This characteristic can compensate for the competitivity gain from the devaluation. Ultimately, the final result will depend on price pass-through and the elasticity of demand for tradable products.

Nominal wage and price rigidities are present in this economy. Both rigidities help to transmit the nominal shock to the real economy. The aim of incorporating nominal wage rigidities is the exclusion of a strong adjustment in income to the household to compensate for the decrease in purchasing power. Moreover, large evidence shows that wages are downwardly nominal rigid (Schmitt-Grohé and Uribe , 2016). Regarding nominal price rigidities, the objective is to control relative price changes and avoid abrupt changes in relative prices. Moreover, this assumption is aligned with the literature that finds an incomplete exchange rate pass-through to prices (Burstein et al. , 2007).[43]

Finally, another assumption is associated with the exchange rate regime. In our baseline model, we assume that nominal exchange rates float, as was the case when devaluation started in Mexico in 1994. Below we conduct a counterfactual analysis to evaluate the implications of this assumption when there is a "fear of floating".

3.8 Calibration

The model simulates the Mexican peso crisis in 1994, and the calibration is intended to match key elements of this episode. Income elasticity parameters are essential to non-homothetic CES preferences, so we discipline those parameters directly from data. There are micro and aggregate moments that the model is targeting. Expenditure share in tradable is the most notable characteristic trying to reproduce for 1994 at the aggregate and micro levels. The Mexican economy in 1994 presented high cross-section income dispersion across households, reflected in consumption level heterogeneity. So, we match the income process to be consistent with micro-consumption dispersion and according to the emerging market characteristics.

[43] Our results are robust to price rigidities assumption. See the discussion below.

Income elasticities and elasticity of substitution. We use the Mexican devaluation episode to estimate the associated income elasticity parameters for non-tradable and tradable (γ_N and γ_T) and the elasticity of substitution. A well-known estimation problem to estimate simultaneously those parameters in the literature is to set a base sector (Comin et al. , 2021). As a robustness, we follow two alternative calibration strategies. First, estimate a single regression of expenditure share between non-tradable and tradable using instrumental variables. Second, estimate expenditure in tradable and non-tradable at a higher level of disaggregation in 35 categories of goods and services using as a base sector their mean (Borusyak and Jaravel , 2021).

The first estimation strategy uses expenditure share in non-tradable and tradable at a household level. It uses equation (8) to construct an empirical counterpart to estimate income elasticity and elasticity of substitution consistently. The challenge is that we need to define a baseline sector to estimate relative income elasticity parameters.[44] In our case, as we have only two sectors, we assign the tradable sector as the base sector. The empirical model corresponds to the ratio between non-tradable and tradable in equation (8) as follows,

$$\ln\left(\frac{b_{hNt}}{b_{hTt}}\right) = \ln\left(\frac{\omega_{hN}}{\omega_{hT}}\right) + (\gamma_N - \gamma_T)\ln(\mathcal{C}_{ht}) + (1-\sigma)\ln\left(\frac{P_{hNt}}{P_{hTt}}\right) + \varepsilon_{ht} \tag{21}$$

where b_{hNt}, b_{hTt} represents expenditure share in non-tradable and tradable, P_{Nt}, P_{Tt} represents prices in non-tradable and tradable, $\ln(\omega_{hN}/\omega_{hT})$ represents relative taste shock at a household level. Specific household characteristics will approximate household-level taste shock. The main assumption is that it is a linear approximation and time-invariant to household characteristics given by age, household size, and income preceptors. Moreover, we control for the region and municipality to control for potential aggregate consumption shocks.

Indirect utility $\mathcal{C}_{ht}$ is approximated by real total monetary expenditure. One concern related to expenditure from empirical consumption literature is measurement error (Aguiar and Bils , 2015). To deal with this, we use as an instrument total household income and the economic sector where household heads work. Household-level prices can suffer from a similar problem. As robustness, we instrument prices by using prices at a product level in Chile during the same period because this is a Latin-American country that did not suffer from the large devaluation simultaneously.

Table (2) reports estimation results. Column (1) shows results without considering instrumental variables. The first row presents the difference between income elasticity for non-tradable and tradable, equal to 0.6. A similar estimated coefficient is obtained considering population weights. The elasticity of substitution is 0.43, and with population weights, it increases to 0.6. Column (3) considers instrumental variables for real total monetary expenditure and excludes education and sector of activity as a control variable; column (4) again incorporates those controls. The difference in income elasticity increases to 0.77 and 0.67 if we do not consider population weights. The elasticity of substitution is 0.66 and 0.5. Column (5) considers population weights with similar results to the previous columns. Finally, column (6) considers instrumental variables for real total monetary expenditure and prices, and the results remain stable.[45]

An alternative strategy is to disaggregate tradable and non-tradable at a lower level and consider 35 goods and services. In this case, the base sector is the average across

[44] Structural change literature has assumed an economy with three sectors and assigned one sector as

Table 2: Estimation income elasticities and elasticity of substitution

	(1)	(2)	(3)	(4)	(5)	(6)
$\gamma_N - \gamma_T$	0.5996***	0.6149***	0.7694***	0.6713***	0.6748***	0.6794***
	(0.0132)	(0.0183)	(0.0127)	(0.0163)	(0.0226)	(0.0168)
$1 - \sigma$	0.5724***	0.4003***	0.3434***	0.5083***	0.3390***	0.2209**
	(0.0639)	(0.0858)	(0.0631)	(0.0643)	(0.0872)	(0.0963)
Observations	17,403	17,403	17,403	17,403	17,403	17,403
Weights	N	Y	N	N	Y	N
Adj. R-squared	0.290	0.299	0.276	0.289	0.298	0.287

Note: Relative expenditure share for non-tradable and tradable is the dependent variable. This regression includes as control variables household head age, household size, income recipients, location, education, and activity sector. Column (3) excludes the education and activity sectors. Columns (2) and (5) include population weights. Columns (3)-(6) include instrumental variables as described in the main text. All columns include robust standard errors in parenthesis.

those 35 goods and services. Then, with those results, we can rank and split them between tradable and non-tradable. Again, we start from equation (8), then taking the difference to the mean across goods and services we have,

$$\ln(b_{hjt}) - \overline{\ln(b_{ht})} = \ln(\omega_{hj}) - \overline{\ln(\omega_h)} + (\gamma_j - \overline{\gamma}) \ln(\mathcal{C}_{ht}) + (1-\sigma)(\ln P_{hjt} - \overline{\ln P_{ht}}) + \hat{\varepsilon}_{ht} \tag{22}$$

where variables with an overline denote the average across goods and services. So, we estimate this single OLS equation for 35 goods and services separately. Every equation follows a similar estimation strategy as previously. We consider the same control and instrumental variables.[46]

Table (3) reports estimation results. Columns (1) and (2) show results without and considering instrumental variables. Panel A presents tradable categories ranked by income elasticity in column (2). In the first row *Bread* presents the lowest income elasticity, and *Recreation eq.* the highest one. Panel B presents non-tradable categories. In the first row *Similar to restaurant* presents the lowest income elasticity, and *Educ. non-degree* the highest one. In comparative terms, non-tradable, on average, is larger than tradable. Considering instrumental variable income elasticity for non-tradable in column (2) is 0.15 versus tradable with -0.18. Then, the results using this second strategy

a base, typically the manufacturing sector (Comin et al. , 2021).

[45]Our results are consistent with Comin et al. (2021), which estimates an elasticity of substitution of about 0.3. The elasticity of agriculture is close to 0.2, and for services, it is close to 1.65. So, even if we consider the upper bound income elasticity in our estimation close to 0.8, it is still conservative compared to Comin et al. (2021).

[46]The optimal strategy would be to estimate a GMM system of equations with a common elasticity of substitution across goods and services. However, as consumption bundles are heterogeneous across households, it is not possible at this level of disaggregation.

Table 3: Estimation income elasticities for tradable and non-tradable

Item	**Coef. OLS** (1)	**Coef. IV** (2)
A. Tradable		
Bread	-0.4502***	-0.5298***
Gas	-0.3754***	-0.3693***
Fruits, vegetables	-0.2881***	-0.3372***
Non-alc. beverage	-0.2341***	-0.2496***
Diaries	-0.1865***	-0.2083***
Food outside	-0.2658***	-0.1982***
Pharmaceutical	-0.1545***	-0.1707***
Alc. beverage	-0.1952***	-0.1652***
Gasoline	-0.1800***	-0.1072***
Meat and fish	-0.0565***	-0.0406***
Electric appl. other	0.0617***	0.0972***
Recreation eq.	0.1585***	0.1184***
Avg. Tradable	-0.1805	-0.1800
B. Non-tradable		
Similar to restaurant	-0.2000***	-0.1800***
Domestic serv.	-0.1666***	-0.1225***
Transportation repair	-0.0910***	-0.0275
Transportation	-0.0179	0.0042
Water	-0.0537***	0.0230**
Rent	0.0638**	0.0908***
Other serv.	0.0720***	0.1099***
Medical serv.	0.1809***	0.1298***
Education, degree	0.1651***	0.1859***
Restaurant	0.1567***	0.2336***
Recreation	0.2619***	0,3651***
Communications	0.2512***	0.3740***
Clothing serv.	0.2651***	0.4197***
Educ. non-degree	0.4219***	0.4511***
Avg. Non-tradable	0.0935***	0.1469***

Note: Relative expenditure share to the mean is the dependent variable. This regression includes as control variables household head age, household size, income recipients, and location. Column (1) denotes the estimated coefficient for real total monetary expenditure without considering instrumental variables. Column (2) denotes the estimated coefficient for real total monetary expenditure considering instrumental variables described in the main text. Columns (1) and (2) include population weights. All columns include robust standard errors. ***, **, * corresponds to statistical significance to 1%, 5%, and 10%.

complement the first one and confirm that the income elasticity of non-tradable is larger than that of tradable.

Calibrating expenditure share and consumption level dispersion. At the aggregate level, the objective is to reproduce the expenditure share of tradables for Mexico in 1994. At the household level, we intend to match expenditure share at the income decile that starts at 75% for low-income and goes until 41% for high-income households. Moreover, we target total consumption dispersion across households that starts at 4% of total consumption for low-income and 28% for high-income households.

Income processes are calibrated following HANK open economy literature. It is assumed that labor income follows an AR(1) process with persistence ρ_s 0.97 and innovations with a standard deviation σ_s of 0.75. Although those parameters are calibrated to match micro-moments of expenditure share and consumption dispersion, those closely follow the HANK open economy literature (see Auclert, Bardóczy, Rognlie and Straub (2021), Guo et al. (2023), Hong (2023). The income productivity process is discretized into a seven-point Markov chain via the Rouwenhorst method. Tradable endowment is given to households proportionally to their labor productivity. It is not allowed to borrow $\underline{a} = 0$.

Remainder household-level parameters are taken directly from the HANK literature or internally calibrated. Risk aversion θ equals 2 (McKay et al. , 2016). The annual interest rate is assumed to be 5%. Weight parameters in non-homothetic CES preferences are assumed to sum up to one. The weight parameter ω and discount factor β are internally calibrated equal to 0.82 and 0.8 to target previously described micro-moments.

Figure 8 panel (a) summarizes our calibration results for expenditure share in tradable goods. As was indicated, low-income households spend almost three-quarters of their income on tradable goods. Then, there is a decreasing pattern until high-income households with 41%. The results show that our model closely follows that pattern of expenditure share in tradable across the income distribution due to the flexible structure of non-homothetic CES. In contrast, the homothetic CES structure follows a horizontal line in the aggregate level of the expenditure share of 63%.

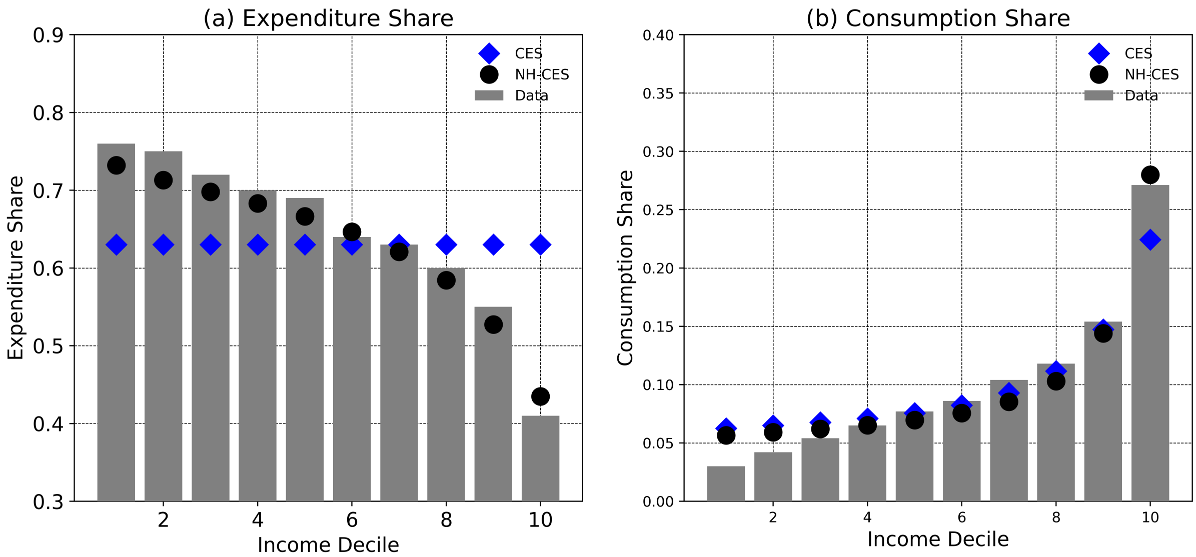
Figure 8 panel (b) summarizes our calibration results for the proportion of consumption in total across households with different income levels. As was indicated, low-income households in the first income decile consume 3% of the aggregate consumption and high-income 30%. This consumption pattern is monotonous across households with increasing income levels. The results in our calibrated model closely follow the inequality pattern observed in the data. Although the tenth decile shows a non-linear higher increase, our model can reproduce it. In contrast, the homothetic model struggles with the high inequality observed in high-income levels.[47]

Remainder aggregate calibration. The calibration of the parameters closely follows the current HANK open economy literature. It takes some parameters directly from the

[47]MPCs are not targeted in our model. Appendix A.6.1 reports MPCs for our baseline calibration and compares them with MPCs estimated for emerging markets by Hong (2023) and reported by Auclert, Rognlie, Souchier and Straub (2021). Our results are consistent with magnitude orders and replicate high and low incomes in emerging markets. Note that our model includes only one asset and no discount factor heterogeneity; including those characteristics would allow us also to capture wealthy hand-to-mouth households (see Kaplan et al. (2014), and Kaplan et al. (2018)).

literature, and others are internally calibrated to match micro and macro moments (see Table 4). On the supply side, the markup of intermediate firms μ equals 1.05, and the slope of the price and wage Phillip curves κ and κ_w equals 0.9 and 0.85, respectively.

Figure 8: Comparison of steady-state between homothetic and non-homothetic CES and observed data in Mexico 1994



Note: Panel (a) shows expenditure share in tradable. It compares the steady-state for homothetic CES (blue diamond) and non-homothetic CES (black circle) models under the baseline calibration with observed expenditure share in tradable in Mexico 1994 per income decile. Panel (b) shows the total consumption share of household income decile with aggregate total consumption. It compares the steady-state for homothetic CES (blue diamond) and non-homothetic CES (black circle) models under the baseline calibration with observed total consumption share in Mexico 1994.
Source: ENIGH-INEGI.

4 Simulation Results

4.1 Revisiting Mexican devaluation in 1994

The main experiment of interest is the devaluation episode in Mexico in 1994. Among other factors, one of the main triggers for the devaluation episode was a sudden increase in the U.S. Federal Funds rate by 75 basis points from 4.75 to 5.5.[48] In our model, we interpret this as an increase of 15% in foreign interest rate from 5% to 5.75%. Our interest is in analyzing the evolution of aggregate consumption of tradable and non-tradable and expenditure share in tradable to contrast them with empirical evidence presented

[48]A large literature has associated an increase in foreign interest rate with economic fluctuations in emerging markets. For instance, among others, Neumeyer and Perri (2005) and Uribe and Yue (2006).

Table 4: Parameter in baseline calibration

Parameter Name	Symbol	Baseline Values
Households		
Income elasticity non-tradable	γ_N	1.5
Income elasticity tradable	γ_T	0.7
Elasticity of substitution	σ	0.4
Weight parameter	ω	0.82
EIS	θ	2
Borrowing limit liquid asset	$\underline{a}$	0
Autocorrelation of earnings	ρ_s	0.97
Standard deviation of log-earnings	σ_s	0.77
Points in Markov chain for s	n_s	7
Discount factor	β	0.8
Firms and union wage		
Frisch elasticity	ν	0.13
Markup	μ	1.05
Slope Wage-Phillips curve	κ_w	0.85
Slope Phillips curve	κ	0.9

earlier. Then, we compare our baseline non-homothetic CES with the homothetic CES model.

Our model incorporates two key elements that make the computation of transition dynamics particularly difficult. First, household heterogeneity represented by idiosyncratic income risk and borrowing constraints, and second, non-homothetic CES preferences. To tackle those challenges, the solution method for dynamic transitions relies on extending the first-order linear approximation around the aggregates proposed by Auclert, Bardóczy, Rognlie and Straub (2021). This methodology is a fast and accurate computation method for models with aggregate shocks and heterogeneous agents. An essential characteristic of this approximation method is that it preserves the nonlinearities related to idiosyncratic income risk and borrowing constraints, and non-homothetic CES preferences.[49]

Figure 9 shows dynamic transitions for consumption of non-tradable, and tradable a 15 % increase in foreign interest rate. Results in panel (a) show a stark contrast between the model with non-homothetic CES and homothetic CES preferences. As was predicted for our model, the former exhibits a significant decrease of 15%, while the last one reacts in the opposite direction with a 1% increase over impact that goes until a 10% increase in the third quarter. This difference between both types of preferences is mainly related to different income elasticities corresponding to a higher income elasticity for non-tradable consumption.

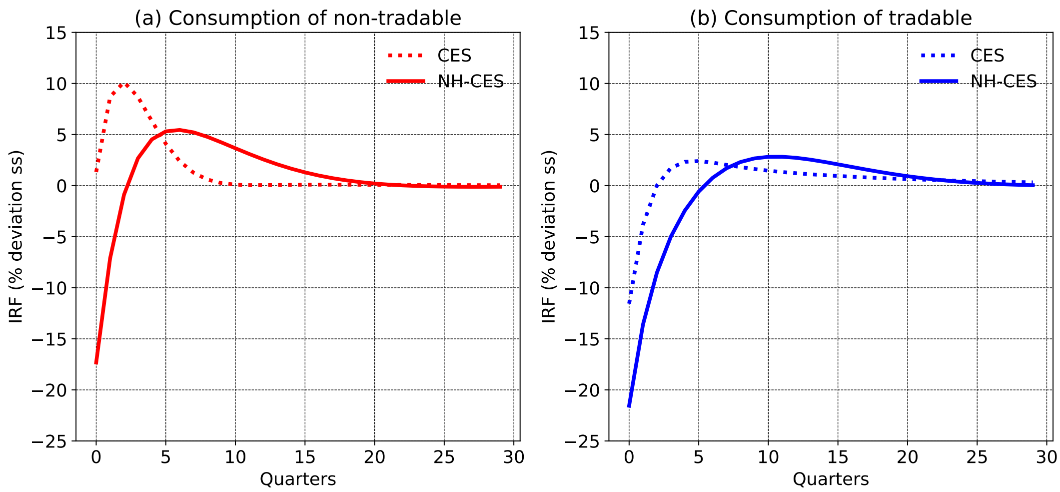
Panel (b) shows the result for tradable consumption. As was expected in both cases,

[49]See Appendix B.5 for additional details of the solution method.

with and without homotheticities, consumption decreases due to the high price effect induced during a devaluation. What is different in this case is that non-homothetic CES preferences produce an additional amplification over the impact with an 8% additional decrease. Although we are calibrating the initial shock for what was observed in the foreign interest rates in 1994, our stylized model produces a decrease in consumption of non-tradable and tradable very close to the micro-data of consumption.

Figure 10 shows the results for expenditure share in tradable goods. It was shown previously that both models are expected to produce a positive response after the foreign shock, although a slightly lower increase for non-homothetic CES over impact. Altogether, the results in Figure 9 and Figure 10 are consistent with the empirical findings discussed previously, i.e., non-tradable consumption can fall as much as tradable, while expenditure share is still increasing. We have to remark that income elasticities used in our baseline calibration are a lower bound for what literature uses.[50]

Figure 9: Tradable and non-tradable consumption responses

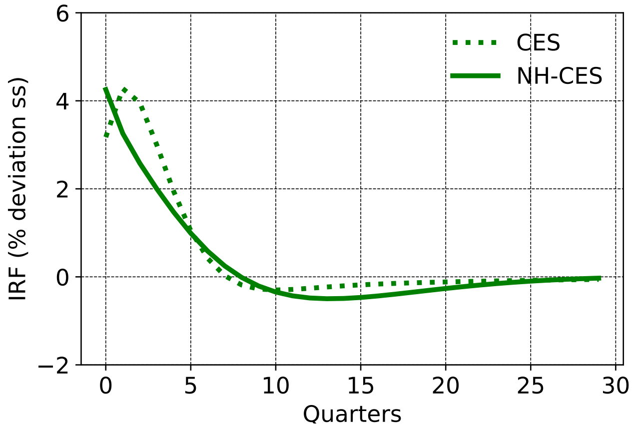


Note: Impulse response of consumption in non-tradable and tradable homothetic CES (dotted line) and non-homothetic CES (continuous line) model to 15% increase in foreign interest rate.

Figure 11 shows the dynamics for other relevant variables in the model. Panel (a) shows the relative price of tradable to non-tradable. The increase in relative prices reflects the exchange rate pass-through of devaluation to the price of tradable and price rigidity assumed in the non-tradable sector. Note that the figure shows the relative price of tradable to non-tradable, which is why it increases more in the CES model. An important result observed in Panel (b) is that net export increases, consistent with the empirical observation of a current account reversal observed in sudden stop episodes, consistent with the external adjustment during those episodes. In our model, the tradable sector is assumed to be an endowment, so this is the result of a decrease in tradable consumption and devaluation. Finally, panel (c) shows the response of real wages in the non-tradable sector. This variable decreases more in the non-homothetic model,

[50] As it was discussed in our calibration section, Comin et al. (2021) use a difference between income elasticities of services and agriculture equal to 1.15, and in Rojas and Saffie (2022) is 4. Our baseline calibration uses a difference between non-tradable and tradable equal to 0.8.

Figure 10: Expenditure share in tradable responses



Note: Impulse response of expenditure share in tradable in the homothetic (dotted line) and non-homothetic CES (continuous line) model to 15% increase in foreign interest rate.

indicating a higher real wage sensitivity and income effect that impact purchasing power in the non-tradable sector. This result shows how an initial shock that affected the tradable sector had a higher impact on the non-tradable sector.[51]

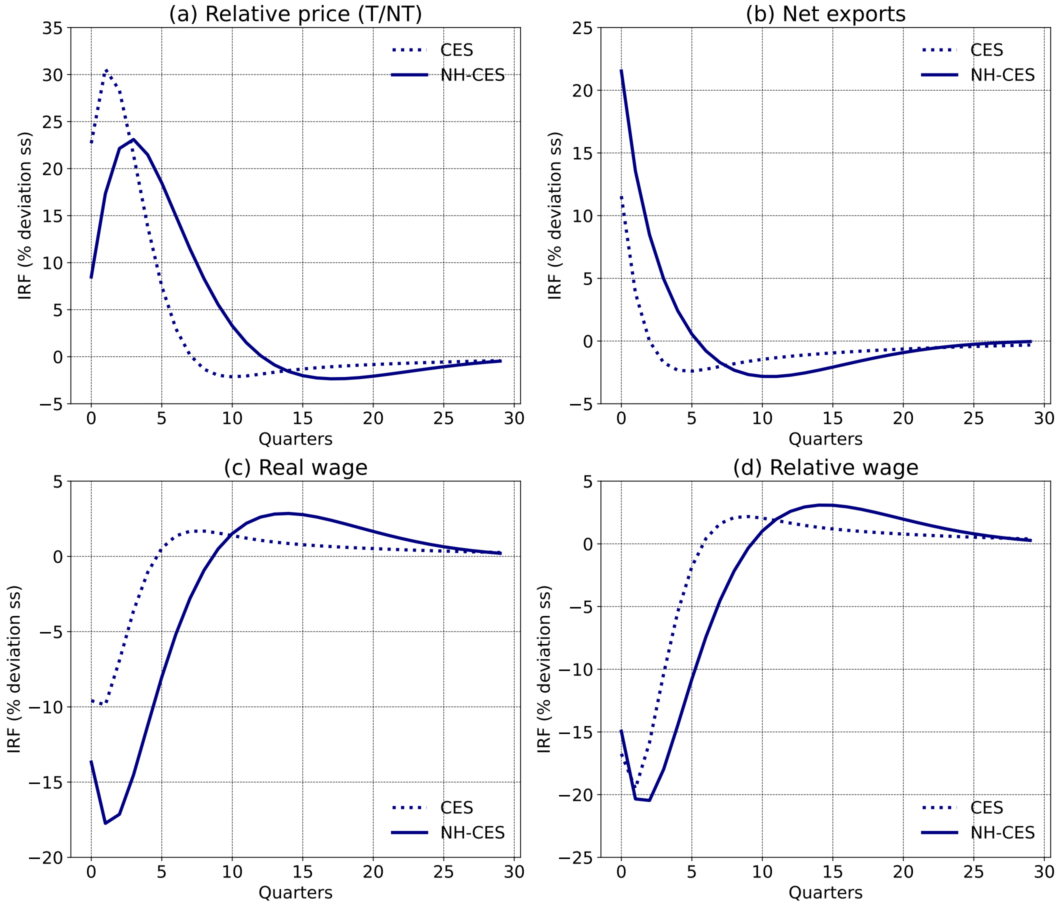
An additional remark is associated with the relevance of the income channel that is present in the heterogeneous agent model. To emphasize this, we compare our previous results to representative agents in a small open economy model. In Appendix A.6.3, we replicate Figure 9, and 10 for a representative agent model with homothetic CES preferences. The results show that non-tradable consumption increases until 7%, and expenditure share increases until more than 4%, as was observed in the heterogeneous agent model. An important difference is related to tradable consumption with a lower decrease of 5%. We still observe the current account reversal, although a higher relative decline in non-tradable prices compensates for the exchange rate devaluation. Those results emphasize the importance of considering heterogeneous households to account for observed patterns in consumption. Particularly, the relevance of the income channel in the heterogeneous agent model amplifies the decrease in tradable consumption.

5 Inspecting the mechanisms and additional exercises

In this section, we implement different exercises to explain the relevance of the elements in the model and to understand the underlying mechanisms present in our previous results. The first exercise shows how non-homothetic CES preferences generate asymmetric intersectoral spillovers. Then, we decompose changes in domestic consumption at the household and aggregate levels to show the relevance of heterogeneity in amplifying the decrease in consumption. Finally, we show the implications of a monetary authority actively responding to a foreign interest rate increase, i.e., ”fear of floating.”

[51] In Appendix A.6.4, we show the sensitivity of our result to less rigid non-tradable prices. Our original results are held, with minor changes in relative prices and a higher decline in non-tradable consumption for non-homothetic CES case.

Figure 11: Foreign interest rate, relative prices, net exports, and real wage responses



Note: Impulse response of relative prices (tradable to non-tradable ratio), net exports, real wage, and relative wage (nominal wage to nominal exchange rate) in the homothetic CES (dotted line) and non-homothetic CES (continuous line) model to 15% increase in foreign interest rate.

5.1 Asymmetric intersectoral spillovers

This section shows how non-homothetic CES preferences generate asymmetric intersectoral spillovers. We show this first in a simplified version of the quantitative model developed in Section 3, assuming a representative agent model. Then, we show that this result generalizes to our heterogeneous agent framework.[52]

5.1.1 Asymmetric intersectoral spillovers in a simplified framework

This section develops a simplified version of the quantitative model in Section 3, assuming a representative agent model. The model is a representative agent small open economy model augmented with NH-CES preferences. It follows a simplified version

[52]This idea is similar to Keynesian supply shock by Guerrieri, Lorenzoni, Straub, and Werning (2022) in a multisector closed economy. The key difference is that in an open economy framework, the tradable sector can export domestically unsold goods; however, the non-tradable sector has a bottleneck if the domestic economy is depressed.

of Schmitt-Grohé and Uribe (2016).

Consider an economy populated by a representative household with the same preference structure and discount factor as in Section 3. The objective function is characterized by the utility function in equation (4).

It is assumed that the consumer divides expenditures between tradable C_t^T and non-tradable C_t^N consumption and has access to an internationally traded one-period, state non-contingent bond A_t^* denominated in foreign currency.[53] Non-homothetic CES preferences are assumed to be the same as in previous sections and determined by equation (6). Then, consumer budget constraint is

$$P_t^N C_{N,t} + P_t^T C_{T,t} + \mathcal{E}_{t+1} A_{t+1}^* = (1 + r_t^*)\mathcal{E}_t A_t^* + W_t N_t + P_t^T Q_t^T + \Pi_t^N \tag{23}$$

where P_t^N is the price of non-tradable goods, P_t^T is the price of tradable goods, $\mathcal{E}_t$ is the nominal exchange rate, W_t is nominal wage in the non-tradable sector assumed downwardly rigid, N_t hours worked, and Π_t^N nominal non-tradable firms profit. In the case of tradable prices, it is assumed that the law of one price holds, and the foreign tradable price is the numeraire, such that

$$P_t^T = \mathcal{E}_t P_t^{T*} = \mathcal{E}_t \tag{24}$$

Household optimality conditions under the previous assumptions correspond to choose sequences of $C_{N,t}, C_{T,t}, A_{t+1}^*$ that maximizes (4) subject to (6) and (23). Then, intratemporal optimality condition implies that

$$\frac{P^N}{P^T} = \left(\frac{\omega_N}{\omega_T}\right)^{\frac{1}{\sigma}} \left(\frac{C_{T,t}}{C_{N,t}}\right)^{\frac{1}{\sigma}} \mathcal{C}_t^{\frac{\gamma_N - \gamma_T}{\sigma}} \tag{25}$$

Equation (25) determines the demand schedule of this economy. If $\gamma_N = \gamma_T = 1$, we are back to the homothetic CES case. However, as we previously show, the empirically relevant case is $\gamma_N > \gamma_T$.

Again, we assume that only the non-tradable sector has production, as the tradable sector is an endowment Q_t^T. Non-traded output is y_t^N and is produced by a competitive firm using technology $F(h_t)$. The firm's optimality condition implies that the non-tradable price is set as

$$P_t^N = \frac{W_t}{F'(h_t)} \tag{26}$$

The supply schedule in this economy comes from this pricing condition, as we are not assuming non-tradable price rigidities. Rearranging condition (26), then we have

$$\frac{P^N}{P^T} = \frac{W_t/\mathcal{E}_t}{F'(F^{-1}(y_t^N))} \tag{27}$$

Using equations (25) and (27), we can characterize the equilibrium in this economy. The first result is that there is an amplification of external shocks in non-homothetic CES when compared with homothetic CES. In equilibrium, under a sudden stop originated by an increase in foreign interest rate, there's a higher decrease in relative wages

[53] We use internationally traded bonds as a simplifying assumption. This assumption is commonly used in sudden-stop representative agent literature (Bianchi and Mendoza , 2020).

$\tilde{w} \equiv W/\mathcal{E}$ if $\gamma_N > \gamma_T$ under a non-homothetic CES economy compared to a homothetic. Moreover, under the previous assumption, there is a higher decrease in non-tradable output compared to the homothetic case. This new result shows how the original foreign shock is amplified through the economy.

Proposition 1 (Amplification of foreign shocks) *If $\gamma_N > \gamma_T$, in an economy characterized by equilibrium conditions described previously, a negative foreign shock produces a higher decrease in relative wages in a non-homothetic economy compared to a homothetic case.*

$$\frac{\frac{\partial \tilde{w}^{NH-CES}}{\partial r^*}}{\frac{\partial \tilde{w}^{CES}}{\partial r^*}} = 1 + (\gamma_N - \gamma_T)\frac{\partial \log \mathcal{C}_t}{\partial \log E}\frac{\partial \log E}{\partial \log C^T} \tag{28}$$

Moreover, a negative foreign shock produces a higher decrease in non-tradable output in a non-homothetic economy compared to a homothetic case under downwardly rigid nominal wages.

Proof. See Appendix B.4.1.

The intuition for Proposition 1 is as follows. A negative shock to foreign interest rates decreases the households' purchasing power of tradable goods originated by the devaluation. It acts as a demand shifter, contracting relative demand for tradable goods. When there are non-homotheticities, an additional channel associated with income elasticities and real income enhances the original effect and feedback through total household demand. The contraction in demand depresses non-tradable prices and affects wages. As a result, real income drops more under the non-homothetic case. Finally, depressed demand, lower non-tradable prices, and market equilibrium in the non-tradable sector determine a higher decline in production.[54]

Figure 11 panel (d) shows the ratio of nominal wage to exchange rate for our model with homothetic CES and non-homothetic CES. The decrease in relative wages is more significant than real wages. It also shows that, as it was indicated in Proposition 1 non-homothetic CES shows a larger decline due to our assumption of $\gamma_N > \gamma_T$. Relative wages in our quantitative model incorporate nominal wage rigidities. Given that external shock affects relative prices on the demand side, wage rigidities determine that the non-tradable sector requires adjusting wages by more, which is not possible due to downwardly rigid nominal wage rigidities.

The second result is associated with how a foreign shock is transmitted across sectors, so it is related to the propagation mechanism. When households present homothetic preferences, the income effect associated with a sectoral shock is symmetric across goods, as they all have the same income elasticity. However, under non-homothetic preferences, this result is no longer true, and income elasticities shape an asymmetric household response. In equilibrium, heterogeneous decreases in consumption produce a differential impact on the production side of the economy. Consequently, relative wage response is asymmetric depending on the economic sector where a shock originated. We call this propagation mechanism asymmetric intersectoral spillovers. The following proposition summarizes it.

[54] Rojas and Saffie (2022) shows amplification of relative prices and tradable consumption decline in an endowment economy with collateral constraints. They interpret a tradable endowment shock as a sudden stop. Our general result in Appendix B.4.2 shows that our result also extends to endowment shock.

Proposition 2 (**Asymmetric intersectoral spillovers**) *In an economy characterized by equilibrium conditions described previously, if we compare non-homothetic and homothetic CES preferences in the representative agent model, we have*

1. *If $\gamma_N \neq \gamma_T$, asymmetric spillovers between sectors.*
2. *If $\gamma_N > \gamma_T$, an external shock originally affecting the consumption of tradables produces a higher response (amplification) of relative wages under non-homothetic compared to homothetic preferences.*
3. *If $\gamma_N > \gamma_T$, a shock originally affecting the consumption of non-tradable produces a lower response of relative wages under non-homothetic in comparison to homothetic preferences.*

Proof. See Appendix B.4.2.

Applying Proposition 2 to the Mexican devaluation in 1994 allows us to understand how household consumption allocation reinforced this economic crisis. Initially, there is a foreign shock that devalues the exchange rate and depresses the consumption of tradable goods. This contraction induces a higher-than-expected change in relative wage. It decreases non-tradable output higher in magnitude than the homothetic case due to $\gamma_N > \gamma_T$. Proposition 2 indicates that if the original shock had originated in the non-tradable sector, the adjustment process through the tradable sector would have been less painful. This proposition can be an additional argument for why negative foreign shocks are so damaging in emerging markets with open economies.

5.1.2 Amplification and asymmetric intersectoral spillovers with heterogeneous agents

This section returns to our original quantitative framework with heterogeneous households and non-homothetic CES preferences to show that Proposition 1 and Proposition 2 still hold under this general setup.

Proposition 3 (**Amplification and asymmetric spillovers with heterogeneous agents**) *In an economy characterized by equilibrium conditions described in Section 3 with heterogeneous agents, if we compare non-homothetic and homothetic CES preferences in the representative agent model, then points 1., 2. and 3., in Proposition 2 still hold.*

Proof. See Appendix B.4.3.

When comparing non-homothetic with homothetic CES preferences, we have the relative results for a representative agent still holds under the most general case of heterogeneous agents. However, in absolute terms, the response under both results differs from the representative agent. Under heterogeneous agents, the sector-level aggregate consumption response is affected by different elements that can amplify or dampen the response; for instance, intertemporal substitution changes across sectors, sector-level marginal propensities to consume appear, and expenditure shares are also relevant.

5.2 Amplification of consumption changes across households

In this section, we study the transmission of shock across households. To do this, we return to our heterogeneous agent economy in Section 3, and we extend the consumption decomposition by Auclert (2019) by incorporating a two-sector open economy with non-homothetic CES preferences. We show that a sufficient statistic that allows measuring the additional impact across households of non-homotheticities is given by the interaction between MPCs and expenditure shares.

Proposition 4 (Consumption decomposition) *Assume a two-period version endowment economy of the model described in Section 3 and generalized non-homothetic CES preferences. A first-order perturbation in foreign interest rates produces the following response in consumption of good j for household h.*

$$
\begin{aligned}
d\ln c_{hj} = & \underbrace{MPC_{hj}\Big(dP^N\big(\hat{Y}_h^N\big) + P^N\big(d\hat{Y}_h^N\big) + dP^T\big(\hat{Y}_h^T\big) + P^T\big(d\hat{Y}_h^T\big)\Big)}_{\text{Income channel}} \\
& + \underbrace{MPC_{hj}\big(\hat{a}_h^R\big)d\ln P^N}_{\text{Fisher channel}} + \underbrace{MPC_{hj}\big(P_{t+1}^N\hat{a}_{ht+1}^R\big)d\ln R}_{\text{Interest rate exposure}} \\
& - \underbrace{MPC_{hj}\big(b_{hj}d\ln P^j\big)}_{\text{Expenditure channel}} + \underbrace{\sigma\big(b_{hj}-1\big)d\ln P^j}_{\text{Price Substitution}} - \underbrace{\hat{\sigma}_{hj}M\hat{P}S_h d\ln R}_{\text{Intertemporal Substitution}} \qquad (29)
\end{aligned}
$$

Proof. See Appendix B.4.4.

Proposition 4 is a generalization to non-homothetic CES preferences of Auclert (2019) first-order approximation of consumption change per household h. The first term on the right-hand side is the income channel associated with changes in real income and valuation of income. The second line corresponds to all wealth-related components in this decomposition, and we denominate fisher channel and interest rate exposure similar to Auclert (2019).[55] In this case, non-homothetic CES preferences modify those terms only through interaction with sector-specific MPCs.

The third line shows modifications associated with the structure of the economy. The expenditure channel is the interaction between sectoral MPCs, expenditure shares, and prices. Expenditure shares were defined in equation (8) and differ across households. A novel result is that expenditure share changes across households and weighs sectoral prices accordingly under non-homothetic CES preferences. In contrast, expenditure shares are equal across households under homothetic preferences, so only scale up or down the MPCs. This new term produces additional amplification in consumption decrease when price increases. The second term is the price substitution effect, which also changes across households and allows us to understand the pricing impact directly across consumers. The last term is the intertemporal substitution; this component differs from the standard case with homothetic CES preferences as it now also changes across goods and time and is affected by income elasticities and expenditure shares.

To gain additional intuition about the implications of incorporating non-homothetic CES and the interaction with households facing idiosyncratic income shocks to analyze

[55] Refer to Auclert (2019) for a complete analysis of these effects. Appendix B.4.4 shows the derivation.

the economy at the aggregate level, we construct sectoral and aggregate consumption change. Proposition 5 explores this result.

Proposition 5 (Aggregation) *Assuming conditions in Proposition 4 are satisfied. The following expressions define aggregate sectoral consumption change $d\ln C_j$ and aggregate total consumption change $d\ln C$:*

$$d\ln C_j = \sum_h \omega_h d\ln c_{hj}$$
$$d\ln C = \sum_j b_j \sum_h \omega_h d\ln c_{hj}$$

where $E_h = \omega_h E$ corresponds to the income share of the household in total income across all households, and b_j is the aggregate expenditure share in good j. For aggregate sectoral consumption change $d\ln C_j$, we have:

$$\begin{aligned} d\ln C_j = {} & \mathbb{E}_h\Big[MPC_j\Big(P^N\big(d\hat{Y}^N\big) + P^T\big(d\hat{Y}^T\big) + dP^N\big(\hat{Y}^N\big) + dP^T\big(\hat{Y}^T\big)\Big)\Big] \\ & + \mathbb{E}_h\big[MPC_j\hat{a}^R\big]d\ln P^N + \mathbb{E}_h\big[MPC_j P^N_{t+1}\hat{a}^R_{t+1}\big]d\ln R \\ & - \mathbb{E}_h\big[MPC_j b_j\big]d\ln P^j + \sigma\mathbb{E}_h\big[b_j - 1\big]d\ln P^j - \mathbb{E}_h\big[\hat{\sigma}_j M\hat{P}S\big]d\ln R \end{aligned} \tag{30}$$

Proof. See Appendix B.4.5.

Proposition 5 characterizes the consumption change aggregate responses for sectoral consumption and aggregate consumption.[56] The first term in the third line in Equation (30) is new and only appears under non-homothetic preferences in multisector economies because it requires that b_{hj} changes across households. This term characterizes the amplification of consumption changes associated with the interaction between heterogeneous expenditure shares and MPCs. Moreover, this is complemented with associated terms discussed in Proposition 4 that are modified by non-homothetic CES preferences, particularly sector-level MPCs that now depend on differences in income elasticities and sector-level intertemporal substitution.

The new interactive term associated with the expenditure channel is economically significant. We found that the interaction term $\mathbb{E}_h\big[MPC_j b_j\big]$ associated with the expenditure channel is positive for both tradable and non-tradable for this period, characterizing also positive covariances, amplifying the decrease in consumption produced by the price increase. Estimating the economic significance of this term requires the estimation of MPCs. For Mexico 1994, we approximate them through consumption-income elasticities.[57] This interaction for aggregate consumption is estimated at 0.46 in Mexican data. To put it into perspective, we compare it to the price substitution effect in Equation (30). Assuming a price elasticity of substitution σ equal to 0.5, the estimated price substitution is 0.23.[58] In consequence, in relative terms, in the data, this new term can

[56] Appendix B.4.5 shows the full decomposition for $d\ln C$.

[57] Guntin et al. (2023) show that consumption-income elasticities can approximate MPCs in this type of episode.

[58] Expenditure share for tradables in Mexico in 1994 was 63%, and it determines the weight for relative price substitution between non-tradable and tradable.

be more important than price substitution to explain changes in consumption. As this term complements price substitution, this generates additional amplification in consumption decline. As we previously indicated, our model does not target the estimation of MPCs.[59]. This interactive term in our model is 0.18, i.e., about 80% of the price substitution effect. Overall, those results show the economic relevance of the interaction of non-homothetic CES preferences and household heterogeneity to explain changes in consumption.

5.3 Fear of floating

Many emerging markets are reluctant to let the exchange rate float when external shocks affect the economy. In their seminal paper Calvo and Reinhart (2002) finds that countries that intend to float actually do not, which they call "fear of floating." The critical question for monetary authorities is associated with the trade-off of higher interest rates to fight exchange rate devaluation or allow the exchange rate to float freely to shift demand towards domestic goods. In this subsection, we analyze this concern by modifying the baseline assumption of a Taylor rule without considering the response to the exchange rate and analyzing the impact on consumption.

Our baseline model considers a central bank actively responding to inflation. However, if the monetary authority also cares about the exchange rate, the nominal interest rate can also respond to movements in this variable. The augmented Taylor rule considered now is

$$i_t = r_{ss} + \alpha_\pi \pi_t + \alpha_\mathcal{E} \pi_{\mathcal{E}t} + \epsilon_t$$

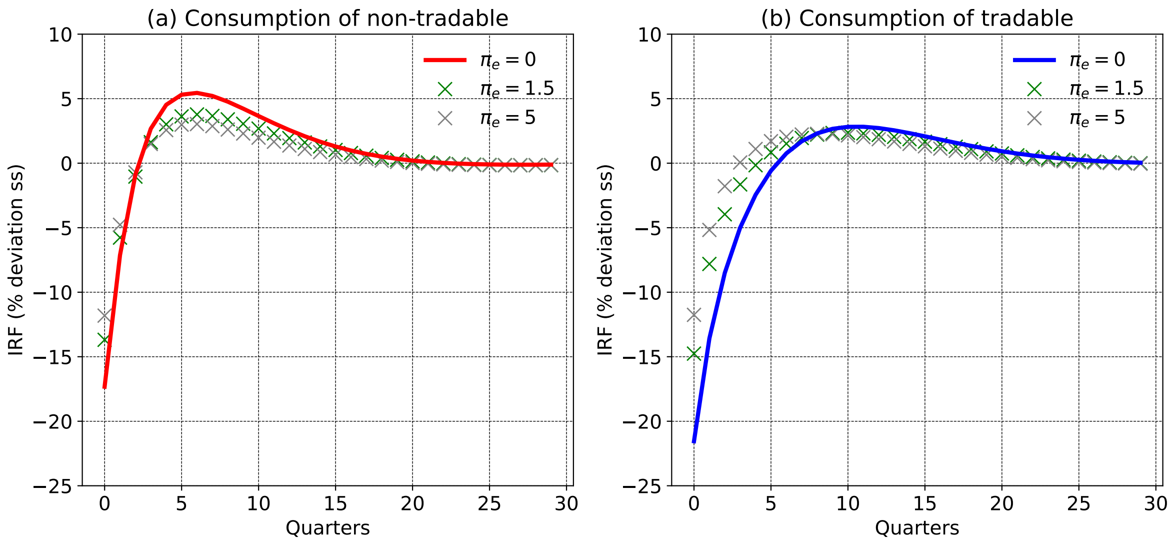
Where $\pi_\mathcal{E} = \frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} - 1$, and the strength of the response to exchange is governed by $\alpha_\mathcal{E}$. If $\alpha_\mathcal{E} = 0$ we are back to the baseline calibration. Higher $\alpha_\mathcal{E}$ is associated with a stronger interest rate response with the limiting case of fully answering this variable and fixing the exchange rate.

Figure 12 shows consumption response for non-tradable and tradable under fear of floating. This exercise shows that controlling exchange rate devaluation can decrease consumption decline.[60] When the central bank controls the exchange rate response, household consumption is less affected. Moreover, if we compare the response of non-tradable versus tradable, tradable consumption decline is more dampened as it directly depends on real exchange rates. This exercise shows that although under the assumptions in this model, the monetary authority can control the exchange rate, a foreign increase in interest rate still affects domestic consumption due to contractionary domestic monetary policy response.

[59]See the discussion in Section 3.8. In Appendix A.6.2 we show sector-level MPCs in our model. An important result is associated with non-tradable MPCs. Given our calibration, high-income levels have higher MPCs.

[60]A similar result has been found by Zhou (2022), when households have assets and debt in foreign currency.

Figure 12: Consumption response to fear of floating



Note: Impulse response of consumption to 15% increase in foreign interest rate when monetary authority responds to nominal exchange rate fluctuations. $\alpha_e = 0$ is our baseline calibration (solid line), and it increases until $\alpha_e = 1.5$ (green crosses), $\alpha_e = 5$ (gray crosses).

6 Conclusions

In this paper, we study massive drops in consumption of non-tradable and tradable associated with large contractionary devaluation episodes. We show that during those episodes, the tight connection between the relative consumption of tradable and non-tradable and relative prices is broken as non-tradable consumption presents a considerable decrease similar to tradable. This result is mainly explained by high-income households that experienced a significant non-tradable consumption decline. Moreover, we provide evidence that expenditure share in tradable is lower for higher income households, which also concentrate expenditure on non-tradable. This evidence points toward non-linear Engel curves.

Then, we build an open economy framework with heterogeneous agents and non-homothetic CES preferences. We show that non-homothetic CES preferences are an essential mechanism to explain the propagation to the non-tradable sector of shocks originating in the tradable sector through household consumption decisions. It also provides an additional rationale for high involuntary unemployment over those episodes. In addition, we provide evidence, on top of the real income channel existent in Heterogeneous Agent New Keynesian models (Auclert, Bardóczy, Rognlie and Straub , 2021), through a sufficient statistic of amplification in consumption decline produced by the interaction between heterogeneous expenditure share across households and MPCs.

An important result from this analysis is that households can be a significant source of the propagation of external shocks through allocation decisions. Compared to homothetic CES preferences and assuming higher non-tradable income elasticity, when a shock starts from the tradable sector, the relative price changes more than when it starts from the non-tradable. This asymmetric response in relative prices also implies an asymmetric response in consumption. This result is an important step toward understanding why shocks that originated abroad can be so devastating in emerging economies and raises questions about how to avoid this and about optimal monetary and fiscal policy. This analysis also warns about the relevance of labor market rigidities. Those concerns are left for future research.

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A Appendix

A.1 Data description

A.1.1 Aggregate data

In the empirical section, we use aggregate annual data for consumption growth rate, GDP growth rate, nominal exchange rate, and different consumption categories to analyze Iceland, Mexico, and Thailand. In this section, we describe the main sources and definitions for those variables.

In the cases of consumption growth rate, GDP growth rate, and nominal exchange rate, the source is the World Development Indicators of The World Bank. The consumption growth rate corresponds to the annual percentage growth of household and NPISHs final consumption expenditure based on constant local currency. The GDP growth rate corresponds to the annual percentage growth rate of GDP at market prices based on constant local currency. The nominal exchange rate corresponds to the official exchange rate local currency unit (LCU) per USD, period average. The period of the event is indexed to each country's devaluation, where the period is set to zero for Iceland in 2007, for Mexico in 1994, and for Thailand in 1996.

Regarding tradable and non-tradable consumption, data comes from the COICOP international classification reported by the OECD (Iceland and Mexico) or the Central Bank of Thailand. The real consumption index in Mexico and Iceland are at 2015 constant prices, and for Thailand, it is chain volume with the reference year 2002. In the case of expenditure, share expenditure at current prices is used. Finally, tradable goods correspond to non-durable classification according to COICOP, which also includes some tradable services, such as electricity and gas, and non-tradable corresponds to services according to this classification. This classification is used to make the different countries comparable and is compatible with the classification used by Bank of Mexico for tradable and non-tradable.

The selection of the cases Iceland, Mexico, and Thailand are based on higher exchange rate devaluation and significant economic effects in terms of consumption and output. We start from Burstein and Gopinath (2013) that document 10 cases of large devaluation in emerging and advanced economies between 1990-2010. 6 Out of 10 episodes have a devaluation higher than 40% in 12 months. The cases with available data are Iceland, Korea, Mexico, and Thailand. During episodes with a lower devaluation with available data, it is not true that both stylized facts appear simultaneously, as a strong real income decline is required for this effect associated with different income elasticities to appear. Korea is not considered in the analysis.

A.1.2 Survey data

The income and expenditure household survey data for Mexico corresponds to *Encuesta Nacional de Ingresos y Gastos de los Hogares* (ENIGH) that is conducted by *Instituto Nacional de Estadística, Geografía e Informática* (INEGI) which is the Mexican national institute of statistics. The objective of this survey is to generate statistics on the amount, structure, and distribution of household income and expenses survey. This has been run continuously from 1992 until 2020 with a biannual frequency.[61] We use data between 1992-2020 with a focus on the 1994 and 1996 waves.

It is a representative sample at a national level and also of urban and rural areas. The 1994 survey wave was conducted between September 22nd and December 17th of 1994, and the 1996 survey wave was conducted between August 11th and November 16th of 1996. So, the time window is coherent with our analysis as it is just before devaluation started on 20th December 1994. The sample size was 14,380 and 16,403 households in 1994 and 1996, respectively. Then, we apply standard filters in consumption literature. We consider households with heads aged 25-60.

We consider the entire basket of goods and services consumed by Mexican households over this period. However, we split this sample among tradable and non-tradable goods and services.[62] Tradable goods included are non-durable consumption, among them food, non-alcoholic beverages, cleaning and personal care products, oil, gas, medical, and related education products. Non-tradable services included are non-durable services, among them food away from home, restaurants, domestic services, hotels, transportation services, car services, rent, water and electricity supply, health and communication services, and education. Those expenditures are deflated at a good level in October prices to be treated as consumption. This contrasts with Cugat (2018) and Guntin et al. (2023), who use aggregate prices to deflate.[63]

Another variable included in the empirical analysis is income. We consider monetary income as the relevant variable. It incorporates wages, other business, transfers received (including government transfers), income derived from assets, and other monetary incomes. Real income is nominal income deflated by the aggregate consumer price index. Other variables included in regressions are gender, age, and education of the household's head, household size, number of income perceptors, and region of residence.

A.2 Changes in consumption across goods distribution

This appendix studies consumption at a higher level of disaggregation of goods. The first exercise compares consumption decline across household income decile and opens up tradable in food and non-food and non-tradable in utility and non-utility. Then, the second exercise aggregates consumption per good across households per year and compares consumption decline per good across the distribution of tradable and non-tradable.

First, we explore the possibility of different household patterns in a higher disaggregation of tradable and non-tradable. We split the household income distribution across income deciles and then sum up consumption across households per each good

[61] The only exception was 2005, which was annual; that year is not our focus as it was not part of any economic crisis in Mexico.

[62] The classification between tradable and non-tradable follows the strategy in Cravino and Levchenko (2017) and Gagnon (2009), which follows the Bank of Mexico classification.

[63] Using aggregate prices to deflate consumption of tradable and non-tradable imposes a bias associated with the change in relative prices during a devaluation when calculating. For instance, between October 1994 and October 1996, non-tradable prices increased about 40% less than tradable. So, it attributes a higher drop to non-tradable. See Appendix A.2 for further discussion.

$c_{kd,t} \equiv \sum_{h \in \mathcal{I}_{d,t}} c_{kh,t}$, where $c_{kh,t}$ is the consumption for good or service k, for household h of income decile d. After that, we open up tradable in food and non-food goods, and non-tradable between utilities and non-utilities services. Then, we compare the synthetic cohorts across time, before and after the devaluation episode.

Figure 13 Panel (a) shows the results for opening up tradable between food and non-food. It reveals a declining pattern across the income distribution for both consumption drop in food and non-food. An important result is that consumption decline is lower for food in comparison to non-food. The lower decline in food is unrelated to price differences as they are not systematically different in this episode. Then, it is associated with differences in income elasticities between food and non-food, i.e., non-homotheticities. Earlier literature on structural change has treated this difference as the existence of a subsistence level in consumption that households can not avoid ((Herrendorf et al. , 2013)).

Non-tradable consumption is in Figure 13 panel (b). This figure shows a contrast between utilities and non-utilities. In the case of utilities, this figure shows that the declining pattern in consumption is similar to tradable as higher-income households decline in consumption more than low-income. In contrast, for non-utilities services from deciles 3 to 10, we observe a declining pattern as it was for tradable. Deciles 1 and 2 show a more considerable decline in consumption, similar to deciles 9 and 10. Therefore, panel (b) shows that the U-shape observed in Figure 6 is not coming from the decline in utilities consumption, and it is mainly motivated by non-utilities.

Second, we examine the idea that empirical observation in stylized fact 3 comes from specific goods and services by analyzing the distribution of goods aggregated through households. We sum up consumption per good and year across households to measure aggregate consumption change per good or service between 1994 and 1996. Then, we split the distribution of goods and services between tradable and non-tradable. Moreover, in this exercise, we show the relevance of using different price product levels of aggregation to measure consumption change across goods.

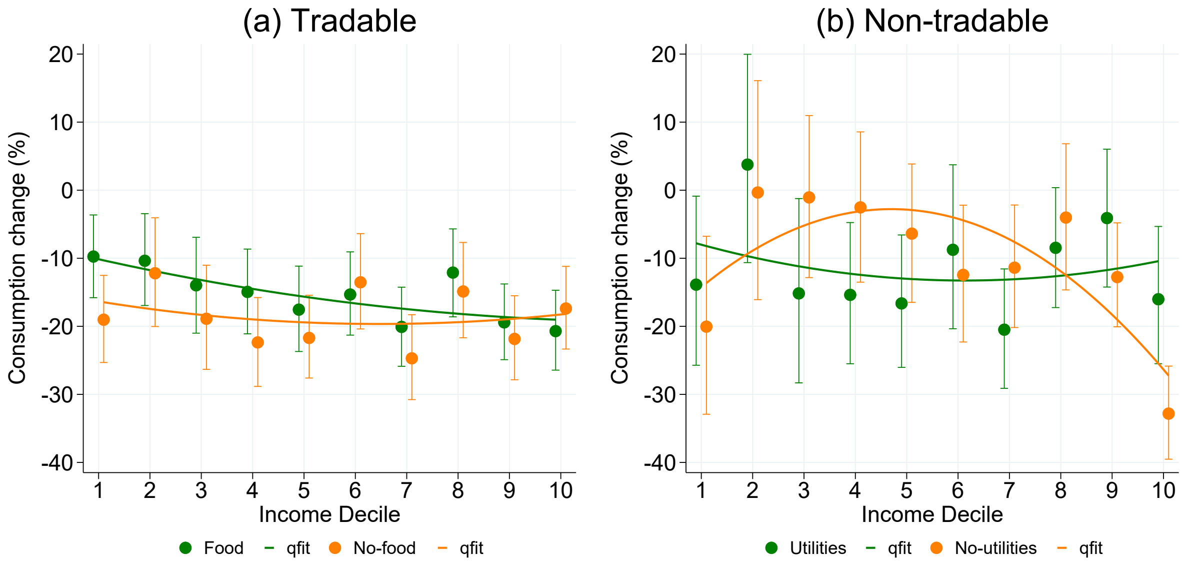
Figure 14 Panel (a) shows the results when we deflate expenditure for the aggregate consumer price index (CPI). The results indicate that the median across tradable and nontradable are quite different. The median of non-tradables is below the lower quartile of tradables. Moreover, the dispersion of changes is higher for non-tradable.

Finally, Figure 14 Panel (b) shows the results when we deflate expenditure for the price of each good or service in the consumer bundle. This is the Benchmark deflator we used in the empirical section because this is the most conservative way to show our results. The results indicate that the median tradable is slightly lower. The dispersion of changes is higher for non-tradable, with a decline at the same magnitude for the third quartile of tradable and non-tradable. These results reveal that stylized fact 1 was observed across different categories of goods. Moreover, it shows that deflators for expenditure used in previous exercises are a lower bound for stylized facts 3.

A.3 Consumption inequality for tradable and non-tradable goods

In this appendix, we describe higher moments of household-level expenditure distribution data to account for consumption inequality and concentration in tradable and non-tradable goods. We present evidence that higher income households highly con-

Figure 13: Household consumption change for main components in tradable and non-tradable per household income decile in Mexico, 1994-1996



Note: Panel (a) shows the percentage change in household consumption for tradables by dividing it between food and non-food components between 1994 and 1996 per household income decile. Panel (b) shows the percentage change in household consumption for non-tradable by dividing it between utility and non-utility components between 1994 and 1996 per household income decile. The shaded gray area corresponds to 90% confidence intervals, estimated using bootstrap with 1000 replications.
Source: ENIGH-INEGI.

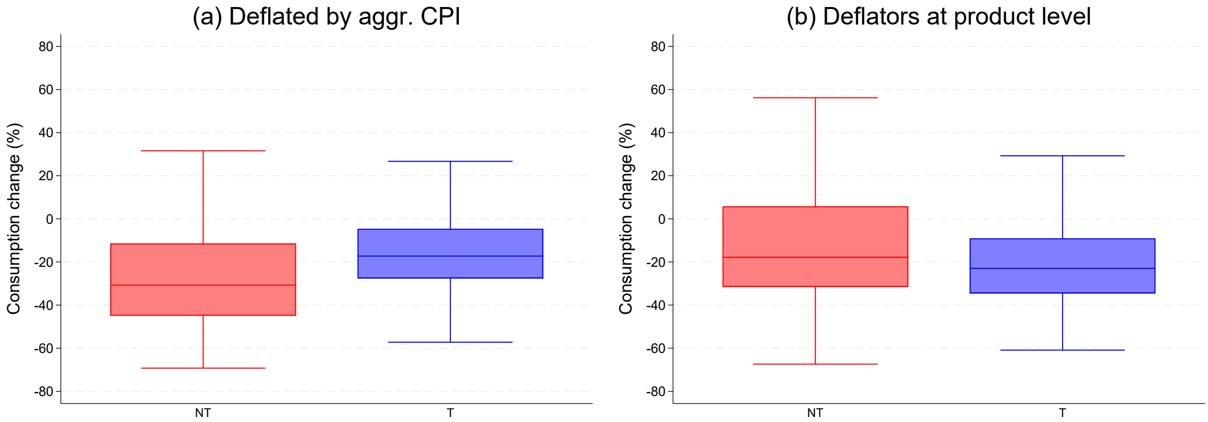
centrate expenditure on non-tradable.

Table 5 shows the portion of total expenditure for households in different income deciles, and then the total expenditure is split by tradable and non-tradable goods in 1994 and 1996. This table shows the 10:10, 20:20, and Palma ratio, i.e., the expenditure share of the top 10 percent of households to the bottom 40 percent. The results reveal a well-known fact for Mexico the high level of income inequality is represented as expenditure inequality in this case. Moreover, an interesting finding appears: Expenditure inequality decreased after the devaluation by about 20% under the three different measures. This expenditure fall complements the finding that higher-income households decreased consumption more than low-income households.[64]

Table 5 also reveals another important finding, which is that expenditure inequality for non-tradable goods is much higher than for tradable goods. Let's look at the ratio of 10:10 in 1994. For tradable goods, 10% of highest income people spend 6.4 times more than 10% of lowest income people. In contrast, for non-tradable, this ratio goes to 22.7. This empirical finding is observed for the ratio 20:20 (4.7 vs. 13.1), and the Palma ratio (1.0 vs. 3.1). Same as in the case for the total expenditure, for the ratio 10:10, 20:20, and tradable and non-tradable expenditure inequality fell between 1994 and 1996.

[64]This finding has been documented in Argentina and other devaluation cases (Blanco et al. , 2019). Moreover, it was also documented for the US after the Great Recession (Meyer and Sullivan , 2013).

Figure 14: Percentage change between 1994 and 1996 in consumption across goods distribution grouped by tradable and non-tradable in Mexico



Note: This figure shows the distribution of consumption changes per product grouped by non-tradable and tradable goods. Panel (a) deflacts expenditure in each product by aggregate consumption price index. Panel (b) deflacts expenditure in each product by product-level consumption price index.
Source: ENIGH-INEGI.

Table 5: Share of expenditure by each household group

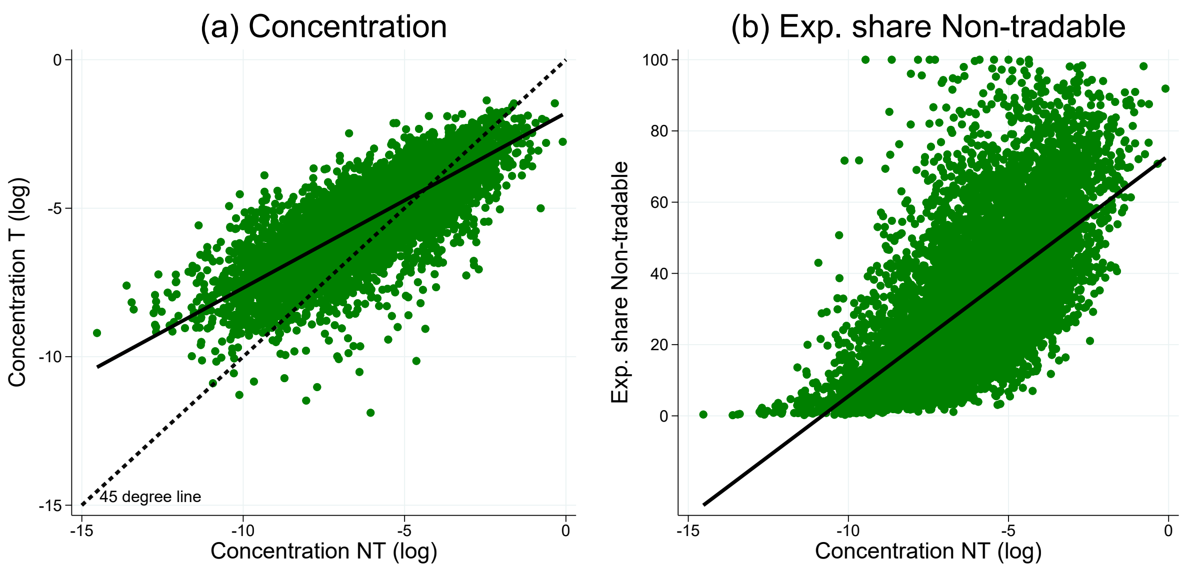
	1994			1996		
	Total Expenditure	Tradable	Non-Tradable	Total Expenditure	Tradable	Non-Tradable
Poorest 10%	0.040	0.018	0,017	0.034	0.044	0.018
Poorest 20%	0.072	0.094	0.044	0.083	0.103	0.050
Poorest 40%	0.190	0.240	0.127	0.211	0.252	0.146
Richest 20%	0.425	0.338	0.535	0.387	0.326	0.485
Richest 10%	0.271	0.189	0.375	0.234	0.184	0.313
Ratio 10:10	8.974	4.713	21.360	6.909	4.197	17.708
Ratio 20:20	5.926	3.604	12.279	4.685	3.171	9.685
Palma (10:40)	1.425	0.789	2.950	1.107	0.732	2.147

Note: This table shows the portion of total expenditure for households in different income deciles in 1994 and 1996. Column Total Expenditure is the portion of total expenditure by each group of households in aggregate expenditure. Column Tradable (Non-Tradable) is the portion of tradable (non-tradable) expenditure by each group of households in aggregate tradable expenditure. Ratio 10:10 (20:20) compares the expenditure share of the top 10% (20%) of the population (the richest) to the expenditure share of the bottom 10% (20%) of the population (the poorest). The Palma ratio is similar to the previous ratios, comparing the top 10% to the bottom 40%.

Figure 15 Panel (a) shows the relationship between the consumption share of tradables in aggregate against the consumption share of non-tradables in aggregate. In this case, at the household level, households with higher concentration in non-tradable concentrate more than in tradable. Moreover, Figure 15 Panel (b) shows stylized fact 3 from a different perspective. It shows that households that concentrate on non-tradable consumption also exhibit a higher expenditure share in non-tradable. The opposite relationship is observed for tradable expenditures.

Among the implications of the previous result is that aggregate expenditure in non-tradable depends mainly on high-income households. Stylized fact 1 shows that non-tradable consumption can fall as much as tradable consumption at the aggregate level. However, stylized fact 3 shows that in 3 out of 10 deciles this happens, and the tenth decile exhibits the highest decline with almost 30%. So, Table 5 reveals that high-income households motivate this finding.

Figure 15: Consumption concentration and expenditure shares in Mexico, 1994



Note: Panel (a) shows the relationship between the consumption share of tradables in aggregate (Concentration T) against the consumption share of non-tradables in aggregate (Concentration NT). The segmented line is 45 degrees. Panel (b) shows the relationship between the expenditure share in tradables and the consumption share of non-tradables in aggregate (Concentration NT).
Source: ENIGH-INEGI.

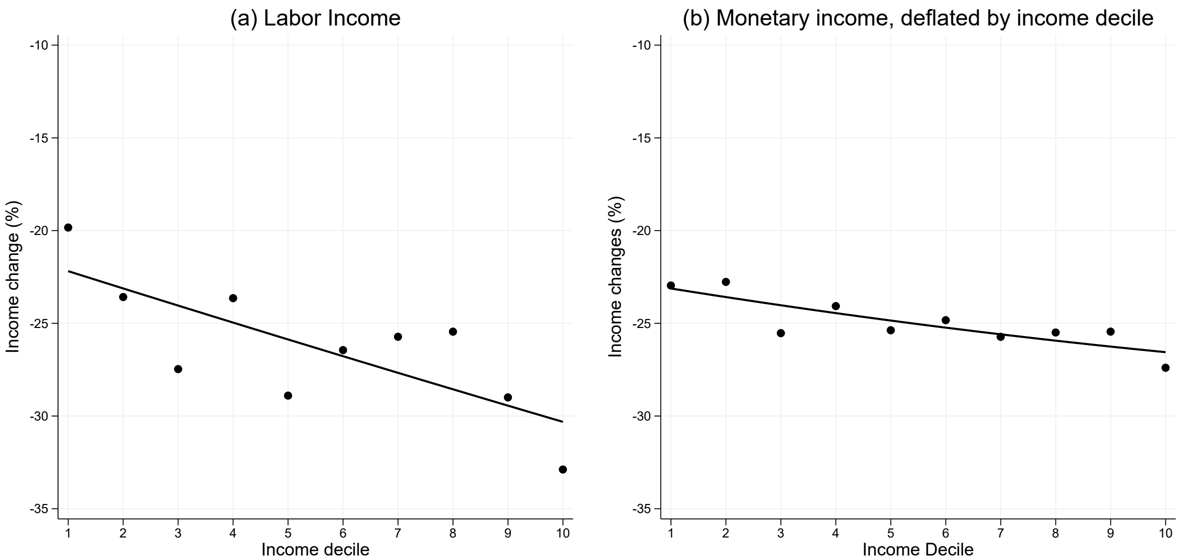
A.4 Monetary and labor income changes in Mexico 1994

In this appendix, we compare monetary income change per household income decile in Mexico 1994-1996 with labor income and a different approach to deflate income. The objective of this appendix is to determine how income was affected during the devaluation.

In Figure 16 Panel (a), we show household labor income change between 1994 and 1996 per household income decile in Mexico. In the main text, we show a strong declining pattern for monetary income as the income decile increases. Monetary income includes labor and business incomes, rents, transfers, and other incomes. In Panel (a), we show that labor incomes also decline in percentage terms for every income decile. It is still observed a declining pattern as the income decile increases, with highest income decile with the most significant drop. In this case, the pattern is noisier, with households' income decile seventh and eighth more similar to lower than median income decile.

In Figure 16 Panel (b), we show household monetary income change between 1994 and 1996 per household income decile in Mexico. In this case, monetary income is deflated by CPI at the household decile level. The declining pattern shows a less steep slope associated with higher prices that low-income households face.

Figure 16: Household labor and monetary income change per household income decile in Mexico, 1994-1996



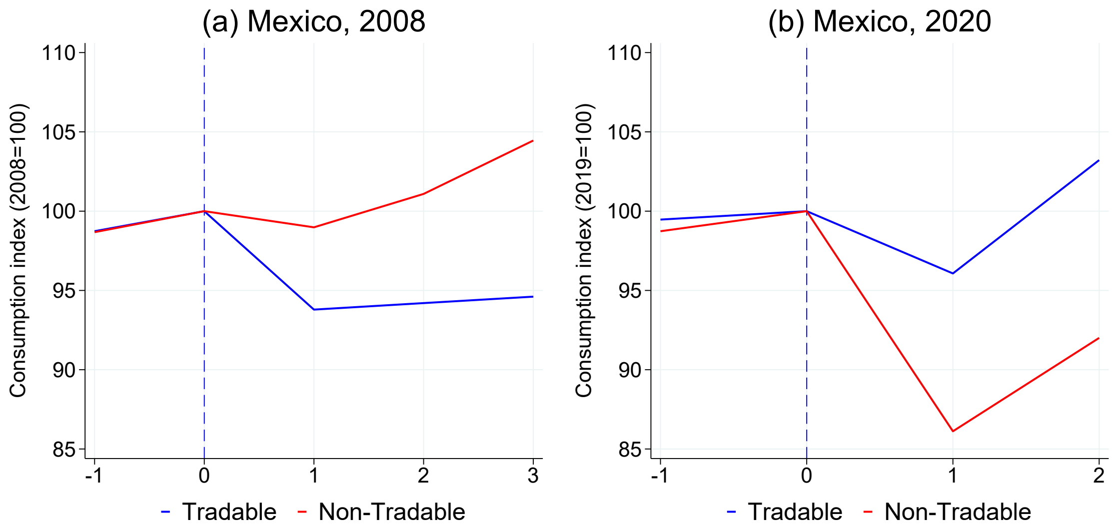
Note: Panel (a) shows the percentage change in household labor income change between 1994 and 1996 per household income decile. Aggregate CPI deflates it. Panel (b) shows the percentage change in household monetary income change between 1994 and 1996 per household income decile. CPI for every decile deflates monetary income.
Source: ENIGH-INEGI.

A.5 Additional robustness, comparing Mexico 1994 with Mexico in 2008 Global Financial Crisis and Mexico 2020 Pandemics

In this section, we compare the aggregate consumption of tradable and non-tradable and the expenditure share of tradable in Mexico in 2008 for the Global Financial Crisis and 2020 Pandemics. The objective is to show that tradable consumption can also respond more than non-tradable in Mexico.

First, in Figure 17, we compare the aggregate consumption of tradable and non-tradable in Mexico in 2008 for the Global Financial Crisis and 2020 Pandemics. It is important to note that in both cases, 12-month changes between tradable prices and aggregate CPI is about 2%.[65] Panel (a) shows that consumption of tradables decreased about 5% more than non-tradables during the Global Financial Crisis. In contrast, Panel (b) shows that consumption of non-tradables decreased about 10% more than tradables after the Pandemic. In the case of the Global Financial Crisis, homothetic CES can help to explain observed patterns in consumption. However, it does not help with Pandemics, an economic crisis that started in the non-tradable sector mainly associated with massive lock-downs nationwide.

Figure 17: Consumption of tradable and non-tradable of sudden stops with large devalua- tions



Note: This figure shows the real aggregate household consumption index for tradable and non-tradable for Mexico in 2008, 2020 in annual frequency. The real aggregate household consumption index equals 100 in the year starting the economic crisis. The vertical segmented blue line equals zero in the year starting the economic crisis.
Sources: OECD.

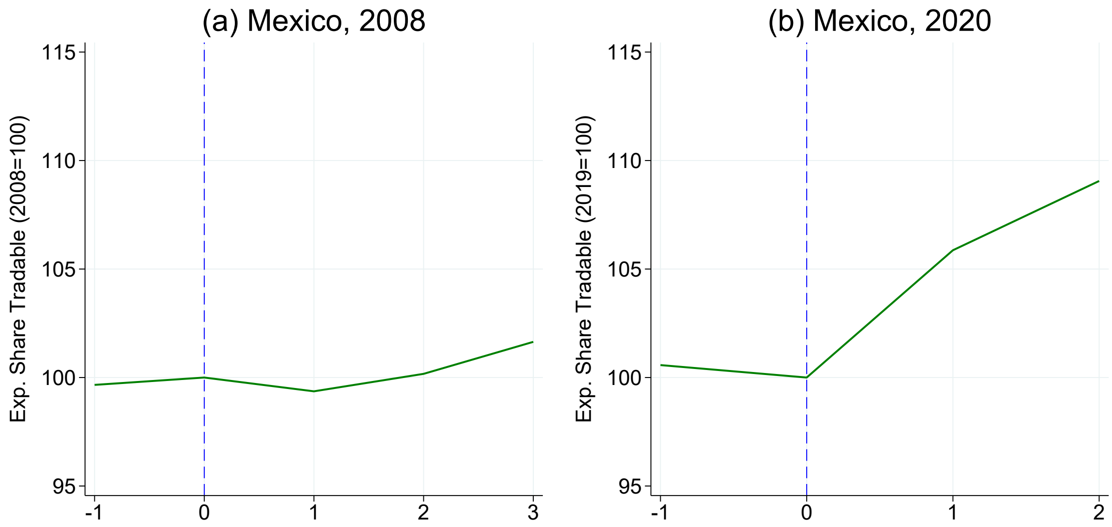
As for consumption changes, we compare expenditure share in tradable in different crisis episodes in Mexico. Figure 19 shows the evolution of expenditure share in tradable for Mexico during the Global Financial Crisis 2008 and the most recent COVID-19 crisis. Panel (a) shows that expenditure share in tradables was stable during the Global Financial Crisis. Panel (b) shows that it strongly increases after the Pandemic, so this is a similar combination that in the devaluation 1994 episode without a large devaluation. Combined those empirical observations show that changes in relative prices are not closely connected with relative changes in consumption, and in the case of pandemics with expenditure share in tradable either.

Finally, we examine expenditure share in tradable across time per household income decile. For every episode, expenditure share increases, and it is also the case that increases per income quintile.[66] The highest increase is observed during the pandemic which is mainly motivated by a decrease in non-tradable consumption.

[65] In both cases, we use merchandise price reported by Bank of Mexico as a proxy for tradable prices.

[66] Expenditure survey was raised at the end of 2008 and at the end of 2010 for the Global Financial

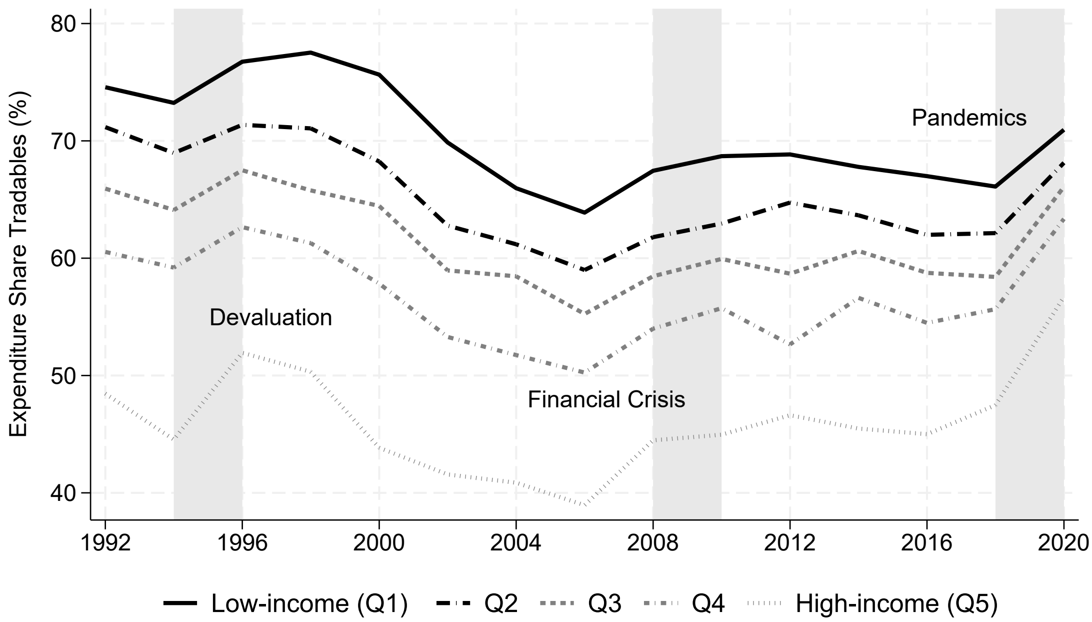
Figure 18: Expenditure share of sudden stops with large devaluations



Note: This figure shows the expenditure share in the tradable index for Mexico in 2008, 2020 in annual frequency. The expenditure share in the tradable index equals 100 in the year starting the economic crisis. The vertical segmented green line equals zero in the year starting the economic crisis.
Sources: OECD.

Crisis, so the timing for the survey in 2010 is when the economy was completely recovered from the crisis so that is one of the reasons that we observe increase in expenditure share in the survey but not in aggregate data.

Figure 19: Expenditure share of tradable in Mexico by income quintile, 1992-2008

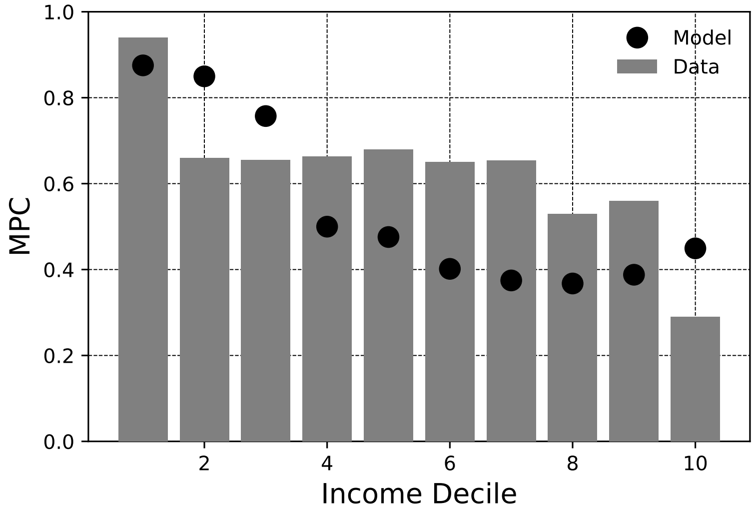


Note: This figure shows the expenditure share in tradable for Mexico by income quintile between 1992-2020in 2008, 2020 in annual frequency. The vertical gray area reflects the economic crisis in Mexico, Devaluation in 1994, Global Financial Crisis in 2008, and Pandemics in 2020. *Sources*: ENIGH-INEGI.

A.6 Additional Quantitative Exercises

A.6.1 Marginal propensities to consume for total consumption in the model

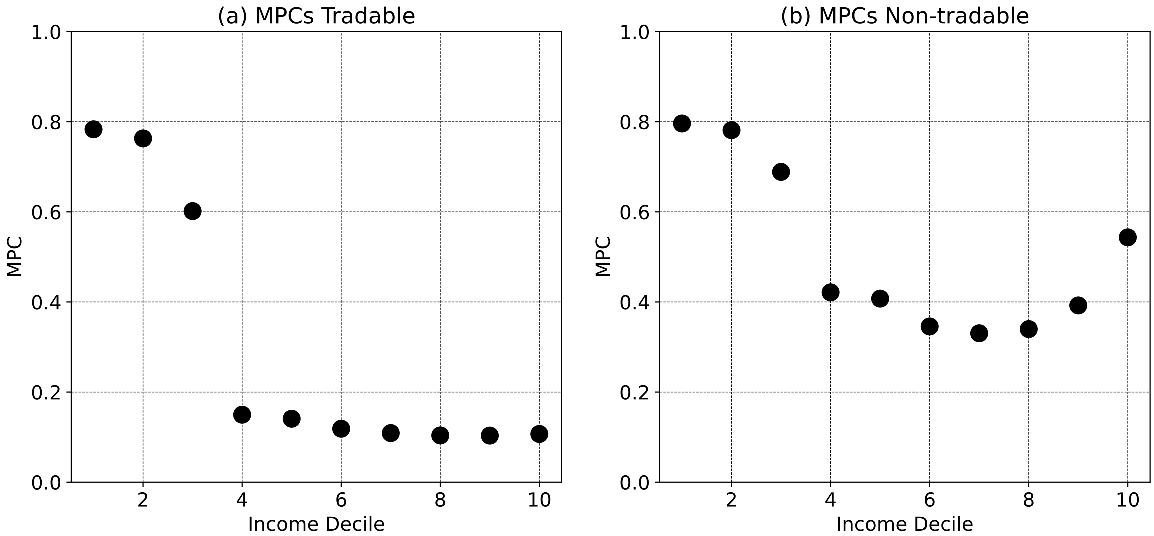
Figure 20: Marginal propensity to consume (MPC) for total consumption



Note: Marginal propensity to consume corresponds to those for baseline calibration. MPCs are not targeted in our model with one asset and no discount factor heterogeneity. Data corresponds to MPCs estimated for Peru reported by Hong (2023).

A.6.2 Marginal propensities to consume for for tradable and non-tradable consumption

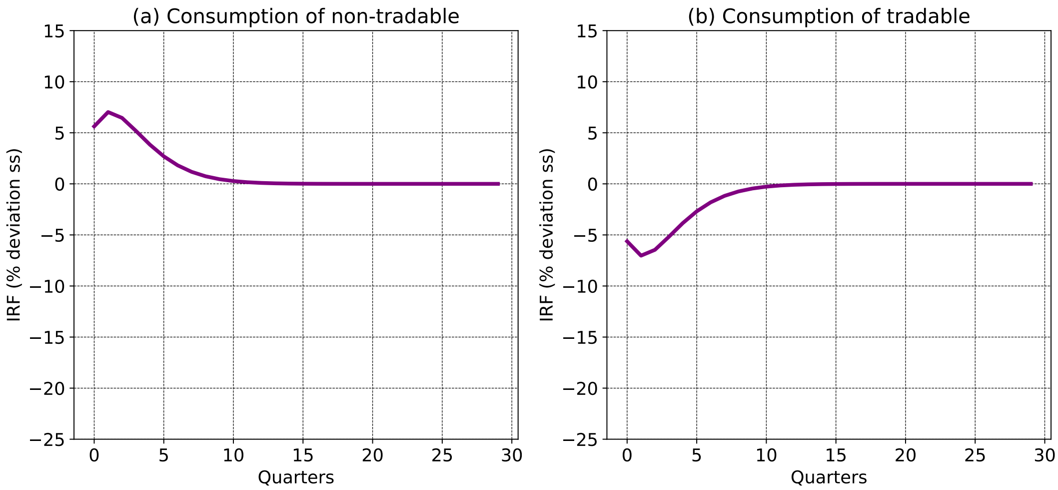
Figure 21: Marginal propensity to consume (MPC) for tradable and non-tradable consumption



Note: Marginal propensity to consume corresponds to those for baseline calibration. Panel (a) shows the marginal propensity to consume for tradable. Panel (b) shows the marginal propensity to consume for non-tradables.

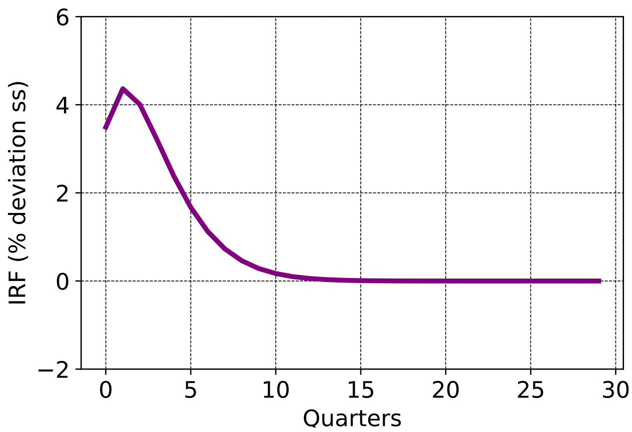
A.6.3 Simulations with a representative agent model with homothetic CES

Figure 22: Tradable and non-tradable consumption responses



Note: Impulse response of consumption in non-tradable and tradable homothetic CES representative agent model to 15% increase in foreign interest rate.

Figure 23: Expenditure share in tradable responses



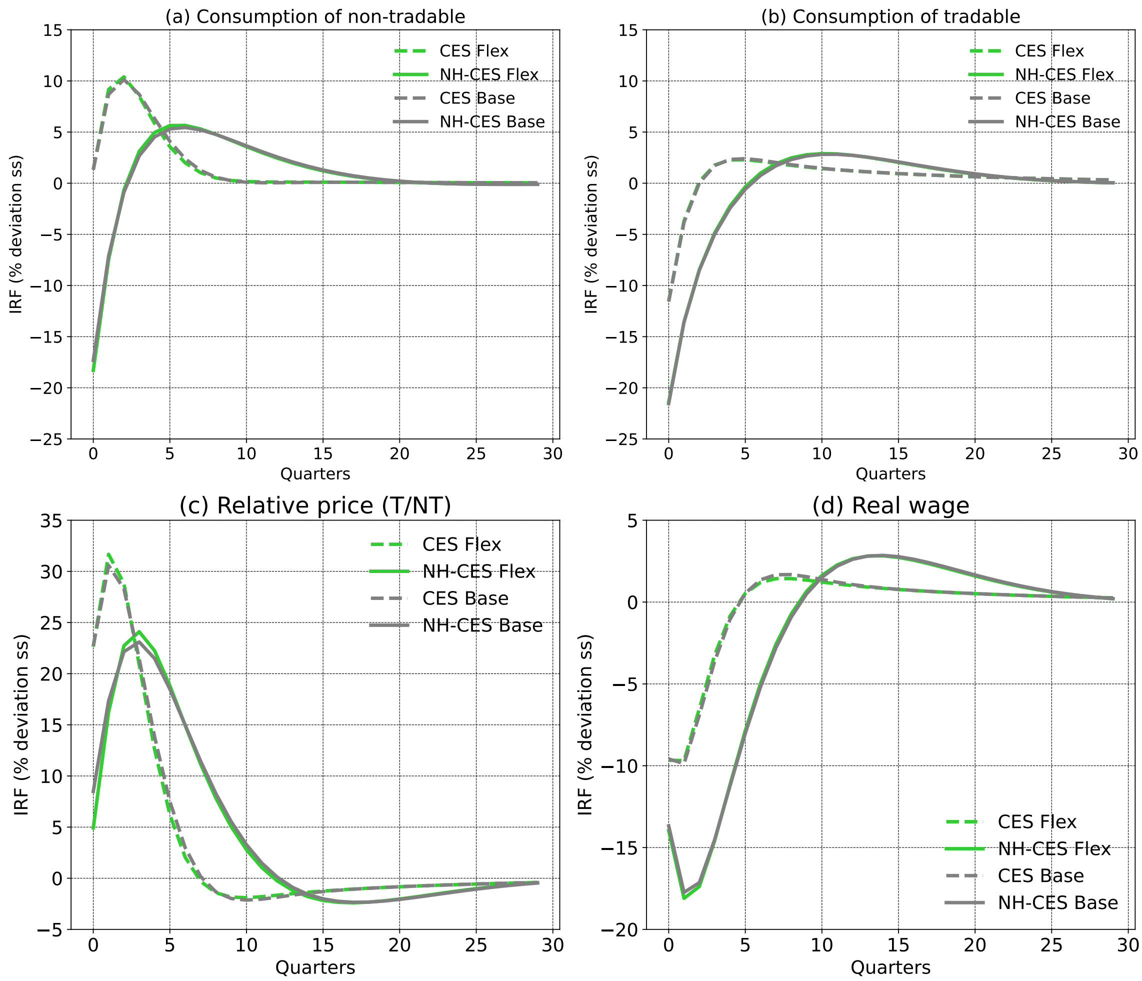
Note: Impulse response of expenditure share in tradable in the homothetic CES representative agent model to 15% increase in foreign interest rate.

A.6.4 Non-tradable price rigidities

Our baseline calibration considers price rigidities in the non-tradable sector. As indicated previously, this assumption helps to produce incomplete exchange rate pass-through in this sector, as was observed in the data. In this Appendix, we study the implications of this assumption on our main results.

We modify nominal rigidities to make prices in the non-tradable sector more flexible. Figure 24 shows the response in consumption. The results in panel (a) show that the non-tradable consumption is more affected than in baseline calibration. This is associated with an increased response of non-tradable relative prices in panel (c). The results in panels (b) and (d) show that the response of tradable consumption and real wages are almost unaffected under both homothetic and non-homothetic CES models.

Figure 24: Robustness to non-tradable price rigidities



Note: Impulse response of non-tradable and tradable consumption, relative prices, and real wages to 15% increase in foreign interest rate. The green line shows homothetic CES (dashed line) and non-homothetic CES model (solid line) with non-tradable prices more flexible ($\kappa = 1.8$). The gray line shows homothetic CES (dashed line) and non-homothetic CES model (solid line) with non-tradable prices baseline calibration ($\kappa = 0.9$).

B Additional details and Proofs

B.1 Representative agent tradable and non-tradable endowment economy model

This section presents a standard tradable and non-tradable model with homothetic CES preferences used in the empirical section. To simplify the problem, it is assumed to be an infinite horizon problem with logarithmic utility and the existence of one internationally traded asset. An additional assumption is that there is no production, so households own an endowment of tradable and non-tradable goods.

Households solve the following problem:

$$\max_{\{C_t^T, C_t^N, A_{t+1}\}} \mathbb{E}_t \sum_t \beta^t \ln(C_t)$$

Subject to budget constraints and homothetic CES aggregator of consumption:

$$P_t^T C_t^T + P_t^N C_t^N + A_{t+1} = P_t^T Q_t^T + P_t^N Q_t^N + \big(1 + r_t\big) A_t$$
$$C_t = \Big(\omega (C_t^T)^{1-(1/\sigma)} + (1-\omega)(C_t^N)^{1-(1/\sigma)}\Big)^{\sigma/(\sigma-1)}$$

where C_t^T (C_t^N) corresponds to tradable (non-tradable) consumption, P_t^T (P_t^N) is tradable (non-tradable) prices, A is an internationally traded bond with interest rate r. The intratemporal allocation for this problem is:

$$\frac{C_t^T}{C_t^N} = \left(\frac{P_t^N}{P_t^T}\frac{\omega}{1-\omega}\right)^{\sigma} \tag{31}$$

Then, taking log differences to equation (31), the relationship between tradable and non-tradable consumption and relative prices is:

$$d\ln C_t^T - d\ln C_t^N = \sigma(d\ln P_t^N - d\ln P_t^T) \tag{32}$$

Assuming the elasticity of substitution σ equals one, we have the equation (1) in the main text. Starting from optimality conditions, it is possible to show that the expenditure share for good j, in period t, b_{jt} is:

$$b_{jt} = \frac{\omega_j^{\sigma} P_{jt}^{1-\sigma}}{P_t^{1-\sigma}} \tag{33}$$

Then, taking log differences to equation (33), we obtain the equation (2) in the text.

B.2 Household proofs

To derive expenditure shares in equation (8) let's start from $\frac{\partial E}{\partial P_j}$ where expenditure was defined in equation (7),

$$\frac{\partial E}{\partial P_j} = \frac{1}{1-\sigma} E \frac{(1-\sigma)\omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{-\sigma}}{\sum_j \omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}$$

$$\frac{\partial E}{\partial P_j} = \frac{1}{1-\sigma} \frac{E}{P_j} \frac{(1-\sigma)\omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}{\sum_j \omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}$$

$$\frac{\partial E}{\partial P_j} = \frac{E}{P_j} \frac{\omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}{\sum_j \omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}$$

$$\frac{\partial \log E}{\partial \log P_j} = \frac{\omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}{\sum_j \omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}} \tag{34}$$

Then, equation (8) directly follows from equation (34),

$$b_{hjt} = \frac{\partial \log E_t(\mathbb{P}_t, \mathcal{C}_t)}{\partial \log P_{jt}} = \frac{\partial E_t(\mathbb{P}_t, \mathcal{C}_t)}{\partial P_{jt}} \frac{P_{jt}}{E_t(\mathbb{P}_t, \mathcal{C}_t)} = \frac{\omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}{E} \tag{35}$$

To derive equation (9), a couple of additional steps are required. Applying log difference to expenditure share:

$$d\log b_j = (1-\sigma)\Big(d\log P_j - d\log E\Big) + (\gamma_i - \sigma) d\log \mathcal{C} \tag{36}$$

An intermediate step is deriving $\frac{\partial \log E}{\partial \log \mathcal{C}}$,

$$\frac{\partial E}{\partial \mathcal{C}} = \frac{1}{1-\sigma} E \sum_j \frac{(\gamma_j - \sigma)\omega_j \mathcal{C}_t^{\gamma_j-\sigma-1} P_{jt}^{1-\sigma}}{\sum_j \omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}$$

$$\frac{\partial E}{\partial \mathcal{C}} = \frac{1}{1-\sigma} \frac{E}{\mathcal{C}} \sum_j \frac{\omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}{\sum_j \omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}} (\gamma_j - \sigma)$$

$$\frac{\partial E}{\partial \mathcal{C}} = \frac{1}{1-\sigma} \frac{E}{\mathcal{C}} \sum_j b_j (\gamma_j - \sigma)$$

$$\frac{\partial \log E}{\partial \log \tilde{\mathcal{C}}} = \frac{1}{1-\sigma} \sum_j b_j(\gamma_j - \sigma) > 0 \tag{37}$$

Taking log difference to expenditure function and using equation (37), we have:

$$d\log E - \mathbb{E}_b(d\log P) = \frac{\sum_j b_j(\gamma_j - \sigma)}{1-\sigma} d\log \mathcal{C} \tag{38}$$

Finally, replacing $d\log \mathcal{C}$ in equation (38) into equation (36):

$$d\log b_j = (1-\sigma)\Big(d\log P_j - d\log E\Big) + (\gamma_j - \sigma)\frac{1-\sigma}{\mathbb{E}_b(\gamma - \sigma)}\Big(d\log E - \mathbb{E}_b(d\log P)\Big) \tag{39}$$

Rearranging this expression, we have equation (9).

B.3 Balance of payment

$$NFA_{t+1} = \frac{P_t^T}{P_t}(Q_t^T - C_{T,t}) + (1 + r_t)NFA_t$$

Proof:
Starting from the budget constraint:

$$\frac{P_t^N}{P_t}C_{N,t} + \frac{P_t^T}{P_t}C_{T,t} + A_{t+1} = (1 + r_{t+1}^p)A_t + w_t N_t + \frac{P_t^T}{P_t}Q_t^T \tag{40}$$

Remember that $NFA = A - p$

$$\begin{aligned}(1 + r_{t+1}^p)A_t &= (1 + r_t)A_t + (r_{t+1}^p - r_t)A_t \\ &= (1 + r_t)(p_t + NFA_t) + (r_{t+1}^p - r_t)A_t \\ &= p_{t+1} + d_{t+1} + (1 + r_t)NFA_t + (r_{t+1}^p - r_t)A_t\end{aligned}$$

Then,

$$\frac{P_t^N}{P_t}C_{N,t} + \frac{P_t^T}{P_t}C_{T,t} + NFA_{t+1} + p_{t+1} = p_{t+1} + d_{t+1} + (1 + r_t)(NFA_t) + (r_{t+1}^p - r_t)A_t + w_t N_t + \frac{P_t^T}{P_t}Q_t^T$$

Substitute dividends, market clear, and $r_{t+1}^p = r_t$

$$\begin{aligned}\frac{P_t^N}{P_t}C_{N,t} + \frac{P_t^T}{P_t}C_{T,t} + NFA_{t+1} &= \frac{P_t^N}{P_t}Y_t - w_t N_t - \phi_t^F + (1 + r_t)NFA_t + w_t N_t + \frac{P_t^T}{P_t}Q_t^T \\ \frac{P_t^T}{P_t}C_{T,t} + NFA_{t+1} &= (1 + r_t)NFA_t + \frac{P_t^T}{P_t}Q_t^T \\ NFA_{t+1} &= \frac{P_t^T}{P_t}(Q_t^T - C_{T,t}) + (1 + r_t)NFA_t\end{aligned}$$

B.4 Proof Propositions

B.4.1 Proof Proposition 1

Starting from equations (25) and (27) and market clearing in non-tradable sector,

$$\tilde{w}_t \equiv \frac{W_t}{\mathcal{E}_t} = \left(\frac{\omega_N}{\omega_T}\right)^{\frac{1}{\sigma}} C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{1-\frac{1}{\sigma}} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}} \tag{41}$$

Let's assume that in steady state, non-homothetic and homothetic CES demand conditions coincide

$$\left(\frac{\omega_N}{\omega_T}\right) = \left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)\bar{\mathcal{C}}_t^{\frac{\gamma_N-\gamma_T}{\sigma}} \tag{42}$$

Derive equation (41) respect r^*,

$$\frac{\partial \tilde{w}_t^{NH}}{\partial r^*} = \left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} \frac{1}{\sigma} C_{T,t}^{\frac{1}{\sigma}-1} C_{N,t}^{1-\frac{1}{\sigma}} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}} \frac{\partial C_{T,t}}{\partial r^*} + \tag{43}$$

$$\left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{1-\frac{1}{\sigma}} \frac{\gamma_N-\gamma_T}{\sigma} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}-1} \frac{\partial \mathcal{C}_t}{\partial C_t^T} \frac{\partial C_{T,t}}{\partial r^*} \tag{44}$$

Then, for homothetic CES we derive it against r^*,

$$\frac{\partial \tilde{w}_t^{H}}{\partial r^*} = \left(\frac{\omega_N}{\omega_T}\right)^{\frac{1}{\sigma}} \frac{1}{\sigma} C_{T,t}^{\frac{1}{\sigma}-1} C_{N,t}^{1-\frac{1}{\sigma}} \frac{\partial C_{T,t}}{\partial r^*} \tag{45}$$

Then, relative derivatives correspond to the equation in Proposition 1,

$$\frac{\frac{\partial \tilde{w}^{NH}}{\partial r^*}}{\frac{\partial \tilde{w}^{H}}{\partial r^*}} = 1 + (\gamma_N - \gamma_T) C_T \mathcal{C}^{-1} \frac{\partial \mathcal{C}}{\partial E} \frac{\partial E}{\partial C^T} \tag{46}$$

If $\gamma_N > \gamma_T$, then the second term on the right-hand side is positive if $\frac{\partial \log \mathcal{C}}{\partial \log E} > 0$. We derived expression $\frac{\partial \log \mathcal{C}}{\partial \log E}$ in equation (37), we have that

$$\frac{\partial \log E}{\partial \log \mathcal{C}} = \frac{1}{1-\sigma} \sum_j b_j(\gamma_j - \sigma) > 0 \tag{47}$$

It is positive under our assumption of $\sigma < 1$. Note that the previous result is more general than only associated with shocks to foreign interest rates and is associated with any shock affecting only $C_{T,t}$, such as a tradable endowment shock to Q^T. The second part of this proposition is derived from first establishing the relative result between non-homothetic and homothetic preferences on relative prices on the demand side, then the optimal condition of firms in the non-tradable sector gives the result.

B.4.2 Proof Proposition 2

Again, let's assume that in a steady state, non-homothetic and homothetic CES demand conditions coincide. Moreoever, assume any shock affecting only C^T, such as foreign interest rate r^* or endowment shock Q^T. From a similar procedure than in Proposition 1 derive equation (41) respect C^T,

$$\frac{\partial \tilde{w}_t^{NH}}{\partial C^T} = \left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} \frac{1}{\sigma} C_{T,t}^{\frac{1}{\sigma}-1} C_{N,t}^{1-\frac{1}{\sigma}} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}} + \tag{48}$$

$$\left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{1-\frac{1}{\sigma}} \frac{\gamma_N-\gamma_T}{\sigma} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}-1} \frac{\partial \mathcal{C}_t}{\partial C_t^T} \tag{49}$$

For homothetic CES, we derive it against C^T,

$$\frac{\partial \tilde{w}_t^{H}}{\partial C^T} = \left(\frac{\omega_N}{\omega_T}\right)^{\frac{1}{\sigma}} \frac{1}{\sigma} C_{T,t}^{\frac{1}{\sigma}-1} C_{N,t}^{1-\frac{1}{\sigma}} \frac{\partial C_{T,t}}{\partial C^T} \tag{50}$$

Then, we have

$$\frac{\frac{\partial \tilde{w}^{NH-CES}}{\partial C^T}}{\frac{\partial \tilde{w}^{CES}}{\partial C^T}} = 1 + (\gamma_N - \gamma_T) \frac{\partial \log \mathcal{C}_t}{\partial \log E} \frac{\partial \log E}{\partial \log C^T} \tag{51}$$

For the non-tradable sector, derive equation (41) respect to C^N,

$$\frac{\partial \tilde{w}_t^{NH}}{\partial C^N} = \left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} \left(1 - \frac{1}{\sigma}\right) C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{-\frac{1}{\sigma}} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}} + \tag{52}$$

$$\left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{1-\frac{1}{\sigma}} \frac{\gamma_N-\gamma_T}{\sigma} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}-1} \frac{\partial \mathcal{C}_t}{\partial C_t^N} \tag{53}$$

For homothetic CES,

$$\frac{\partial \tilde{w}_t^{H}}{\partial C^N} = \left(\frac{\omega_N}{\omega_T}\right)^{\frac{1}{\sigma}} \left(1 - \frac{1}{\sigma}\right) C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{-\frac{1}{\sigma}} \tag{54}$$

Then, relative derivatives correspond to the equation in Proposition 2,

$$\frac{\frac{\partial \tilde{w}^{NH-CES}}{\partial C^N}}{\frac{\partial \tilde{w}^{H-CES}}{\partial C^N}} = 1 - \left(\frac{\gamma_N - \gamma_T}{1-\sigma}\right) \frac{\partial \log \mathcal{C}}{\partial \log E} \frac{\partial \log E}{\partial \log C^N} \tag{55}$$

If $\gamma_N = \gamma_T$, then in the previous equation, we are back to homothetic CES, and any shock affecting tradable or non-tradable consumption produces the same pricing effect.

If $\gamma_N \neq \gamma_T$, the effect on prices associated with tradable or non-tradable consumption differs. In the empirically relevant case $\gamma_N > \gamma_T$, with $\sigma \in (0,1)$ an external shock affecting the consumption of tradable produces a higher effect on relative prices than a shock affecting the consumption of non-tradables in the non-homothetic case. On the inverse, a shock affecting the consumption of non-tradables produces a lower effect on relative prices than a shock affecting the consumption of tradables in the non-homothetic case.

B.4.3 Proof Proposition 3

Let's start with relative expenditure shares for tradable and nontradable from equation (8) under non-homothetic CES preferences. Then, by linearizing and aggregating across households, we have

$$P^N - P^T = \frac{1}{\sigma}\mathbf{C_T} - \frac{1}{\sigma}\mathbf{C_N} + \frac{\gamma_N - \gamma_T}{\sigma}\mathcal{C} \tag{56}$$

From the firm and equilibrium in the non-tradable sector, we have

$$\tilde{w} = P^N - P^T + \mathbf{C^N} \tag{57}$$

Then, our equilibrium condition is similar to the representative agent,

$$\tilde{w}^{NH} = \frac{1}{\sigma}\mathbf{C_T} + \big(1 - \frac{1}{\sigma}\big)\mathbf{C_N} + \frac{\gamma_N - \gamma_T}{\sigma}\mathcal{C} \tag{58}$$

Partial derivatives for a shock affecting only to $\mathbf{C_T}$, we have

$$\frac{\partial \tilde{w}^{NH}}{\partial \mathbf{C_T}} = \frac{1}{\sigma} + \frac{\gamma_N - \gamma_T}{\sigma}\frac{\partial \mathcal{C}}{\partial \mathbf{C_T}} \tag{59}$$

Similar steps for homothetic CES,

$$\frac{\partial \tilde{w}^{H}}{\partial \mathbf{C_T}} = \frac{1}{\sigma} \tag{60}$$

Finally, taking the ratio of the two previous equations, we have our result. On the other hand, for non-tradable consumption, partial derivatives for a shock affecting only to $\mathbf{C_N}$, we have our result for non-tradable

$$\frac{\partial \tilde{w}^{NH}}{\partial \mathbf{C_N}} = -\big(\frac{1-\sigma}{\sigma}\big) + \frac{\gamma_N - \gamma_T}{\sigma}\frac{\partial \mathcal{C}}{\partial \mathbf{C_N}} \tag{61}$$

Similar steps for homothetic CES,

$$\frac{\partial \tilde{w}^{H}}{\partial \mathbf{C_N}} = -\big(\frac{1-\sigma}{\sigma}\big) \tag{62}$$

Finally, taking the ratio of the two previous equations, we have the second result.

B.4.4 Proof Proposition 4

Proposition 3 (consumption decomposition): Extended version of first-order perturbation in consumption of good j for household h.

$$d\ln c_{hj} = \underbrace{MPC_{hj}\Big(dP^N(\hat{Y}^N_h) + P^N(d\hat{Y}^N_h) + dP^T(\hat{Y}^T_h) + P^T(d\hat{Y}^T_h)\Big)}_{\text{Income channel}} + \underbrace{MPC_{hj}(\hat{a}^R_h)d\ln P^N}_{\text{Fisher channel}} + \underbrace{MPC_{hj}(P^N_{t+1}\hat{a}^R_{ht+1})d\ln R}_{\text{Interest rate exposure}} - \underbrace{MPC_{hj}(b_{hj}d\ln P^j)}_{\text{Expenditure channel}} + \underbrace{\sigma(b_{hj}-1)d\ln P^j}_{\text{Price Substitution}} - \underbrace{\hat{\sigma}_{hj}M\hat{P}S_h d\ln R}_{\text{Intertemporal Substitution}} \tag{63}$$

Let's begin with household budget constraints in this two-period economy.[67] Nominal budget constraints in $t=1$ and $t=2$ at the household level are[68]:

$$P^T_1 c^T_1 + P^N_1 c^N_1 + P^N_2 a^R_2 = P^N_1 Y^N_1 + P^T_1 Y^T_1 + P^T_1 a^R_1 \tag{64}$$

$$P^T_2 c^T_2 + P^N_2 c^N_2 + = P^N_2 Y^N_2 + P^T_2 Y^T_2 + RP^N_2 a^R_2 \tag{65}$$

Consolidated nominal budget constraint:

$$P^T_1 c^T_1 + P^N_1 c^N_1 + \frac{P^T_2 c^T_2 + P^N_2 c^N_2}{R} = P^N_1 Y^N_1 + P^T_1 Y^T_1 + \frac{P^N_2 Y^N_2 + P^T_2 Y^T_2}{R} + P^N_1 a^R_1 \tag{66}$$

Income Perturbation dy around the first period is given by:

$$dy = dP^N_1(Y^N_1 + a^R_1) + P^N_1(dY^N_1 + da^R_1) + dP^T_1(Y^T_1) + P^T_1(dY^T_1) + \frac{P^N_2}{R}dY^N_2 + \frac{P^T_2}{R}dY^T_2 - \frac{P^N_2 Y^N_2 + P^T_2 Y^T_2}{R^2}dR \tag{67}$$

Standard identity from microeconomic literature $h_j(P_j, R, U) = c_j(P_j, R, E(P_j, R, U))$. Change in good j's consumption per household h, dc_j, after a small perturbation and using slutsky equation produces:

$$dc_j = \frac{\partial h_j}{\partial P_j}dP_j - \frac{\partial c_j}{\partial y}\frac{\partial E}{\partial P_j}dP_j + \frac{\partial h_j}{\partial R}dR - \frac{\partial c_j}{\partial y}\frac{\partial E}{\partial R}dR + \frac{\partial c_j}{\partial y}dy \tag{68}$$

$$= \frac{\partial c_j}{\partial y}\frac{E}{c_j}c_j d\ln y - \frac{\partial c_j}{\partial y}\frac{E}{c_j}\frac{\partial E}{\partial R}\frac{R}{E}c_j d\ln R - \frac{\partial c_j}{\partial y}\frac{E}{c_j}c_j b_j d\ln P_j + \frac{\partial h_j}{\partial P_j}\frac{P_j}{c_j}c_j d\ln P_j + h_j\epsilon_{h_j R}d\ln R \tag{69}$$

$$d\ln c_j = \epsilon_{cy}\Bigg(d\ln y - \epsilon_{yR}d\ln R - b_j d\ln P_j\Bigg) + \epsilon_{h_j P_j}d\ln P_j + \epsilon_{h_j R}d\ln R \tag{70}$$

Note that marginal propensities to consume now are sector-level marginal propensities to consume. To derive the above Equation (70), we used the Slutsky equation that connects compensated and uncompensated demand:

$$\frac{\partial h_j}{\partial P_j} = \frac{\partial c_j}{\partial P_j} + \frac{\partial c_j}{\partial E}\frac{\partial E}{\partial p_j} \tag{71}$$

$$\frac{\partial h_j}{\partial R} = \frac{\partial c_j}{\partial R} + \frac{\partial c_j}{\partial E}\frac{\partial E}{\partial R} \tag{72}$$

[67] This proof follows along the lines of Auclert (2019). A similar approach is followed by Clayton et al. (2018) and Zhou (2022).

[68] We skip subscript h per each household to simplify notation.

Now, we derive each component of Equation (70). Let's begin with the components inside the parenthesis.First, note that from Equation (66), $\frac{\partial E}{\partial R}dR$ corresponds to:

$$\frac{\partial E}{\partial R}dR = -\frac{P_2^T c_2^T + P_2^N c_2^N}{R}\frac{dR}{R} = -\left(\frac{P_2^N Y_2^N + P_2^T Y_2^T}{R} + a_2^N\right)\frac{dR}{R} \tag{73}$$

Then, we use Equation (73) to derive the first component inside the parenthesis in Equation (70):

$$\begin{aligned} dy - \frac{\partial E}{\partial R}dR = {} & dP_1^N\left(Y_1^N + a_1^R\right) + P_1^N\left(dY_1^N + da_1^R\right) + dP_1^T\left(Y_1^T\right) + P_1^T\left(dY_1^T\right) \\ & + \frac{P_2^N}{R}dY_2^N + \frac{P_2^T}{R}dY_2^T - \frac{P_2^N Y_2^N + P_2^T Y_2^T}{R^2}dR + \left(\frac{P_2^N Y_2^N + P_2^T Y_2^T}{R} + a_2^N\right)\frac{dR}{R} \end{aligned} \tag{74}$$

$$\begin{aligned} dy - \frac{\partial E}{\partial R}dR = {} & dP_1^N\left(Y_1^N + a_1^R\right) + P_1^N\left(dY_1^N + da_1^R\right) + dP_1^T\left(Y_1^T\right) + P_1^T\left(dY_1^T\right) \\ & + \frac{P_2^N}{R}dY_2^N + \frac{P_2^T}{R}dY_2^T + a_2^N\frac{dR}{R} \end{aligned} \tag{75}$$

Finally, we can use Equation (75)

$$d\ln y - \epsilon_{yR}d\ln R = \frac{1}{E}\left(dy - \frac{\partial E}{\partial R}dR\right) \tag{76}$$

$$= dP_1^N\left(\hat{Y}_1^N + \hat{a}_1^R\right) + dP_1^T\hat{Y}_1^T + P_1^N d\hat{Y}_1^N + P_1^T d\hat{Y}_1^T + \hat{a}_2^N\frac{dR}{R} \tag{77}$$

where variables with hat are represented as ratios of total expenditure E as $\hat{X} = X/E$, we assumed income returns to stationary equilibrium in the second period, and assets do not change.
Alternatively, divisia index definition allows redefining income terms in nominal terms such that $dP_1^j\hat{Y}_1^j + P_1^j d\hat{Y}_1^j = d(P^j\hat{Y}^j)$.

Let's derive components outside the parenthesis in Equation (70). Calculating h_j derivatives with respect to P_j, where $h_j = \omega_j U^{\gamma^j - \sigma}(E/P_j)^\sigma$:

$$\frac{\partial h_j}{\partial P_j} = (-\sigma)P_j^{-\sigma-1}\omega_j U^{\gamma^j-\sigma}E^\sigma + \frac{\sigma h_j}{E}\frac{\partial E}{\partial P_j}\frac{P_j}{P_j} = -\sigma P_j^{-1}h_j + \sigma P_j^{-1}h_j b_j = \sigma P_j^{-1}h_j(b_j - 1) \tag{78}$$

Then, we have the result

$$\epsilon_{h_j P_j} d\ln P_j = \sigma h_j\left(b_j - 1\right)d\ln P_j \tag{79}$$

The last component to derive is the intertemporal substitution. To derive this element, we rely on the Euler equation per good j. From household optimality conditions, the Euler equation corresponds to:

$$v'_{j,1}(c_1^j) = \beta R v'_{j,2}(c_2^j) \tag{80}$$

where $v'_{j,1}(c_1^j) \equiv \partial v/\partial\mathcal{C} \times \partial\mathcal{C}/\partial c^j \times 1/P_j$. Then, inverting the Euler equation we obtain $c_2^j = (v'_{j,2})^{-1}[v'_{j,1}(c_1^j)(\beta R)^{-1}]$. Let's assume a constant level of utility that households want to achieve $\bar{V}$, such that $\bar{V} = v(c_1) + \beta v(c_2)$. Taking derivatives with respect to interest rates on both sides, we have:

$$0 = v'_{j,1}\frac{\partial c_1^j}{\partial R} + \beta v'_{j,2}\frac{1}{v''_{j,2}}\frac{v''_{j,1}}{\beta R}\frac{\partial c_1^j}{\partial R} + \beta v'_{j,2}\frac{1}{v''_{j,2}}\frac{v'_{j,1}}{\beta}(-R^{-2}) \tag{81}$$

$$v'_{j,1}\frac{v'_{j,2}}{v''_{j,2}}(R^{-2}) = v'_{j,1}\frac{\partial c_1^j}{\partial R}\left(1 + \frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}\frac{1}{R}\right) \tag{82}$$

$$\frac{v'_{j,1}}{v''_{j,1}}v'_{j,1}\frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}(R^{-2}) = v'_{j,1}\frac{\partial c_1^j}{\partial R}\left(1 + \frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}\frac{1}{R}\right) \tag{83}$$

$$(-\sigma_1^j c_1^j)\frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}(R^{-2}) = \frac{\partial c_1^j}{\partial R}\left(1 + \frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}\frac{1}{R}\right) \tag{84}$$

Where we define the intertemporal elasticity of substitution for non-homothetic CES preferences as $\sigma_1^j \equiv -\frac{v'_{j,1}}{v''_{j,1}c_1^j}$ and changes over time. Then, rearranging the utility perturbation in Equation (84), and deriving budget constraints we obtain MPCs:

$$\begin{aligned}
(-\sigma_1^j)\frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}\frac{1}{R} &= \frac{\partial c_1^j R}{\partial R c_1^j}\left(1 + \frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}\frac{1}{R}\right) \\
(-\sigma_1^j)\frac{MPS}{MPC_j} &= \frac{\partial c_1^j R}{\partial R c_1^j}\left(\frac{MPC_j + MPS}{MPC_j}\right) \\
(-\sigma_1^j)\frac{MPS}{MPS + MPC_j} &= \frac{\partial c_1^j R}{\partial R c_1^j} \\
\epsilon_{h_j R} = \frac{\partial c_1^j}{\partial R}\frac{R}{c_1^j} &= -\sigma_1^j M\hat{P}S
\end{aligned}$$

B.4.5 Proof Proposition 5

Aggregation across households:

We define $\sum_h \omega_h(.) = \mathbb{E}_h(.)$, and given the assumption of fixed assets and purely transitory shocks, Proposition 5 shows that

$$d\ln C_j = \sum_h \omega_h d\ln c_{hj}$$

Using Equation (63) and aggregating consumption across households we have:

$$\begin{aligned}
d\ln C_j = &\ \mathbb{E}_h\Big[MPC_j\Big(P^N\big(d\hat{Y}^N\big) + P^T\big(d\hat{Y}^T\big) + dP^N\big(\hat{Y}^N\big) + dP^T\big(\hat{Y}^T\big)\Big)\Big] \\
&+ \mathbb{E}_h\big[MPC_j a^R\big]d\ln P^N + \mathbb{E}_h\big[MPC_j P^N_{t+1}a^R_{t+1}\big]d\ln R \\
&- \mathbb{E}_h\big[MPC_j b_j\big]d\ln P^j + \sigma\mathbb{E}_h\big[\big(b_j - 1\big)\big]d\ln P^j - \mathbb{E}_h\big[\tilde{\sigma}_j M\tilde{P}S\big]d\ln R
\end{aligned} \tag{85}$$

Aggregation across households and goods:

We define $\sum_j b_j(.) = \mathbb{E}_j(.)$, and given the assumption of fixed assets and purely transitory shocks, Proposition 5 defines

$$d\ln C = \sum_j b_j d\ln C_j = \sum_j b_j \sum_h \omega_h d\ln c_{hj}$$

Then, using Equation (85) and aggregating consumption across households we have:

$$\begin{aligned} d\ln C = \sum_j b_j d\ln C_j = \mathbb{E}_{h,j}\Big[MPC_j\Big(P^N\big(d\hat{Y}^N\big) + P^T\big(d\hat{Y}^T\big) + dP^N\big(\hat{Y}^N\big) + dP^T\big(\hat{Y}^T\big)\Big)\Big] \\ + \mathbb{E}_{h,j}\big[MPC_j a^R\big]d\ln P^N + \mathbb{E}_{h,j}\big[MPC_j P^N_{t+1} a^R_{t+1}\big]d\ln R \\ - \mathbb{E}_{h,j}\big[MPC_j b_j\big]d\ln P^j + \sigma\mathbb{E}_{h,j}\big[\big(b_j - 1\big)\big]d\ln P^j - \mathbb{E}_{h,j}\big[\tilde{\sigma}_j M\tilde{P}S\big]d\ln R \end{aligned} \tag{86}$$

B.5 Solution method

As it was discussed in the main text, our model incorporates two key elements that make the computation of transition dynamics difficult. First, household heterogeneity represented by idiosyncratic income risk and borrowing constraints, and second, non-homothetic CES preferences. We face those challenges by extending the computation method in Auclert, Bardóczy, Rognlie and Straub (2021) to incorporate non-homothetic CES preferences. The important aspect of this methodology is that it first-order linear approximates the aggregates, but it preserves the nonlinearities related to idiosyncratic shocks and borrowing constraints at the household level that are essential to capture the income effect associated with non-homothetic CES preferences. Another advantage of this methodology is that the equilibrium is written in the sequence space, making it more efficient and accurate in computational terms.[69]

First, we compute the steady state. We discretize the asset states into a finite grid of 500 assets and calibrate a Markov chain such that idiosyncratic income risk approximates an AR(1).[70] We assign endowment of tradable proportional to idiosyncratic income risk. At the household level, the intratemporal and intertemporal optimality conditions are modified by non-homothetic CES preferences. Then, taking prices as given by households, we obtain policy functions by using endogenous grids.[71] Then, using backward and forward iteration, we obtain steady-state policies and asset distribution.

Our solution method for general equilibrium relies on the computation of Sequence-Space Jacobians that correspond to the derivatives of equilibrium mappings between aggregate sequences around the steady state. These jacobians are sufficient statistics that summarize every aspect relevant to the general equilibrium model, including the evolution over time of the distribution of agents. Then, assuming perfect foresight for aggregates, the sequence space can be written as the solution to a nonlinear system: $H(U, Z) = 0$ where U is the aggregate path of unknown sequences and Z is exogenous shocks. Under certain assumptions, impulse response functions come from the implicit function theorem as $dU = -H_U^{-1} H_Z dZ$. Then, the difficulty in applying this method is finding the jacobians H_U and H_Z.

An essential contribution of Auclert, Bardóczy, Rognlie and Straub (2021) is a fast algorithm to compute the previously indicated jacobians by applying the chain rule and ordering in a specific manner the system of equations to compute the solution. By exploiting the linearized structure of the heterogeneous agent problem around the steady-state, it provides a critical speed improvement related to the typically used method

[69]Several additional computational methods exist to solve heterogeneous agents with aggregate shocks. One of the first methods was *approximate aggregation* by Krusell and Smith (1998), which indicates that it is possible to summarize the wealth distribution by a small set of moments. Similarly, Winberry (2018) approximates the distribution with a flexible parametric function family. An alternative method was proposed by Reiter (2009) and combines elements of projection method and perturbation around the steady state to solve the model numerically. In addition, Ahn et al. (2018) uses a mix of finite difference methods and perturbation. Finally, similarly to Auclert, Bardóczy, Rognlie and Straub (2021), Boppart et al. (2018) also uses sequence space to avoid large state space systems; however, iteration over guesses may not guarantee convergence.

[70]The functional form for cyclical income risk is specified in Section **??**.

[71]See Carroll (2006).

(Direct method) by a factor of about T, where T is about 300 typically. For instance, Auclert, Bardóczy, Rognlie and Straub (2021) shows that in a typical Krusell-Smith model (Krusell and Smith, 1998), the computing time for jacobians with the Direct method is 21 seconds, while the method they propose (Fake News method) is 0.086 seconds.