Title

Essays on Monetary and International Economics

Author

Cabezas, Luis Agustin

Publication Date

2024

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA

Los Angeles

Essays on Monetary and International Economics

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Economics

by

Luis Agustin Cabezas Venegas

2024

ABSTRACT OF THE DISSERTATION

Essays on Monetary and International Economics

by

Luis Agustin Cabezas Venegas

Doctor of Philosophy in Economics
University of California, Los Angeles, 2024
Professor Andrew G. Atkeson, Chair

This dissertation contains three essays on monetary and international economics. In the first chapter, I study massive drops in household consumption 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 decreases as much as tradable. Then, employing micro-data, I show that the previous result is motivated by high-income households who concentrate their expenditure on non-tradable. Moreover, expenditure share in non-tradable increases with income level, reflecting non-homotheticities. Based on this evidence, I build a new open economy framework that combines a Heterogeneous Agent New Keynesian structure and non-homothetic CES preferences and allows for reconciling micro and macro evidence of the Mexican 1994-peso crisis. Moreover, a novel result emerges: The propagation of disturbances across economic sectors through household consumption decisions is asymmetric, depressing production more when it starts in the tradable sector.

In the second chapter (with Bernardo Candia and Youyou Xu), we use detailed microdata from Chile to analyze the role of currency invoicing for exchange rate pass-through (ERPT) at the border and the store at different time horizons. At the border, we find a predominant role

for the USD for ERPT; however, bilateral exchange rates matter for longer time horizons. For imports, the bilateral ERPT is higher for consumption goods, while for exports, it is higher for non-consumption goods. Next, at the store, we show that exchange rate fluctuations do not affect retail prices on impact, consistent with sticky prices set in the consumer's currency. For longer time horizons, as nominal rigidities ease, bilateral and USD exchange rates affect store prices at a lower rate than at the border.

In the third chapter (with Luis Felipe Cespedes and Patricio Toro), we study whether changes in market competition were a significant driver of the post-pandemic global inflation episode. We empirically assess how firm's markups reacted to high inflation episodes in the last two decades and whether local markets' competitiveness can explain this relationship beyond changes in demand. Using detailed microdata for OECD countries and a staggered difference-in-difference approach, we show that the last inflation episode was different from previous ones. Markups reacted more, and changes in demand were less significant in explaining this reaction. Instead, market competitiveness appears to have played a more significant role through larger firms in relatively more concentrated sectors, which increased less in jurisdictions with stricter antitrust regulations.

The dissertation of Luis Agustin Cabezas Venegas is approved.

Ariel T. Burstein

Sebastian Edwards

Oleg Itskhoki

Andrew G. Atkeson, Committee Chair

University of California, Los Angeles

2024

To my wife and son, for infinite love and support;

To my parents and brother

Contents

List of Figures

List of Tables

ACKNOWLEDGMENTS

I will forever thank Andrew G. Atkeson for his great encouragement and advice. I deeply thank Ariel T. Burstein and Oleg Itskhoki for their continual support and guidance. I especially thank Sebastian Edwards for his unconditional support over the years.

I want to thank all the faculty in the macroeconomics field at UCLA, particularly Lee Ohanian, for support and discussions, and Saki Bigio, Joao Guerreiro, and Pierre-Olivier Weill for their useful comments and suggestions.

I would also like to thank Andres Blanco, Alvaro Boitier, Akira Ishide, Federico Mandelman, Fatih Ozturk, and Mariano Palleja for their great discussions and suggestions. I am also grateful to my coauthors, Bernardo Candia, Luis Felipe Cespedes, Patricio Toro, and Youyou Xu, for their invaluable contributions. The views and conclusions expressed in Chapter 3 are those of the authors and do not necessarily represent the views of the Central Bank of Chile or its board members.

VITA

Luis Agustin Cabezas Venegas

Education

Universidad de Chile

M.A. in Economics 2012-2013

Universidad de Chile

B.A. in Economics 2008-2011

Research in Progress

Large Devaluations, Heterogeneous Consumption Adjustments, and Macroeconomic Implications

Exchange Rate Pass-Through and Invoicing Currency: Different Patterns at the Border and the Store (with Bernardo Candia and Youyou Xu)

Firms' price setting and market power during episodes of high inflation (with Luis Felipe Cespedes and Patricio Toro)

Articles

Exchange rate pass-through, monetary policy, and real exchange rates: Iceland and the 2008 crisis (with Sebastian Edwards). Open Economies Review, Vol. 33 (2), pp. 197-230, 2022.

Accumulation of reserves in emerging and developing countries: mercantilism versus insurance (with Jose De Gregorio). Review of World Economics, 155, pp. 819-857, 2019.

International banking and cross-border effects of regulation: Lessons from Chile (with Alejandro Jara). International Journal of Central Banking, 13(S1), 95-127, 2017.

Relevant Positions

Federal Reserve Bank of Atlanta

Dissertation Fellowship	Summer 2023

Central Bank of Chile

Dissertation Internship	Summer 2023
Junior Economist	2014-2018

University of California Los Angeles (UCLA)

Teaching Fellow	2022-2024
Graduate Student Researcher, Sebastian Edwards	2019-2024

Universidad de Chile

Research Assistant for Manuel Agosin	2013-2014

Scholarships and Awards

Internal scholarship, graduate studies, UCLA	2019-2024
Summer Fellowship, UCLA	2020
Excellence scholarship, foreign graduate studies, ANID	2020-2022
Excellence scholarship, foreign graduate studies, Central Bank of Chile	2018-2020
Graduated with highest honors, Master of Economics, Universidad de Chile	2014
Excellence scholarship, domestic graduate studies, CONICYT	2013-2014
Circle of Academic Excellence, undergraduate, Universidad de Chile	2008-2011

Chapter 1

Large Devaluations, Heterogeneous Consumption Adjustments, and Macroeconomic Implications

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 of amplification in consumption decline produced by the interaction between heterogeneous expenditure share across household 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, 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

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

preferences is tightly connected 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.

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. The opposite is observed for non-tradable: It increases as income 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. 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

---

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

[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.

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 combining a heterogeneous agent structure and non-homothetic CES preferences is essential to replicating 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 approximates household expenditure share in tradable and total consumption share allocation across households to Mexico in 1994.[6]

[4]The departure point is the canonical open economy model with two sectors in Schmitt-Grohe 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.

[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).

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 can still reproduce the current account reversal. Consequently, the heterogeneous agent open economy model, combined with non-homothetic CES, is a powerful device that reproduces 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

[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).

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, involuntary unemployment in non-tradable was the equilibrium response under nominal rigidities. 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.

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

Related literature. Our paper relates to several strands of literature. First, a large body of literature in international macroeconomics studies business cycles in emerging markets and sudden stops. This is associated with theories explaining the interaction between macroeconomic fluctuations' sources and key mechanisms. 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 (Cespedes, 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 crisis, even in the absence of a

[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 (Cravino and Levchenko, 2017).

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, Bardoczy, 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

[12] Cugat (2018) first reported changes in aggregate consumption of tradable and non-tradable with microdata 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.

(Guo, et al., 2023), exchange rate regimes (Oskolkov, 2023), fiscal devaluations (Giagheddu, 2020), and the business cycle (Hong, 2020).[13] 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.[14] 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.[15]

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, 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. concludes.

[13] Our paper also closely relates to a growing body of literature that embeds non-homothetic CES preferences into HANK models in closed economies to study fiscal and monetary policy transmission (Garcia, et al., 2023; Schaab and Tan, 2023).

[14] 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).

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

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

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 (2014), 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.[16] In those cases, devaluation in terms of the bilateral exchange rate with the US and nominal effective exchange rate (NEER) is more than 40%.[17] According to national account data, consumption in Mexico and Iceland are at 2015 constant prices; for Thailand, it is chain volume with the reference year 2002.

[16] See more details related to aggregate data and selection of these countries in Appendix 7.1.

[17] According to Burstein and Gopinath (2014) 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%.

Figure 1.1 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.[18] As will be shown below, the combination of large devaluation and a contraction of GDP can be associated with an important decline in the consumption of tradable and non-tradable.

Figure 1.1: 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.

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-

[18]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).

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:

$$d \ln C_t^T - d \ln C_t^N = d \ln P_t^N - d \ln P_t^T \tag{1.1}$$

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.[19]

Figure 1.2 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%.[20] In this case, according to Equation (1.1), almost a 20% higher tradable consumption fall than non-tradable is expected.

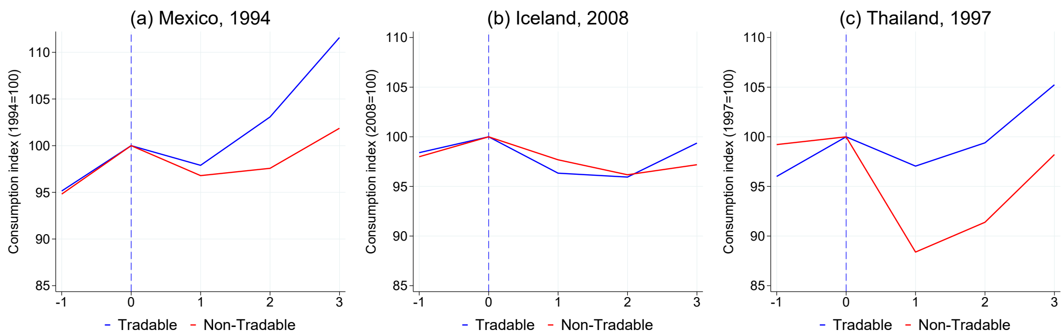
Figure 1.2 panel (a) shows that for Mexico in 1994, the opposite is observed. Although there are about 2% differences between relative consumption change in tradable and non-tradable after one year of the devaluation, the magnitude order is at least one level below, and the sign is opposite the expected. Under homothetic preferences, this empirical observation is inconsistent with cobb-douglas preferences. Even assuming the

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

[19] Appendix 7.4 derives the household problem with CES preferences.

[20] Data from Burstein and Gopinath (2014).

Figure 1.2: Consumption of tradable and non-tradable during 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.

usually uses 0.5.[21]

Figure 1.2 panels (b) and (c) show the same exercise for Iceland in 2008 and Thailand in 1997. After one year of devaluation, Iceland showed 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, the 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 tradable depends on relative prices and elasticity of substitution as follows:

[21] Appendix 7.2 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.

$$d \ln b_{T,t} = (1 - \sigma)(d \ln P_t^T - d \ln P_t) \tag{1.2}$$

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 previously discussed, under a large devaluation, exchange rate pass-through implies that tradable prices increase 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 1.3: Expenditure share of tradable during 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, the expenditure share in tradable goods is expected to increase after the large devaluation.

Again, first, we focus on Mexico in 1994, at the aggregate level, and the results are in Figure 1.3 Panel (a). The results show an increase in the expenditure share of tradable goods. They 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 incompatible with cobb-douglas preferences as expenditure share does not change with relative prices under those preferences.[22] 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 matching either stylized facts 1 or 2 is impossible. 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.

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, 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 ideal for reconciling 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

[22] Appendix 7.2 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.

those at the aggregate level described in the previous section.

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).[23] 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.[24]

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.[25] 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

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

[24] See Appendix 7.1 for a detailed description of this survey data.

[25] See Appendix 7.1 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).

reflects the economic condition before and after. Finally, expenditures in each good or service are deflated by October of the same year's product-level price to construct the consumption index.[26]

Episode overview and identification strategy

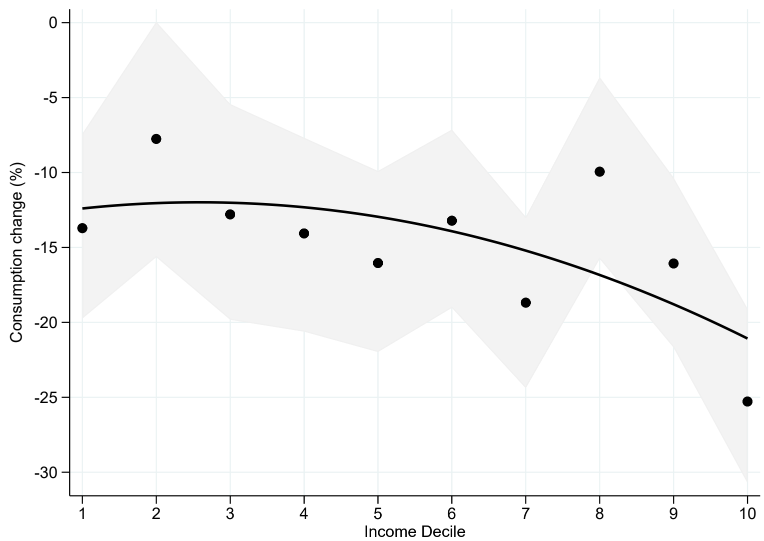
In December 1994, a small devaluation announced by the Mexican government quickly became a huge event that affected Mexican output, consumption, and the economic performance of other emerging markets. At the beginning of December 1994, the new Mexican government, headed by President Zedillo, took office 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, the 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 left Mexico and 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.

[26] 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.

Figure 1.4 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, reflecting that this economic crisis affected households with different income profiles.[27]

Figure 1.4: Aggregate consumption change by income decile in Mexico, 1994-1996



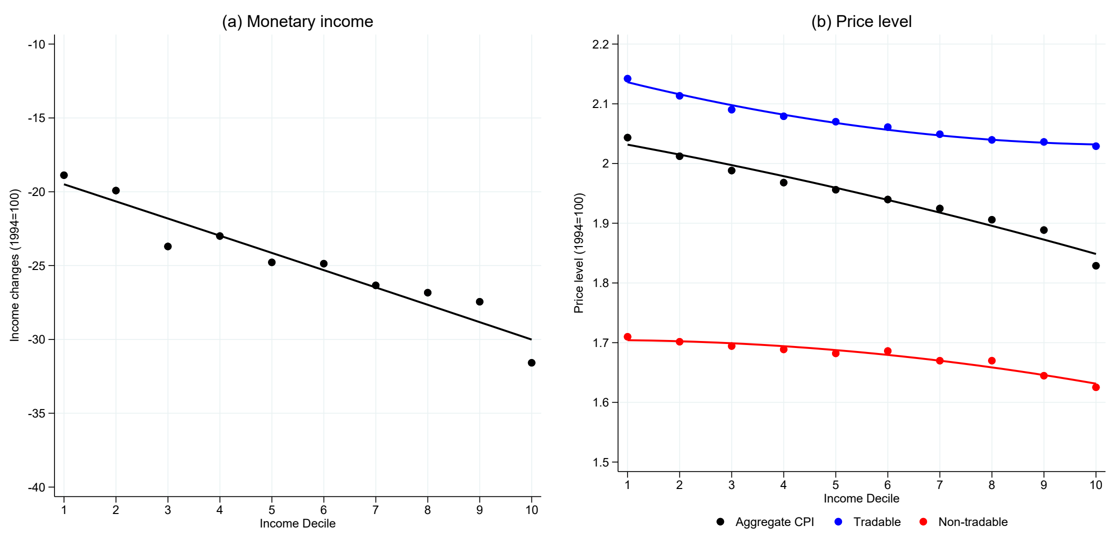
Note: This figure shows the total aggregate household consumption growth between 1994 and 1996 per household income decile. The shaded gray area corresponds to 90% confidence intervals, estimated using a bootstrap with 1000 replications.
Source: ENIGH-INEGI.

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.

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

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 income was severely damaged. Figure 1.5 Panel (a) shows real monetary income across income deciles.[28] The first two deciles decreased monetary income by nearly 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 other economic crises in advanced economies (Aguiar and Bils, 2015).

Figure 1.5: Monetary income change and price level by 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).

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

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

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 1.5 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 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.

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.[29] Then, we compare the synthetic cohorts across time, before and after the devaluation episode.

Figure 1.6 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

is about 8% consumption decline. Although there is heterogeneity, it shows that tradable consumption for higher-income households declined by more.[30]

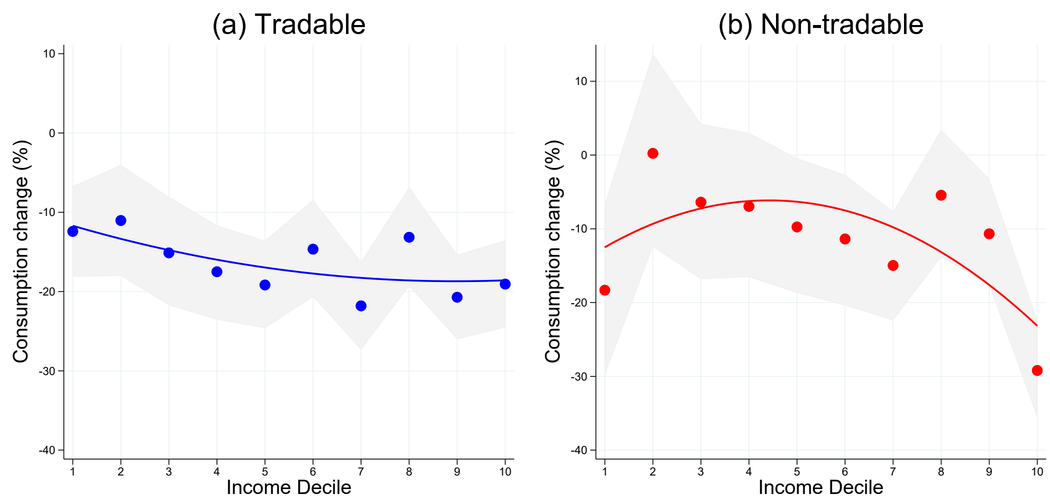
Non-tradable consumption change is in Figure 1.6 panel (b). In this case, the first income decile shows an important decline of 18%, while the last one is 29%. If we consider the third to tenth income decile, we observe a declining pattern in consumption, as was the case for tradable goods. However, the results are similar to U-shape behavior across the income distribution. [31] 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.

[29] 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 7.2 for an additional discussion.

[30] In appendix 7.2, 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.

[31] 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 7.2.

Figure 1.6: Household consumption change for tradable and non-tradable by 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 a bootstrap with 1000 replications.
Source: ENIGH-INEGI.

Another characteristic that reveals Figure 1.6 is that non-tradable consumption presents 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.[32]

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 in-

[32] Consumption inequality is explored in more detail in Appendix 7.2.

stance, 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.[33] 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 1.7 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 spend a larger portion of their income 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.[34] It implies that Engel curves are non-linear across households with different income levels and reveals the presence of non-homotheticicities in this economy.[35]

---

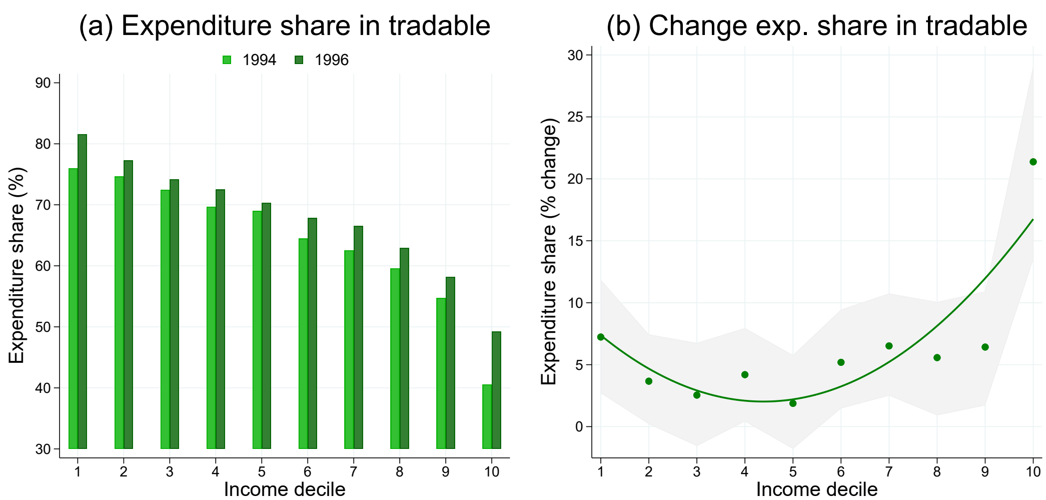
[33]It implies that expenditure share in tradable directly reflects patterns in expenditure share in non-tradable.

[34]Appendix 7.2 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.

[35]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.

Panel (b) of Figure 1.7 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, the share in tradable goods increases. We can observe in Panel (b) that the first and last deciles present a higher increase than other deciles. The underlying factor that motivates this decline is a higher drop in non-tradable consumption. 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 1.7: Expenditure share in tradable by 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 formally analyze 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,

$$ExpShare_{Th,t} = \beta_0 Post_t + \beta_1 Income_{q,t} + \beta_2 Post_t \times Income_{q,t} + \Gamma X_{h,t} + \epsilon_{hj,t} \tag{1.3}$$

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 we should not observe a significant increase in expenditure shares in tradable goods absent the devaluation. Then, controlling by household level characteristics, income level reflects exposure to shock.

Table 1.1 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 1.7 and stylized fact 2 at the household level, i.e., after the devaluation, expenditure share in tradable goods increases and is statistically significant. Column (2) evaluates the hypothesis that expenditure share changes across different income quintiles. The results confirm the observation in Figure 1.7 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 1.7 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.[36]

Table 1.1: 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 × $Post_t$			-0.0525***	-0.0242*
			(0.0072)	(0.0124)
Quintile 3 × $Post_t$			-0.0977***	-0.0339***
			(0.0074)	(0.0122)
Quintile 4 × $Post_t$			-0.1384***	-0.0223*
			(0.0072)	(0.0123)
Quintile 5 × $Post_t$			-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 (1.3) for expenditure share in tradable as dependent variable. It includes household-level control variables and population weights.

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.[37]

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

[37] To make a sharp difference, we can think about low b_L^T versus high-income households b_H^T. Under CES

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.[38] 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.[39]

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.

preferences, in level $b_L^T = b_H^T = \omega_T^\sigma\big(\frac{P^T}{P}\big)^{1-\sigma}$, 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.

[38] 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).

[39] 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.

3.1 Households and non-homothetic CES preferences

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, Bardoczy, 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,

$$\mathbb{E}_t \sum_t \beta^t v\Big(\mathcal{C}_t(E_t; \mathbb{P}_t)\Big) \tag{1.4}$$

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 $a' \geq \underline{a}$.

Then, consumer budget constraint is,

$$P_t^N c_{hN,t} + P_t^T c_{hT,t} + a_{h,t+1} = \Big(1 + r_t\Big) a_{h,t} + W_t n_{h,t} e_{h,t} + P_t^T Q_{h,t}^T e_{h,t} \tag{1.5}$$

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,

$$1 = \omega_T^{\frac{1}{\sigma}} \mathcal{C}^{\frac{\gamma_T - \sigma}{\sigma}} c_T^{\frac{\sigma-1}{\sigma}} + \omega_N^{\frac{1}{\sigma}} \mathcal{C}^{\frac{\gamma_N - \sigma}{\sigma}} c_N^{\frac{\sigma-1}{\sigma}} \tag{1.6}$$

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:

$$E_t(\mathbb{P}_t, \mathcal{C}_t) = \left[\sum_j \omega_j \mathcal{C}_t^{\gamma_j - \sigma} P_{jt}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{1.7}$$

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

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

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

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

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

$$a' \geq 0$$

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 $\mathcal{C}$.

Non-homothetic CES versus homothetic CES preferences

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

$$b_{hjt} = \frac{P_{jt} c_{hjt}}{E_{ht}} = \frac{\omega_j \mathcal{C}_{ht}^{\gamma_j - \sigma} (P_{jt})^{1-\sigma}}{\sum_{j'} \omega_{j'} \mathcal{C}_{ht}^{\gamma_{j'} - \sigma} (P_{j't})^{1-\sigma}} = \frac{\omega_j \mathcal{C}_{ht}^{\gamma_j - \sigma} (P_{jt})^{1-\sigma}}{E_{ht}^{1-\sigma}} \tag{1.8}$$

We can linearize Equation (1.8) such that a change in expenditure share for good j is:[40]

$$d\log b_{hj} = (1-\sigma)\Bigg[\underbrace{\Big(d\log P_j - \mathbb{E}_h(d\log P_j)\Big)}_{\text{Price effect}} + \underbrace{(\frac{\gamma_j - \sigma}{\mathbb{E}_h(\gamma - \sigma)} - 1)\Big(d\log E_h - \mathbb{E}_h(d\log P_j)\Big)}_{\text{Real income effect}}\Bigg] \tag{1.9}$$

Where for a given variable x_h, $\mathbb{E}_h(x) = \sum_h b_h x_h$. Now, we can compare it to the expenditure share of good j in standard homothetic CES:

$$b_{hjt} = \frac{P_{jt} c_{hjt}}{E_{ht}} = \frac{\alpha_j P_{jt}^{1-\sigma}}{\sum_{j'} \omega_j'^{\sigma} P_{j't}^{1-\sigma}} = \frac{\alpha_j P_{jt}^{1-\sigma}}{P_t^{1-\sigma}} \tag{1.10}$$

We can linearize Equation (1.10) such that a change in expenditure share for good j is:

[40]See Appendix 7.4 for derivation.

$$d \log b_{hj} = (1-\sigma) \underbrace{\Big(d \log P_j - d \log P\Big)}_{\text{Price effect}} \tag{1.11}$$

Three key differences arise from comparing homothetic and non-homothetic CES: First, there are no differences across households in standard homothetic CES.[41] 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.[42] Third, price effect changes across households in non-homothetic cases.[43]

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:

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

Each household is assumed to produce 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:

---

[41] 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.

[42] 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 effects appear 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.

[43] 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.

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

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:

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

3.2 Firms

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:

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

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

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:

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

$$\text{s.t.} \quad y_{jt} = Z_t n_{jt}$$

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

$$\phi_t^F = \frac{\mu}{\mu-1}\frac{1}{2\kappa}\Big[\log(1+\pi_{Nt})\Big]^2 Y_t$$

Notice that the firm's production function 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_{jt}^N, and it produces the New-Keynesian Phillips curve:

$$\log(1+\pi_{Nt}) = \kappa\left(\frac{W_t}{P_t^N Z_t} - \frac{1}{\mu}\right) + \frac{1}{1+r_t}\frac{Y_{t+1}}{Y_t}\log(1+\pi_{Nt+1})$$

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

$$d_t = Y_t - \frac{W_t}{P_t^N} N_t - \frac{\mu}{\mu-1}\frac{1}{2\kappa}\Big[\log(1+\pi_{Njt})\Big]^2 Y_t \tag{1.12}$$

Financial sector

The financial sector closely follows across the lines of Auclert, Bardoczy, 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 (1.12), 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^*, which 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_{t+1}^p. 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:

$$1 + i_t = (1 + i_t^*)\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \tag{1.13}$$

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

$$1 + r_t = (1 + i_t)\frac{P_t}{P_{t+1}} \tag{1.14}$$

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

$$1 + r_t = 1 + r_{t+1}^p = \frac{p_{t+1} + d_{t+1}}{p_t} \tag{1.15}$$

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 $NFA_t = A_t - p_t$.

3.3 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 $\pi_t = \frac{P_t}{P_{t-1}} - 1$

3.4 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:

$$\mathcal{C}_t = \int \mathcal{C}_t(a,e) d\Psi_t(a,e) \tag{1.16}$$

$$\mathcal{A}_t = \int a_t(a,e) d\Psi_t(a,e) \tag{1.17}$$

$$\mathcal{N}_t = \int e n_t(a,e) d\Psi_t(a,e) \tag{1.18}$$

$$\Psi_{t+1}(\mathcal{A}, e') = \int \Pi(e,e')\Psi_t(a,e) \tag{1.19}$$

The appendix 7.4 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:

$$Y_t = C_{N,t} + \phi_t^F \tag{1.20}$$

3.5 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 requiring 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. This assumption aims 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, which is 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-Grohe 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).[44]

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”.

3.6 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.

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

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

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 (1.8) to construct an empirical counterpart to consistently estimate income elasticity and elasticity of substitution. The challenge is that we need to define a baseline sector to estimate relative income elasticity parameters.[45] In our case, we assign the tradable sector as the base sector as we have only two sectors. The empirical model corresponds to the ratio between non-tradable and tradable in Equation (1.8) as follows,

$$\ln\left(\frac{b_{hNt}}{b_{hTt}}\right) = \ln\left(\frac{\omega_{hN}}{\omega_{hT}}\right) + (\gamma_N - \gamma_T)\ln(\mathcal{C}_{ht}) + (1-\sigma)\ln\left(\frac{P_{hNt}}{P_{hTt}}\right) + \varepsilon_{ht} \tag{1.21}$$

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

[45]Structural change literature has assumed an economy with three sectors and assigned one sector as a base, typically the manufacturing sector (Comin, et al., 2021).

Bils, 2015). To deal with this, we use the total household income as an instrument and the economic sector where household heads work. Household-level prices can suffer from a similar problem. As robustness, we instrument prices 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 (1.2) 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 results similar to those of the previous columns. Finally, column (6) considers instrumental variables for real total monetary expenditure and prices, and the results remain stable.[46]

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 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 (1.8), then taking the difference to the mean across goods and services we have,

[46]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).

Table 1.2: 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 control variables such as 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.

$$\ln(b_{hjt}) - \overline{\ln(b_{ht})} = \ln(\omega_{hj}) - \overline{\ln(\omega_h)} + (\gamma_j - \overline{\gamma}) \ln(\mathcal{C}_{ht}) + (1-\sigma)(\ln P_{hjt} - \overline{\ln P_{ht}}) + \hat{\varepsilon}_{ht} \tag{1.22}$$

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.[47]

Table 1.3 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 the instrumental variable income elasticity for non-tradable in column (2), it is 0.15 versus tradable with -0.18. Then, the results using this second strategy complement the first one and confirm

[47]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 1.3: 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 household head age, household size, income recipients, and location as control variables. 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%.

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. Labor income is assumed to follow 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, Bardoczy, 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 1.8 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.

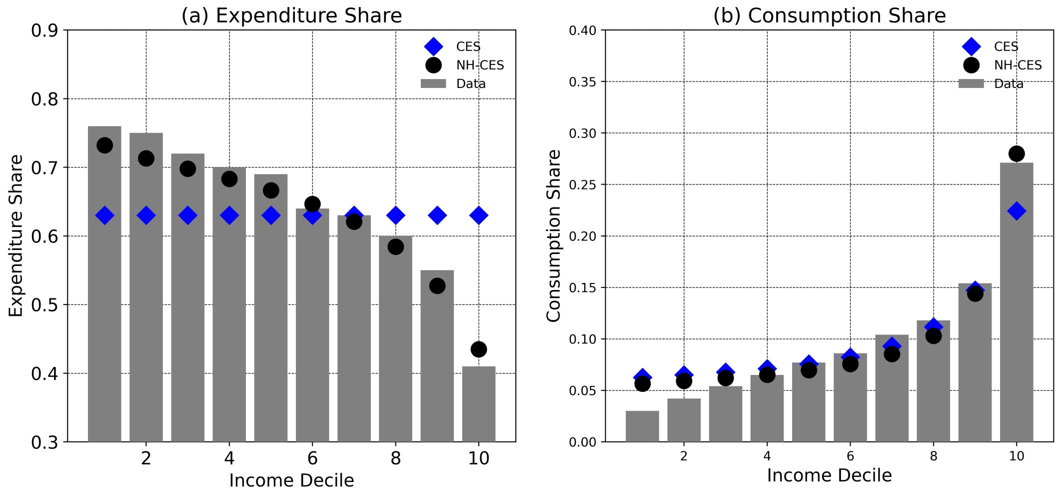
In contrast, the homothetic CES structure follows a horizontal line in the aggregate level of the expenditure share of 63%.

Figure 1.8 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.[48]

Remainder aggregate calibration. The calibration of the parameters closely follows the current HANK open economy literature. It takes some parameters directly from the literature, and others are internally calibrated to match micro and macro moments (see Table 1.4). 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.

[48]MPCs are not targeted in our model. Appendix 7.3 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)).

Figure 1.8: Comparison of steady-state 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 in 1994.
Source: ENIGH-INEGI.

Table 1.4: 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

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.[49] 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 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, Bardoczy, 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, borrowing constraints, and non-homothetic CES preferences.[50]

Figure 1.9 shows dynamic transitions for consumption of non-tradable and tradable a 15 % increase in foreign interest rate. Panel (a) results show a stark contrast between the model with non-homothetic CES and homothetic CES preferences. As was predicted for

[49] 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).

[50] See Appendix 7.5 for additional details of the solution method.

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.

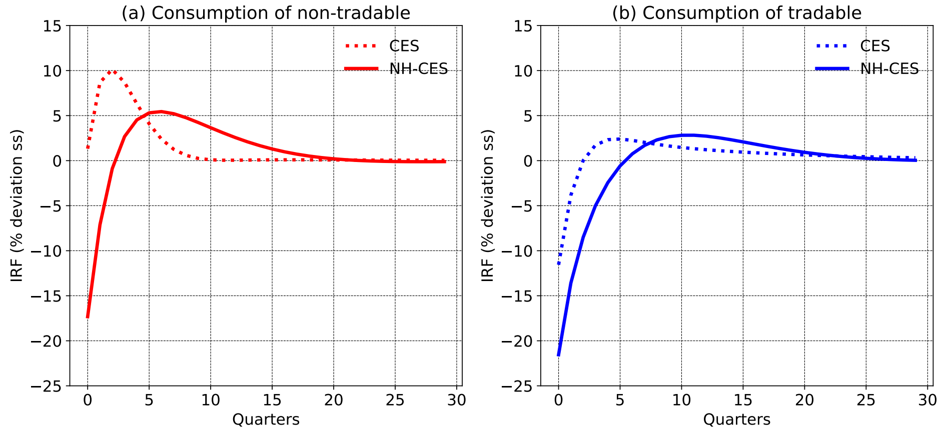
Panel (b) shows the result for tradable consumption. As was expected in both cases, with and without homotheticities, consumption decreases due to the high price effect induced during a devaluation. What is different in this case is that non-homothetic CES preferences produce an additional amplification 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 the consumption of non-tradable and tradable, which is very close to the micro-data of consumption.

Figure 1.10 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 1.9 and Figure 1.10 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.[51]

Figure 1.11 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)

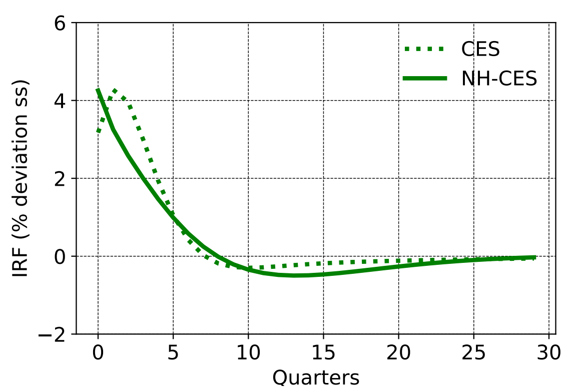
[51] As it was discussed in our calibration section, Comin, et al. (2021) use a difference between income elasticities of services and agriculture equal to 1.15, and in Rojas and Saffie (2022) is 4. Our baseline calibration uses a difference between non-tradable and tradable equal to 0.8.

Figure 1.9: 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.

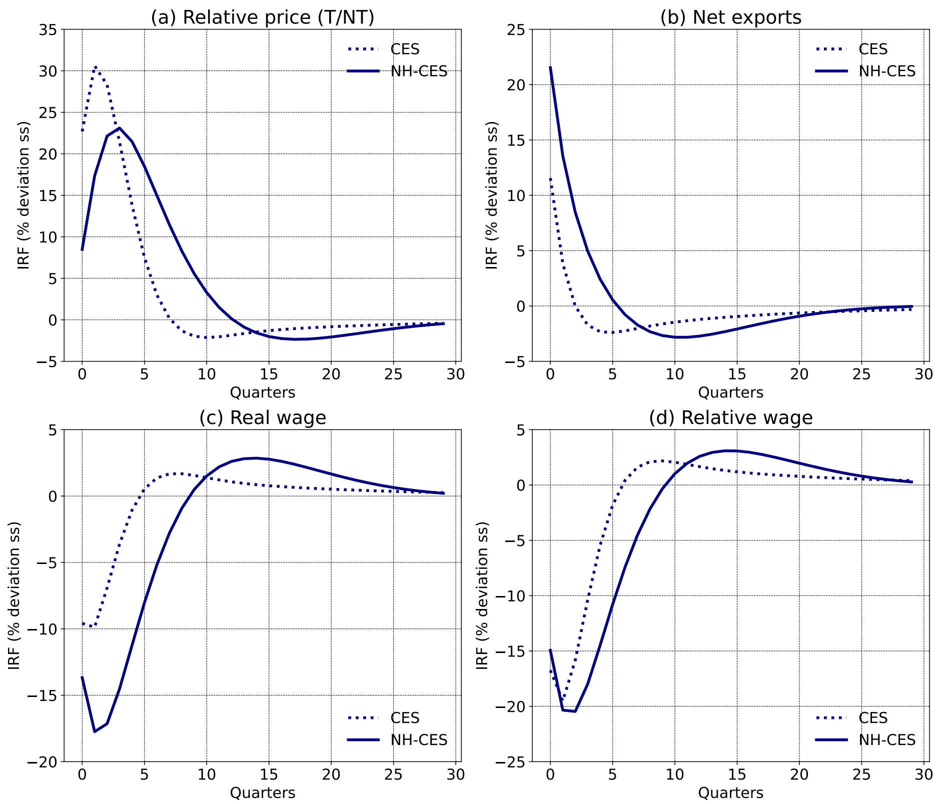
Figure 1.10: Expenditure share in tradable responses



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.

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,

Figure 1.11: 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.

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.[52]

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 7.3, we replicate Figure 1.9, and 1.10 for a representative agent model with homothetic CES preferences. The results

[52] In Appendix 7.3, 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 cases.

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.”

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.[53]

[53]This idea is similar to Keynesian supply shock by Guerrieri, et al. (2022) in a multisector closed economy. The key difference is that in an open economy framework, the tradable sector can export domestically unsold

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 of Schmitt-Grohe 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 (2.11).

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.[54] Non-homothetic CES preferences are assumed to be the same as in previous sections and determined by Equation (1.6). Then, consumer budget constraint is

$$P_t^N C_{N,t} + P_t^T C_{T,t} + \mathcal{E}_{t+1} A_{t+1}^* = \left(1 + r_t^*\right) \mathcal{E}_t A_t^* + W_t N_t + P_t^T Q_t^T + \Pi_t^N \tag{1.23}$$

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

goods; however, the non-tradable sector has a bottleneck if the domestic economy is depressed.

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

$$P_t^T = \mathcal{E}_t P_t^{T*} = \mathcal{E}_t \tag{1.24}$$

Household optimality conditions under the previous assumptions correspond to choose sequences of $C_{N,t}, C_{T,t}, A^*_{t+1}$ that maximizes (2.11) subject to (1.6) and (2.12). Then, intratemporal optimality condition implies that

$$\frac{P^N}{P^T} = \left(\frac{\omega_N}{\omega_T}\right)^{\frac{1}{\sigma}} \left(\frac{C_{T,t}}{C_{N,t}}\right)^{\frac{1}{\sigma}} \mathcal{C}_t^{\frac{\gamma_N - \gamma_T}{\sigma}} \tag{1.25}$$

Equation (1.25) 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

$$P_t^N = \frac{W_t}{F'(h_t)} \tag{1.26}$$

The supply schedule in this economy comes from this pricing condition, as we are not assuming non-tradable price rigidities. Rearranging condition (1.26), then we have

$$\frac{P^N}{P^T} = \frac{W_t/\mathcal{E}_t}{F'(F^{-1}(y_t^N))} \tag{1.27}$$

Using Equations (1.25) and (1.27), 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 $\tilde{w} \equiv W/\mathcal{E}$ 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.*

$$\frac{\frac{\partial \tilde{w}^{NH-CES}}{\partial r^*}}{\frac{\partial \tilde{w}^{CES}}{\partial r^*}} = 1 + (\gamma_N - \gamma_T)\frac{\partial \log \mathcal{C}_t}{\partial \log E}\frac{\partial \log E}{\partial \log C^T} \tag{1.28}$$

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 7.4.

The intuition for Proposition 1 is as follows. A negative shock to foreign interest rates decreases the households' purchasing power of tradable goods originating from 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.[55]

[55] 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 7.4 shows that our result also extends to endowment shock.

Figure 1.11 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, this result is no longer true under non-homothetic preferences, 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.

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 non-tradable consumption produces a lower*

response of relative wages under non-homothetic compared to homothetic preferences.

Proof. See Appendix 7.4.

Applying Proposition 2 to the Mexican devaluation 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 damage emerging markets with open economies.

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 7.4.

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 the interaction between MPCs and heterogeneous expenditure shares due to non-homotheticities generates additional consumption decline.

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.*

$$\begin{aligned} d\ln c_{hj} = & \underbrace{MPC_{hj}\Big(dP^N\left(\hat{Y}_h^N\right) + P^N\left(d\hat{Y}_h^N\right) + dP^T\left(\hat{Y}_h^T\right) + P^T\left(d\hat{Y}_h^T\right)\Big)}_{\text{Income channel}} \\ & + \underbrace{MPC_{hj}\left(\hat{a}_h^R\right)d\ln P^N}_{\text{Fisher channel}} + \underbrace{MPC_{hj}\left(P_{t+1}^N \hat{a}_{ht+1}^R\right)d\ln R}_{\text{Interest rate exposure}} \\ & - \underbrace{MPC_{hj}\left(b_{hj} d\ln P^j\right)}_{\text{Expenditure channel}} + \underbrace{\sigma\left(b_{hj}-1\right)d\ln P^j}_{\text{Price Substitution}} - \underbrace{\hat{\sigma}_{hj} M\hat{P}S_h d\ln R}_{\text{Intertemporal Substitution}} \end{aligned} \tag{1.29}$$

Proof. See Appendix 7.4.

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).[56] 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 (1.8) 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 CES preferences, so only scale up or down the MPCs. This new term produces additional amplification in consumption, which decreases when the 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 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 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* $d\ln C$*:*

[56] Refer to Auclert (2019) for a complete analysis of these effects. Appendix 7.4 shows the derivation.

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

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

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:

$$\begin{aligned} d \ln C_j = {} & \mathbb{E}_h \Big[MPC_j \Big(P^N \big(d\hat{Y}^N \big) + P^T \big(d\hat{Y}^T \big) + dP^N \big(\hat{Y}^N \big) + dP^T \big(\hat{Y}^T \big) \Big) \Big] \\ & + \mathbb{E}_h \Big[MPC_j \hat{a}^R \Big] d \ln P^N + \mathbb{E}_h \Big[MPC_j P^N_{t+1} \hat{a}^R_{t+1} \Big] d \ln R \\ & - \mathbb{E}_h \Big[MPC_j b_j \Big] d \ln P^j + \sigma \mathbb{E}_h \Big[b_j - 1 \Big] d \ln P^j - \mathbb{E}_h \Big[\hat{\sigma}_j M\hat{P}S \Big] d \ln R \end{aligned} \tag{1.30}$$

Proof. See Appendix 7.4.

Proposition 5 characterizes the consumption change aggregate responses for sectoral consumption and aggregate consumption.[57] The first term in the third line in Equation (1.30) 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

[57] Appendix 7.4 shows the full decomposition for $d \ln C$.

1994, we approximate them through consumption-income elasticities.[58] 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 (1.30). Assuming a price elasticity of substitution σ equal to 0.5, the estimated price substitution is 0.23.[59] In consequence, in relative terms, in the data, this term can 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.[60]. 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 in explaining 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.

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

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

[60] See the discussion in Section 3.6. In Appendix 7.3 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.

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

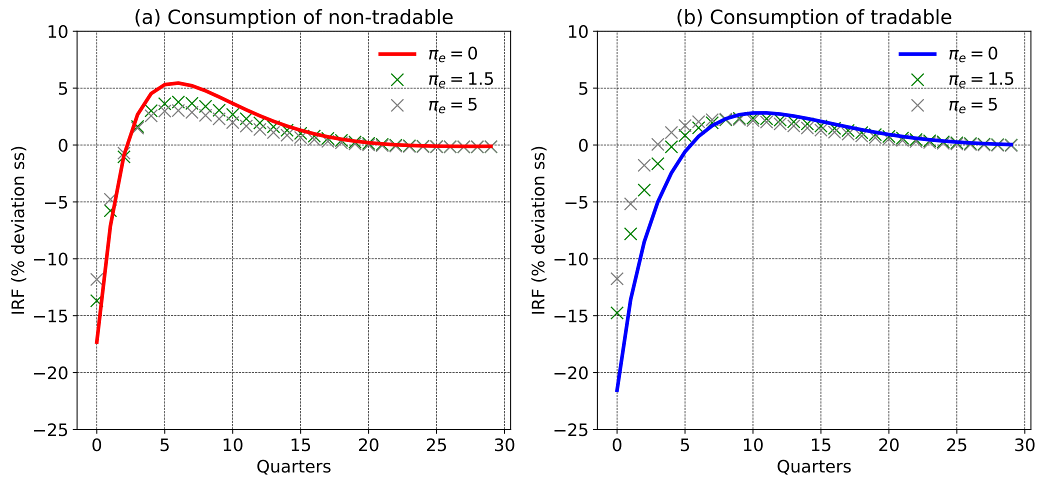
$$i_t = r_{ss} + \alpha_\pi \pi_t + \alpha_\mathcal{E} \pi_{\mathcal{E}t} + \epsilon_t$$

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 return 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 1.12 shows consumption response for non-tradable and tradable under fear of floating. This exercise shows that controlling exchange rate devaluation can decrease consumption decline.[61] 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.

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

Figure 1.12: 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 for explaining the propagation of shocks originating in the tradable sector through household consumption decisions to the non-tradable sector. 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, Bardoczy, Rognlie and Straub, 2021) 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.

7. Appendix

7.1 Data description

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. This section describes 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; 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 goods correspond to services according to this classification.

This classification is used to make the different countries comparable and is compatible with the classification used by the 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 (2014) 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 of available data, it is not true that both stylized facts appear simultaneously, as a strong real income decline is required for this effect to appear, which is associated with different income elasticities. Korea is not considered in the analysis.

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.[62] We use data between 1992-2020, focusing 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

[62] 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.

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.[63] Tradable goods included are non-durable consumption: food, non-alcoholic beverages, cleaning and personal care products, oil, gas, medical, and related education products. Non-tradable services include non-durable services, including 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.[64]

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 household head's education, household size, number of income perceptors, and region of residence.

[63]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.

[64]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 7.2 for further discussion.

7.2 Additional empirical exercises

Changes in consumption across goods distribution

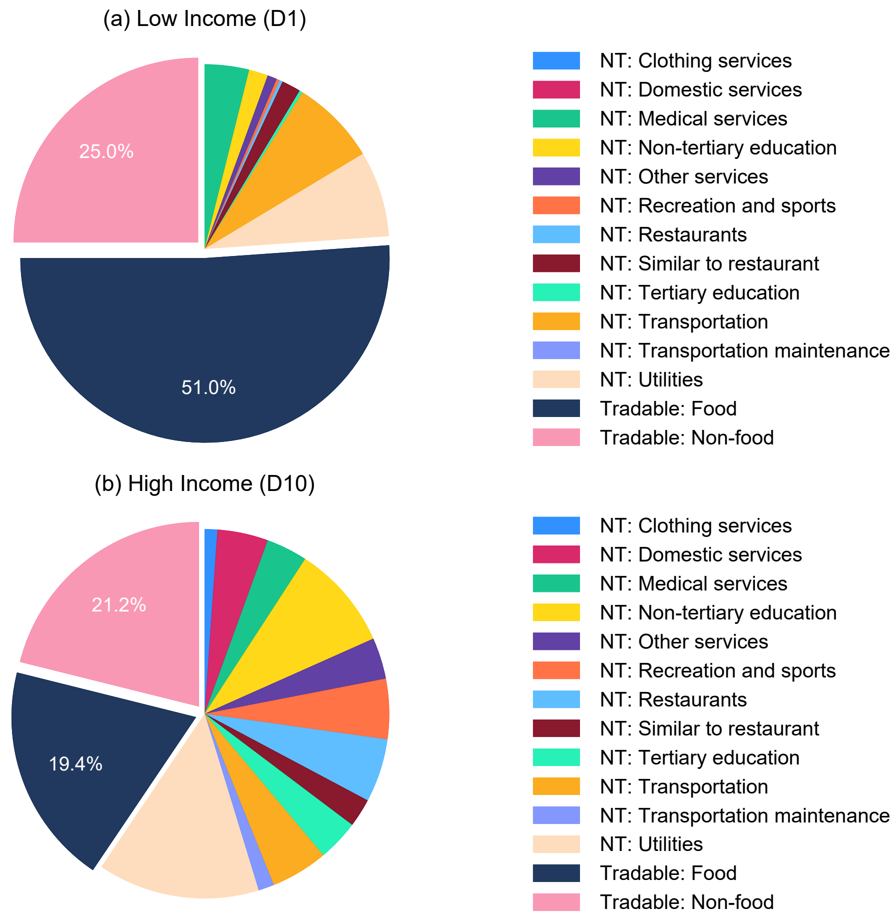
This appendix studies consumption at a higher level of disaggregation of goods. The first exercise compares consumption decline across household income decile and opens up tradable in food and non-food and non-tradable in utility and non-utility. Then, the second exercise aggregates consumption per good 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 $c_{kd,t} \equiv \sum_{h \in \mathcal{I}_{d,t}} c_{kh,t}$, where $c_{kh,t}$ is the consumption for good or service k, for household h of income decile d. After that, we opened 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.

In the main text, we show that expenditure shares in tradable and non-tradable changes for low and high-income households. In Figure 1.13, we show expenditure shares at a higher level of disaggregation for low and high-income households. The main opening is in non-utilities for non-tradable. In Panel (a) for low-income households, non-utilities are less than 25%, and the main components are transportation, medical services, and non-tertiary education. In contrast, in Panel (b) for high-income households, non-utilities are less than 45%, and the main components are non-tertiary education, restaurants, and recreation and sports.

Now, we examine changes in consumption. Figure 1.14 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

Figure 1.13: Expenditure share in goods and services for first and tenth income decile in Mexico, 1994

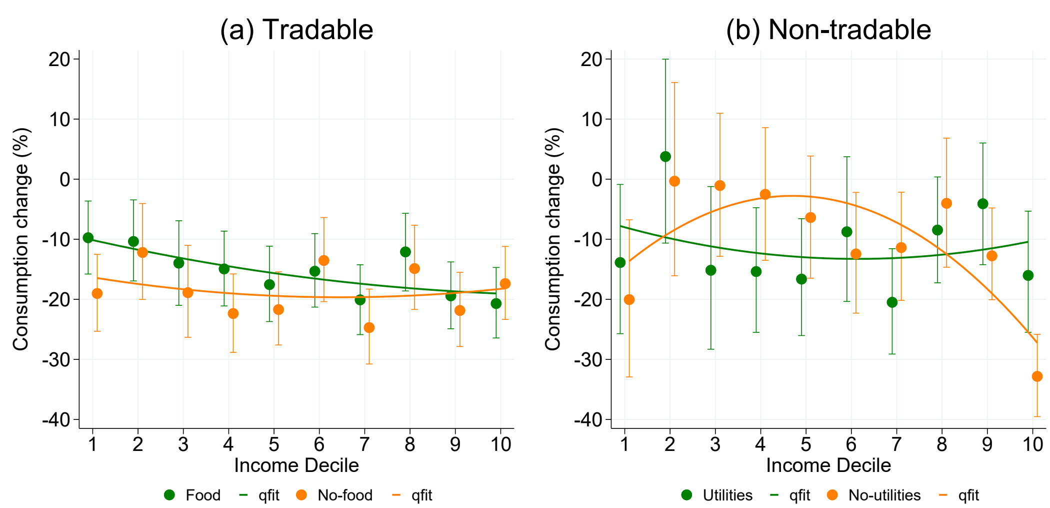


Note: This figure shows a higher disaggregation of expenditure share in tradable food, non-food, and non-tradable in utility and non-utility in 1994. Moreover, it opens up non-utilities in non-tradable in the main categories. Panel (a) shows the expenditure share for the first household income decile. Panel (b) shows the expenditure share for the tenth household income decile.
Source: ENIGH-INEGI.

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 1.14 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 1.6 is not coming from the decline in utilities consumption, and it is mainly motivated by non-utilities.

Figure 1.14: Consumption change for tradable and non-tradable by 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 a bootstrap with 1000 replications.
Source: ENIGH-INEGI.

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 1.15 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.

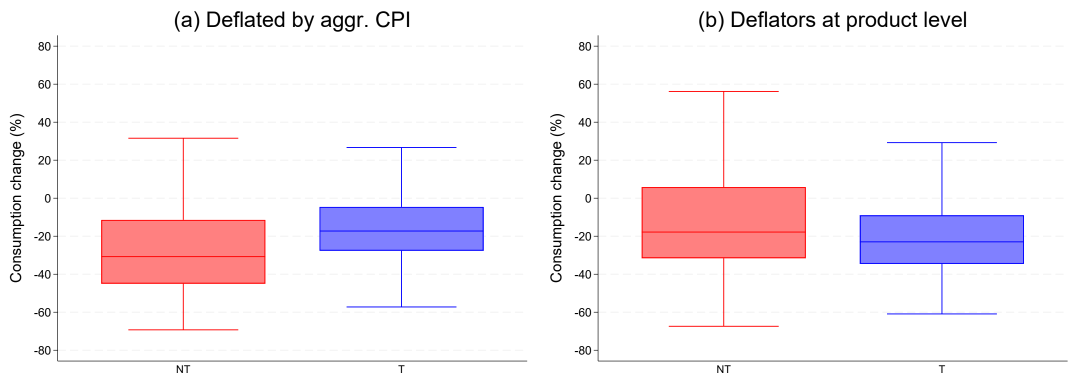
Finally, Figure 1.15 Panel (b) shows the results when we deflate expenditure for the price of each good or service in the consumer bundle. This is the Benchmark deflator we used in the empirical section because this is the most conservative way to show our results. The results indicate that the median 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.

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 concentrate expenditure on non-tradable.

Table 1.5 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

Figure 1.15: Consumption change across goods distribution by tradable and non-tradable in Mexico, 1994-1996



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.

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.[65]

Table 1.5 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.

[65]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).

Table 1.5: Share of expenditure by each household group

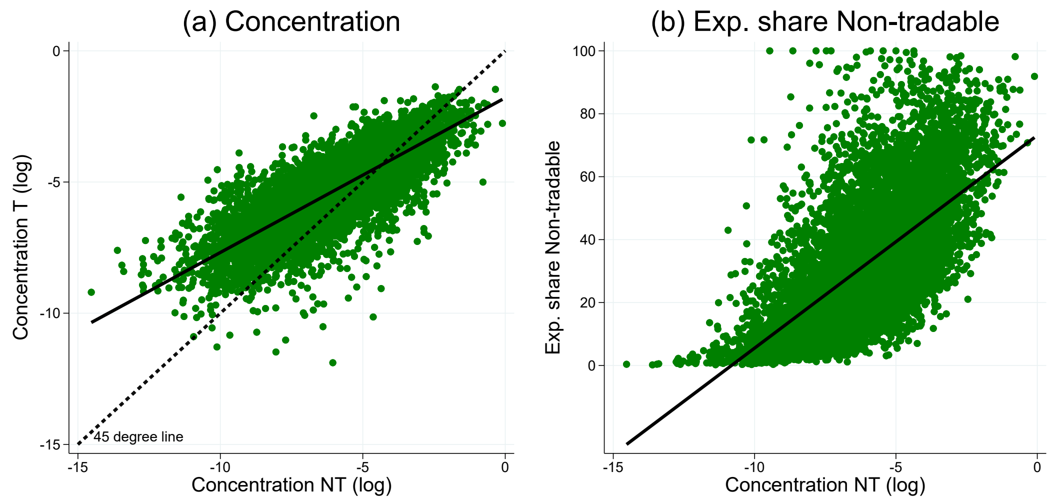
	1994			1996		
	Total Expenditure	Tradable	Non-Tradable	Total Expenditure	Tradable	Non-Tradable
Poorest 10%	0.040	0.018	0,017	0.034	0.044	0.018
Poorest 20%	0.072	0.094	0.044	0.083	0.103	0.050
Poorest 40%	0.190	0.240	0.127	0.211	0.252	0.146
Richest 20%	0.425	0.338	0.535	0.387	0.326	0.485
Richest 10%	0.271	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 1.16 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 concentrations of non-tradable concentrate more than those with tradable. Moreover, Figure 1.16 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 this happens in 3 out of 10 deciles, and the tenth decile exhibits the highest decline with almost 30%

Figure 1.16: 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.

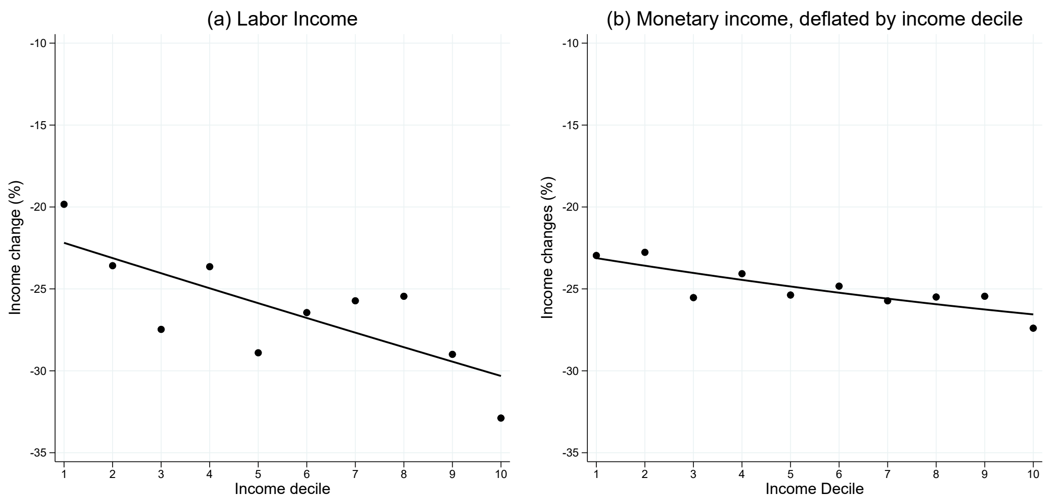
Monetary and labor income changes in Mexico 1994

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

In Figure 1.17 Panel (a), we show household labor income change between 1994 and 1996 per household income decile in Mexico. The main text shows a strong declining pattern for monetary income as the income decile increases. Monetary income includes labor and business incomes, rents, transfers, and other incomes. Panel (a) shows that labor incomes also decline in percentage terms for every income decile. A declining pattern is still observed as the income decile increases, with the highest income decile having the most significant drop. In this case, the pattern is noisier, with households' income deciles seventh and eighth being more similar to lower than median income deciles.

In Figure 1.17 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 1.17: Labor and monetary income change by income decile in Mexico, 1994-1996



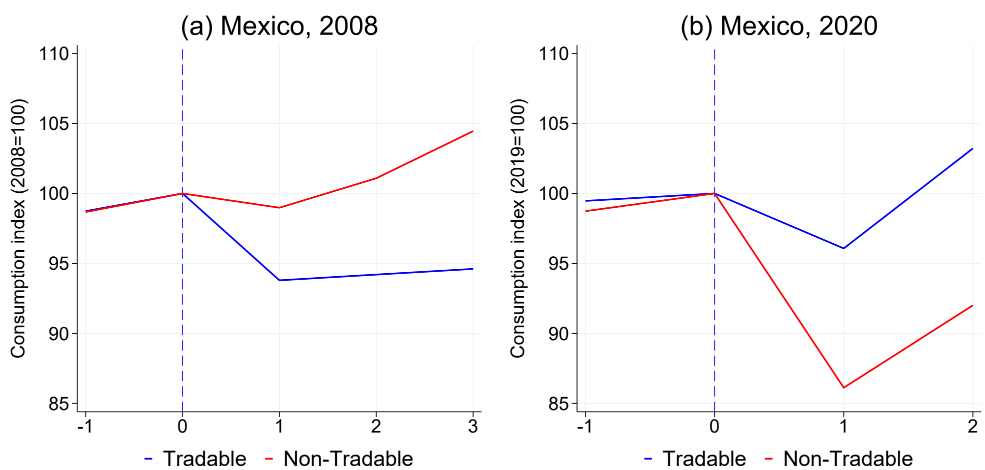
Note: Panel (a) shows the percentage change in household labor income change between 1994 and 1996 per household income decile. Aggregate CPI deflates it. Panel (b) shows the percentage change in household monetary income change between 1994 and 1996 per household income decile. CPI for every decile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

Additional robustness, Mexico in 1994. 2008, and 2020

In this section, we compare the aggregate consumption of tradable and non-tradable goods and the expenditure share of tradable goods 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 goods in Mexico.

First, in Figure 1.18, 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%.[66] 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 explain observed consumption patterns. However, it does not help with pandemics, an economic crisis that started in the non-tradable sector and is mainly associated with massive lockdowns nationwide.

Figure 1.18: Consumption of tradable and non-tradable of sudden stops with large devaluations



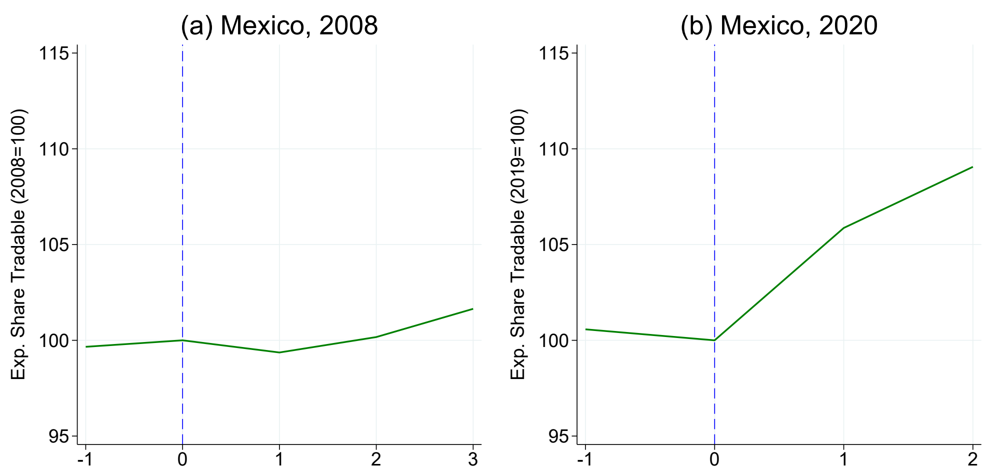
Note: This figure shows the real aggregate household consumption index for tradable and non-tradable for Mexico in 2008, 2020 in annual frequency. The real aggregate household consumption index equals 100 in the year starting the economic crisis. The vertical segmented blue line equals zero in the year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

As for consumption changes, we compare expenditure share in tradable in different crisis episodes in Mexico. Figure 1.20 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

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

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.

Figure 1.19: Expenditure share of sudden stops with large devaluations

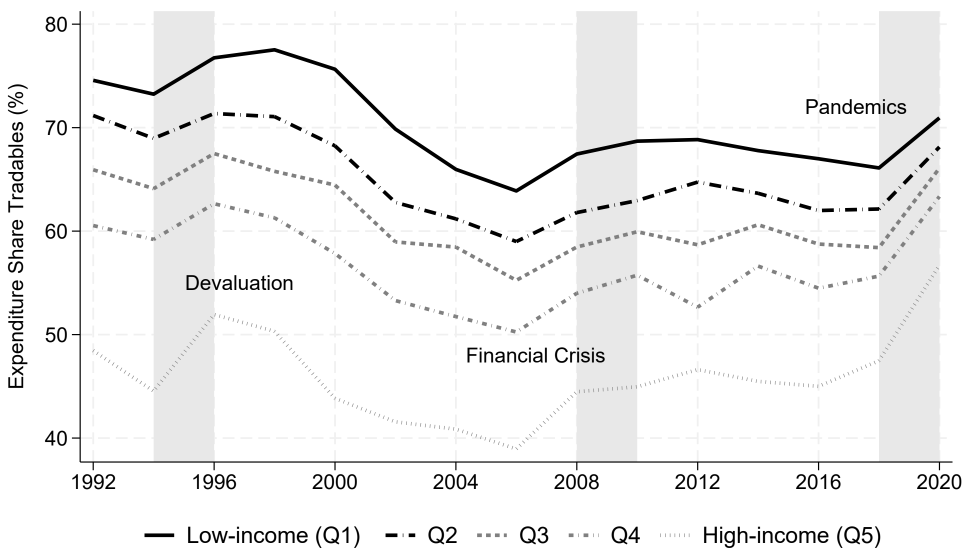


Note: This figure shows the expenditure share in the tradable index for Mexico in 2008, 2020 in annual frequency. The expenditure share in the tradable index equals 100 in the year starting the economic crisis. The vertical segmented green line equals zero in the year starting the economic crisis.
Sources: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

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.[67] The highest increase is observed during the pandemic, mainly motivated by a decrease in non-tradable consumption.

[67]Expenditure survey was raised at the end of 2008 and at the end of 2010 for the Global Financial 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 1.20: Expenditure share of tradable in Mexico by income quintile, 1992-2008

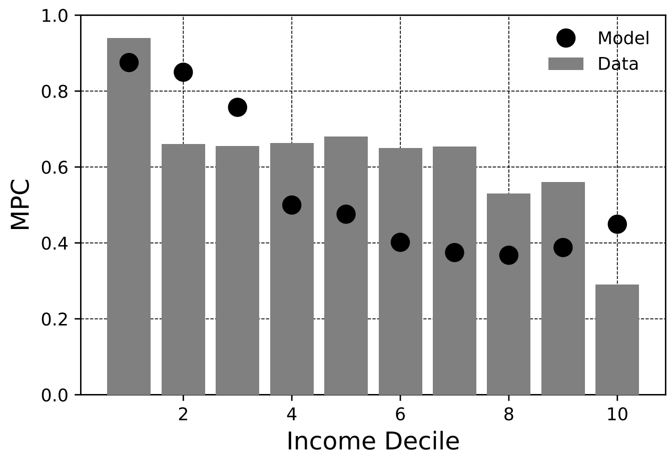


Note: This figure shows the expenditure share in tradable for Mexico by income quintile between 1992-2020in 2008, 2020 in annual frequency. The vertical gray area reflects the economic crisis in Mexico, the Devaluation in 1994, the Global Financial Crisis in 2008, and the Pandemic in 2020. *Sources*: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

7.3 Additional quantitative exercises

Marginal propensities to consume for total consumption in the model

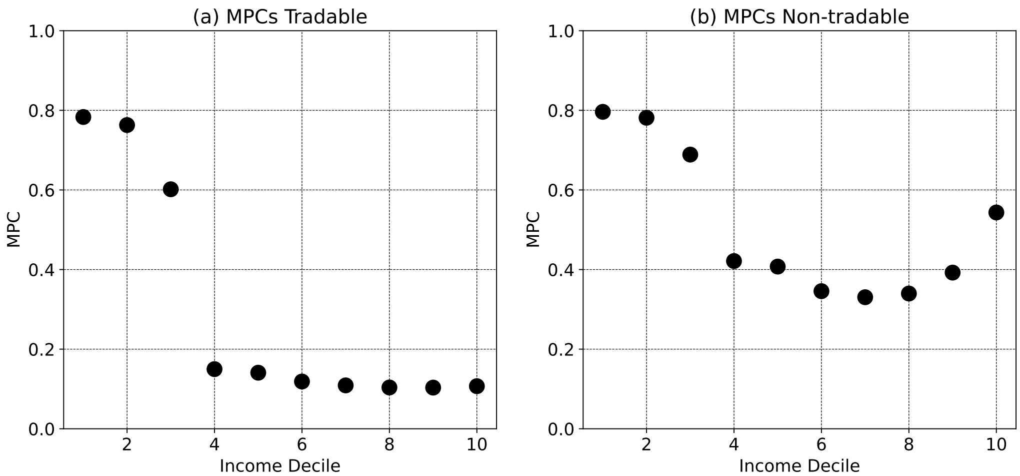
Figure 1.21: Marginal propensity to consume (MPC) for total consumption



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).

Marginal propensities to consume for tradable and non-tradable consumption

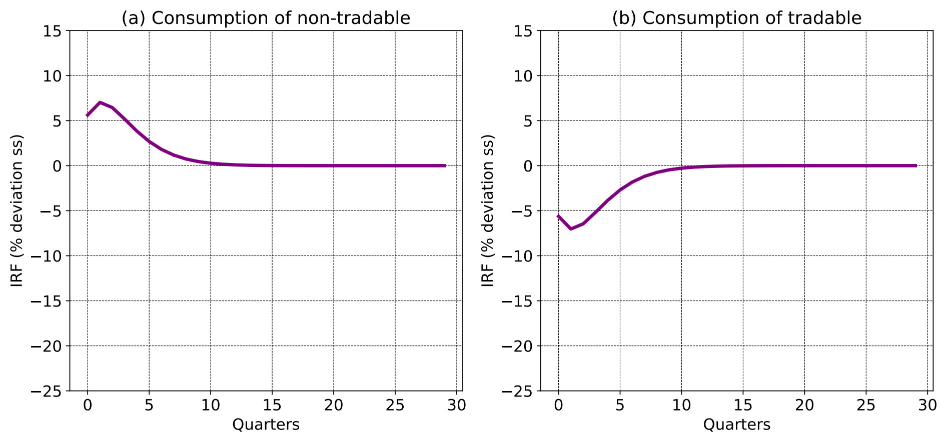
Figure 1.22: Marginal propensity to consume (MPC) for tradable and non-tradable



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

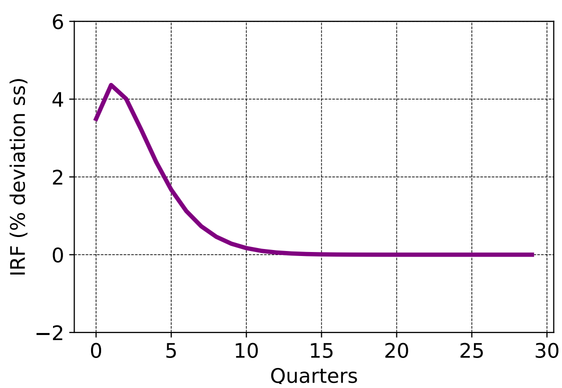
Simulations with a representative agent model with homothetic CES

Figure 1.23: 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 1.24: Expenditure share in tradable responses



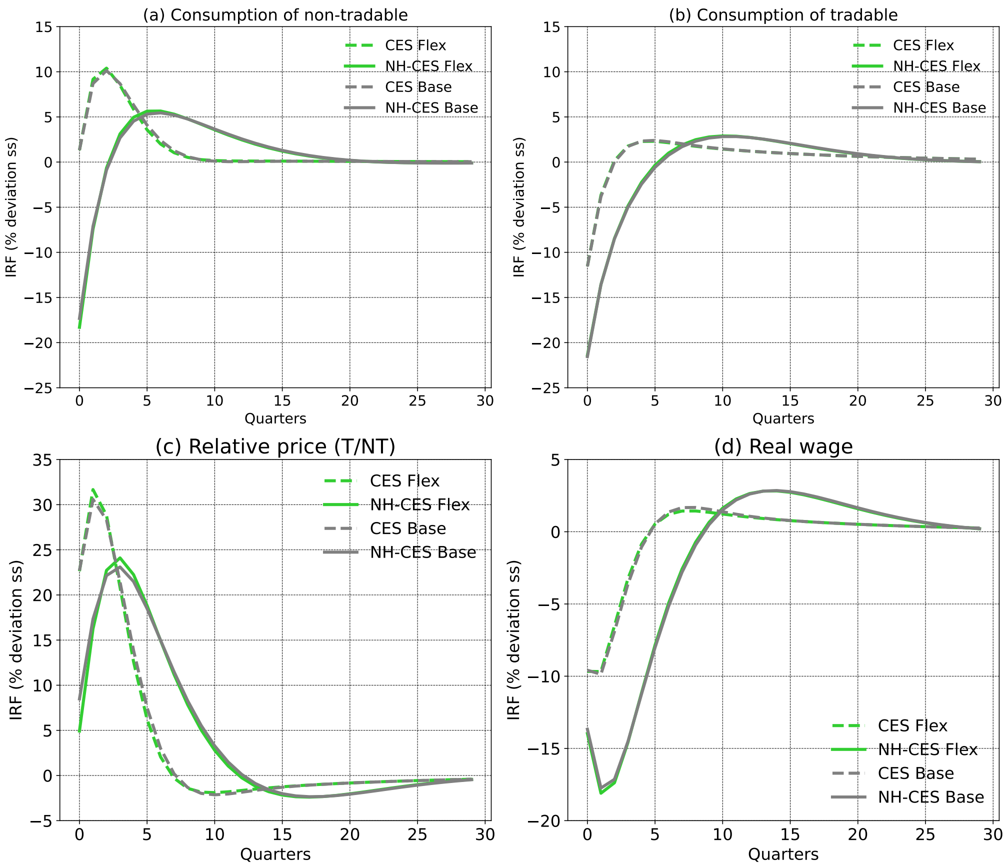
Note: Impulse response of expenditure share in tradable in the homothetic CES representative agent model to 15% increase in foreign interest rate.

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 for our main results.

We modify nominal rigidities to make prices in the non-tradable sector more flexible. Figure 1.25 shows the response in consumption. Panel (a) results show that non-tradable consumption is more affected than 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 1.25: 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 ($\kappa = 0.9$).

7.4 Additional model details and proofs

Representative agent, 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 problems:

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

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:

$$\frac{C_t^T}{C_t^N} = \left(\frac{P_t^N}{P_t^T} \frac{\omega}{1-\omega}\right)^{\sigma} \tag{1.31}$$

Then, taking log differences to Equation (1.31), the relationship between tradable and non-tradable consumption and relative prices is:

$$d \ln C_t^T - d \ln C_t^N = \sigma (d \ln P_t^N - d \ln P_t^T) \tag{1.32}$$

Assuming the elasticity of substitution σ equals one, we have the Equation (1.1) 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:

$$b_{jt} = \frac{\omega_j^{\sigma} P_{jt}^{1-\sigma}}{P_t^{1-\sigma}} \tag{1.33}$$

Then, taking log differences to Equation (1.33), we obtain the Equation (1.2) in the text.

Household proofs

To derive expenditure shares in Equation (1.8) let's start from $\frac{\partial E}{\partial P_j}$ where expenditure was defined in Equation (1.7),

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

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

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

$$\frac{\partial \log E}{\partial \log P_j} = \frac{\omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}{\sum_j \omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}} \tag{1.34}$$

Then, Equation (1.8) directly follows from Equation (1.34),

$$b_{hjt} = \frac{\partial \log E_t(\mathbb{P}_t, \mathcal{C}_t)}{\partial \log P_{jt}} = \frac{\partial E_t(\mathbb{P}_t, \mathcal{C}_t)}{\partial P_{jt}} \frac{P_{jt}}{E_t(\mathbb{P}_t, \mathcal{C}_t)} = \frac{\omega_j \mathcal{C}_t^{\gamma_j-\sigma} P_{jt}^{1-\sigma}}{E} \tag{1.35}$$

To derive Equation (1.9), a couple of additional steps are required. Applying log difference to expenditure share:

$$d \log b_j = (1-\sigma)\Big(d \log P_j - d \log E\Big) + (\gamma_i - \sigma) d \log \mathcal{C} \tag{1.36}$$

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

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

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

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

$$\frac{\partial \log E}{\partial \log \tilde{\mathcal{C}}} = \frac{1}{1-\sigma} \sum_j b_j (\gamma_j - \sigma) > 0 \tag{1.37}$$

Taking log difference to expenditure function and using Equation (1.37), we have:

$$d \log E - \mathbb{E}_b(d \log P) = \frac{\sum_j b_j (\gamma_j - \sigma)}{1-\sigma} d \log \mathcal{C} \tag{1.38}$$

Finally, replacing $d \log \mathcal{C}$ in Equation (1.38) into Equation (1.36):

$$d \log b_j = (1-\sigma)\Big(d \log P_j - d \log E\Big) + (\gamma_j - \sigma) \frac{1-\sigma}{\mathbb{E}_b(\gamma - \sigma)} \Big(d \log E - \mathbb{E}_b(d \log P)\Big) \tag{1.39}$$

Rearranging this expression, we have Equation (1.9).

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:

$$\frac{P_t^N}{P_t} C_{N,t} + \frac{P_t^T}{P_t} C_{T,t} + A_{t+1} = (1 + r_{t+1}^p) A_t + w_t N_t + \frac{P_t^T}{P_t} Q_t^T \tag{1.40}$$

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,

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

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

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

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

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

Proof Propositions

Proof Proposition 1

Proof. Starting from Equations (1.25) and (1.27) and market clearing in non-tradable sector,

$$\tilde{w}_t \equiv \frac{W_t}{\mathcal{E}_t} = \left(\frac{\omega_N}{\omega_T}\right)^{\frac{1}{\sigma}} C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{1-\frac{1}{\sigma}} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}} \tag{1.41}$$

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

$$\left(\frac{\omega_N}{\omega_T}\right) = \left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)\bar{\mathcal{C}}_t^{\frac{\gamma_N-\gamma_T}{\sigma}} \tag{1.42}$$

Derive Equation (1.41) respect r^*,

$$\frac{\partial \tilde{w}_t^{NH}}{\partial r^*} = \left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} \frac{1}{\sigma} C_{T,t}^{\frac{1}{\sigma}-1} C_{N,t}^{1-\frac{1}{\sigma}} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}} \frac{\partial C_{T,t}}{\partial r^*} + \tag{1.43}$$

$$\left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{1-\frac{1}{\sigma}} \frac{\gamma_N-\gamma_T}{\sigma} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}-1} \frac{\partial \mathcal{C}_t}{\partial C_t^T} \frac{\partial C_{T,t}}{\partial r^*} \tag{1.44}$$

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

$$\frac{\partial \tilde{w}_t^{H}}{\partial r^*} = \left(\frac{\omega_N}{\omega_T}\right)^{\frac{1}{\sigma}} \frac{1}{\sigma} C_{T,t}^{\frac{1}{\sigma}-1} C_{N,t}^{1-\frac{1}{\sigma}} \frac{\partial C_{T,t}}{\partial r^*} \tag{1.45}$$

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

$$\frac{\frac{\partial \tilde{w}^{NH}}{\partial r^*}}{\frac{\partial \tilde{w}^{H}}{\partial r^*}} = 1 + (\gamma_N - \gamma_T) C_T \mathcal{C}^{-1} \frac{\partial \mathcal{C}}{\partial E} \frac{\partial E}{\partial C^T} \tag{1.46}$$

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 (1.37), we have that

$$\frac{\partial \log E}{\partial \log \mathcal{C}} = \frac{1}{1-\sigma} \sum_j b_j(\gamma_j - \sigma) > 0 \tag{1.47}$$

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. □

Proof Proposition 2

Proof. Again, let's assume that non-homothetic and homothetic CES demand conditions coincide in a steady state. Moreover, 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 (1.41) respect C^T,

$$\frac{\partial \tilde{w}_t^{NH}}{\partial C^T} = \left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} \frac{1}{\sigma} C_{T,t}^{\frac{1}{\sigma}-1} C_{N,t}^{1-\frac{1}{\sigma}} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}} + \tag{1.48}$$

$$\left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{1-\frac{1}{\sigma}} \frac{\gamma_N - \gamma_T}{\sigma} \mathcal{C}_t^{\frac{\gamma_N-\gamma_T}{\sigma}-1} \frac{\partial \mathcal{C}_t}{\partial C_t^T} \tag{1.49}$$

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

$$\frac{\partial \tilde{w}_t^{H}}{\partial C^T} = \left(\frac{\omega_N}{\omega_T}\right)^{\frac{1}{\sigma}} \frac{1}{\sigma} C_{T,t}^{\frac{1}{\sigma}-1} C_{N,t}^{1-\frac{1}{\sigma}} \frac{\partial C_{T,t}}{\partial C^T} \tag{1.50}$$

Then, we have

$$\frac{\frac{\partial \tilde{w}^{NH-CES}}{\partial C^T}}{\frac{\partial \tilde{w}^{CES}}{\partial C^T}} = 1 + (\gamma_N - \gamma_T) \frac{\partial \log \mathcal{C}_t}{\partial \log E} \frac{\partial \log E}{\partial \log C^T} \tag{1.51}$$

For the non-tradable sector, derive Equation (1.41) respect to C^N,

$$\frac{\partial \tilde{w}_t^{NH}}{\partial C^N} = \left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} \left(1 - \frac{1}{\sigma}\right) C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{-\frac{1}{\sigma}} \mathcal{C}_t^{\frac{\gamma_N - \gamma_T}{\sigma}} + \tag{1.52}$$

$$\left(\frac{\tilde{\omega}_N}{\tilde{\omega}_T}\right)^{\frac{1}{\sigma}} C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{1-\frac{1}{\sigma}} \frac{\gamma_N - \gamma_T}{\sigma} \mathcal{C}_t^{\frac{\gamma_N - \gamma_T}{\sigma} - 1} \frac{\partial \mathcal{C}_t}{\partial C_t^N} \tag{1.53}$$

For homothetic CES,

$$\frac{\partial \tilde{w}_t^{H}}{\partial C^N} = \left(\frac{\omega_N}{\omega_T}\right)^{\frac{1}{\sigma}} \left(1 - \frac{1}{\sigma}\right) C_{T,t}^{\frac{1}{\sigma}} C_{N,t}^{-\frac{1}{\sigma}} \tag{1.54}$$

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

$$\frac{\frac{\partial \tilde{w}^{NH-CES}}{\partial C^N}}{\frac{\partial \tilde{w}^{H-CES}}{\partial C^N}} = 1 - \left(\frac{\gamma_N - \gamma_T}{1 - \sigma}\right) \frac{\partial \log \mathcal{C}}{\partial \log E} \frac{\partial \log E}{\partial \log C^N} \tag{1.55}$$

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

□

Proof Proposition 3

Proof. Let's start with relative expenditure shares for tradable and nontradable from Equation (1.8) under non-homothetic CES preferences. Then, by linearizing and aggregating across households, we have

$$P^N - P^T = \frac{1}{\sigma}\mathbf{C_T} - \frac{1}{\sigma}\mathbf{C_N} + \frac{\gamma_N - \gamma_T}{\sigma}\mathcal{C} \tag{1.56}$$

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

$$\tilde{w} = P^N - P^T + \mathbf{C^N} \tag{1.57}$$

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

$$\tilde{w}^{NH} = \frac{1}{\sigma}\mathbf{C_T} + \Big(1 - \frac{1}{\sigma}\Big)\mathbf{C_N} + \frac{\gamma_N - \gamma_T}{\sigma}\mathcal{C} \tag{1.58}$$

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

$$\frac{\partial \tilde{w}^{NH}}{\partial \mathbf{C_T}} = \frac{1}{\sigma} + \frac{\gamma_N - \gamma_T}{\sigma}\frac{\partial \mathcal{C}}{\partial \mathbf{C_T}} \tag{1.59}$$

Similar steps for homothetic CES,

$$\frac{\partial \tilde{w}^{H}}{\partial \mathbf{C_T}} = \frac{1}{\sigma} \tag{1.60}$$

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

$$\frac{\partial \tilde{w}^{NH}}{\partial \mathbf{C_N}} = -\Big(\frac{1-\sigma}{\sigma}\Big) + \frac{\gamma_N - \gamma_T}{\sigma}\frac{\partial \mathcal{C}}{\partial \mathbf{C_N}} \tag{1.61}$$

Similar steps for homothetic CES,

$$\frac{\partial \tilde{w}^{H}}{\partial \mathbf{C_N}} = -\Big(\frac{1-\sigma}{\sigma}\Big) \tag{1.62}$$

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

Proof Proposition 4

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

$$
\begin{aligned}
d\ln c_{hj} = &\underbrace{MPC_{hj}\Big(dP^N\left(\hat{Y}_h^N\right) + P^N\left(d\hat{Y}_h^N\right) + dP^T\left(\hat{Y}_h^T\right) + P^T\left(d\hat{Y}_h^T\right)\Big)}_{\text{Income channel}} \\
&+ \underbrace{MPC_{hj}\left(\hat{a}_h^R\right)d\ln P^N}_{\text{Fisher channel}} + \underbrace{MPC_{hj}\left(P_{t+1}^N \hat{a}_{ht+1}^R\right)d\ln R}_{\text{Interest rate exposure}} \\
&- \underbrace{MPC_{hj}\left(b_{hj}d\ln P^j\right)}_{\text{Expenditure channel}} + \underbrace{\sigma\left(b_{hj}-1\right)d\ln P^j}_{\text{Price Substitution}} - \underbrace{\hat{\sigma}_{hj}M\hat{P}S_h d\ln R}_{\text{Intertemporal Substitution}}
\end{aligned}
\tag{1.63}
$$

Proof. Let's begin with household budget constraints in this two-period economy.[68] Nominal budget constraints in $t = 1$ and $t = 2$ at the household level are[69]:

$$
P_1^T c_1^T + P_1^N c_1^N + P_2^N a_2^R = P_1^N Y_1^N + P_1^T Y_1^T + P_1^T a_1^R \tag{1.64}
$$

$$
P_2^T c_2^T + P_2^N c_2^N + = P_2^N Y_2^N + P_2^T Y_2^T + RP_2^N a_2^R \tag{1.65}
$$

Consolidated nominal budget constraint:

$$
P_1^T c_1^T + P_1^N c_1^N + \frac{P_2^T c_2^T + P_2^N c_2^N}{R} = P_1^N Y_1^N + P_1^T Y_1^T + \frac{P_2^N Y_2^N + P_2^T Y_2^T}{R} + P_1^N a_1^R \tag{1.66}
$$

Income Perturbation dy around the first period is given by:

$$
\begin{aligned}
dy = dP_1^N\left(Y_1^N + a_1^R\right) + P_1^N\left(dY_1^N + da_1^R\right) + dP_1^T\left(Y_1^T\right) + P_1^T\left(dY_1^T\right) \\
+\frac{P_2^N}{R}dY_2^N + \frac{P_2^T}{R}dY_2^T - \frac{P_2^N Y_2^N + P_2^T Y_2^T}{R^2}dR
\end{aligned}
\tag{1.67}
$$

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:

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

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

$$dc_j = \frac{\partial h_j}{\partial P_j} dP_j - \frac{\partial c_j}{\partial y}\frac{\partial E}{\partial P_j} dP_j + \frac{\partial h_j}{\partial R} dR - \frac{\partial c_j}{\partial y}\frac{\partial E}{\partial R} dR + \frac{\partial c_j}{\partial y} dy \tag{1.68}$$

$$= \frac{\partial c_j}{\partial y}\frac{E}{c_j}\left(c_j d\ln y - \frac{\partial E}{\partial R}\frac{R}{E} c_j d\ln R - c_j b_j d\ln P_j\right) + \frac{\partial h_j}{\partial P_j}\frac{P_j}{c_j} c_j d\ln P_j + h_j \epsilon_{h_j R} d\ln R \tag{1.69}$$

$$d\ln c_j = \epsilon_{cy}\left(d\ln y - \epsilon_{yR} d\ln R - b_j d\ln P_j\right) + \epsilon_{h_j P_j} d\ln P_j + \epsilon_{h_j R} d\ln R \tag{1.70}$$

Note that marginal propensities to consume now are sector-level marginal propensities to consume. To derive the above Equation (1.70), we used the Slutsky equation that connects compensated and uncompensated demand:

$$\frac{\partial h_j}{\partial P_j} = \frac{\partial c_j}{\partial P_j} + \frac{\partial c_j}{\partial E}\frac{\partial E}{\partial p_j} \tag{1.71}$$

$$\frac{\partial h_j}{\partial R} = \frac{\partial c_j}{\partial R} + \frac{\partial c_j}{\partial E}\frac{\partial E}{\partial R} \tag{1.72}$$

Now, we derive each component of Equation (1.70). Let's begin with the components inside the parenthesis.First, note that from Equation (1.66), $\frac{\partial E}{\partial R} dR$ corresponds to:

$$\frac{\partial E}{\partial R} dR = -\frac{P_2^T c_2^T + P_2^N c_2^N}{R}\frac{dR}{R} = -\left(\frac{P_2^N Y_2^N + P_2^T Y_2^T}{R} + a_2^N\right)\frac{dR}{R} \tag{1.73}$$

Then, we use Equation (1.73) to derive the first component inside the parenthesis in Equation (1.70):

$$dy - \frac{\partial E}{\partial R} dR = dP_1^N\left(Y_1^N + a_1^R\right) + P_1^N\left(dY_1^N + da_1^R\right) + dP_1^T\left(Y_1^T\right) + P_1^T\left(dY_1^T\right) + \frac{P_2^N}{R} dY_2^N + \frac{P_2^T}{R} dY_2^T - \frac{P_2^N Y_2^N + P_2^T Y_2^T}{R^2} dR + \left(\frac{P_2^N Y_2^N + P_2^T Y_2^T}{R} + a_2^N\right)\frac{dR}{R} \tag{1.74}$$

$$dy - \frac{\partial E}{\partial R} dR = dP_1^N\left(Y_1^N + a_1^R\right) + P_1^N\left(dY_1^N + da_1^R\right) + dP_1^T\left(Y_1^T\right) + P_1^T\left(dY_1^T\right) + \frac{P_2^N}{R} dY_2^N + \frac{P_2^T}{R} dY_2^T + a_2^N\frac{dR}{R} \tag{1.75}$$

Finally, we can use Equation (1.75)

$$d \ln y - \epsilon_{yR} d \ln R = \frac{1}{E}\left(dy - \frac{\partial E}{\partial R} dR\right) \tag{1.76}$$

$$= dP_1^N\left(\hat{Y}_1^N + \hat{a}_1^R\right) + dP_1^T \hat{Y}_1^T + P_1^N d\hat{Y}_1^N + P_1^T d\hat{Y}_1^T + \hat{a}_2^N \frac{dR}{R} \tag{1.77}$$

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 (1.70). Calculating h_j derivatives with respect to P_j, where $h_j = \omega_j U^{\gamma^j - \sigma}(E/P_j)^\sigma$:

$$\frac{\partial h_j}{\partial P_j} = (-\sigma) P_j^{-\sigma-1} \omega_j U^{\gamma^j - \sigma} E^\sigma + \frac{\sigma h_j}{E} \frac{\partial E}{\partial P_j} \frac{P_j}{P_j} = -\sigma P_j^{-1} h_j + \sigma P_j^{-1} h_j b_j = \sigma P_j^{-1} h_j (b_j - 1) \tag{1.78}$$

Then, we have the result

$$\epsilon_{h_j P_j} d \ln P_j = \sigma h_j \left(b_j - 1\right) d \ln P_j \tag{1.79}$$

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:

$$v'_{j,1}(c_1^j) = \beta R v'_{j,2}(c_2^j) \tag{1.80}$$

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 concerning interest rates on both sides, we have:

$$0 = v'_{j,1}\frac{\partial c_1^j}{\partial R} + \beta v'_{j,2}\frac{1}{v''_{j,2}}\frac{v''_{j,1}}{\beta R}\frac{\partial c_1^j}{\partial R} + \beta v'_{j,2}\frac{1}{v''_{j,2}}\frac{v'_{j,1}}{\beta}(-R^{-2}) \tag{1.81}$$

$$v'_{j,1}\frac{v'_{j,2}}{v''_{j,2}}(R^{-2}) = v'_{j,1}\frac{\partial c_1^j}{\partial R}\left(1 + \frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}\frac{1}{R}\right) \tag{1.82}$$

$$\frac{v'_{j,1}}{v''_{j,1}}v'_{j,1}\frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}(R^{-2}) = v'_{j,1}\frac{\partial c_1^j}{\partial R}\left(1 + \frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}\frac{1}{R}\right) \tag{1.83}$$

$$(-\sigma_1^j c_1^j)\frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}(R^{-2}) = \frac{\partial c_1^j}{\partial R}\left(1 + \frac{v'_{j,2}v''_{j,1}}{v'_{j,1}v''_{j,2}}\frac{1}{R}\right) \tag{1.84}$$

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 (1.84), and deriving budget constraints we obtain MPCs:

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

□

Proof Proposition 5

Proof. **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 (1.63) and aggregating consumption across households we have:

$$
\begin{aligned}
d\ln C_j = \; & \mathbb{E}_h\Big[MPC_j\Big(P^N\big(d\hat{Y}^N\big) + P^T\big(d\hat{Y}^T\big) + dP^N\big(\hat{Y}^N\big) + dP^T\big(\hat{Y}^T\big)\Big)\Big] \\
& + \mathbb{E}_h\Big[MPC_j a^R\Big]d\ln P^N + \mathbb{E}_h\Big[MPC_j P^N_{t+1}a^R_{t+1}\Big]d\ln R \\
& - \mathbb{E}_h\Big[MPC_j b_j\Big]d\ln P^j + \sigma\mathbb{E}_h\Big[\big(b_j - 1\big)\Big]d\ln P^j - \mathbb{E}_h\Big[\tilde{\sigma}_j M\tilde{P}S\Big]d\ln R
\end{aligned} \tag{1.85}
$$

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 (1.85) and aggregating consumption across households we have:

$$
\begin{aligned}
d\ln C = \sum_j b_j d\ln C_j = \; & \mathbb{E}_{h,j}\Big[MPC_j\Big(P^N\big(d\hat{Y}^N\big) + P^T\big(d\hat{Y}^T\big) + dP^N\big(\hat{Y}^N\big) + dP^T\big(\hat{Y}^T\big)\Big)\Big] \\
& + \mathbb{E}_{h,j}\Big[MPC_j a^R\Big]d\ln P^N + \mathbb{E}_{h,j}\Big[MPC_j P^N_{t+1}a^R_{t+1}\Big]d\ln R \\
& - \mathbb{E}_{h,j}\Big[MPC_j b_j\Big]d\ln P^j + \sigma\mathbb{E}_{h,j}\Big[\big(b_j - 1\big)\Big]d\ln P^j - \mathbb{E}_{h,j}\Big[\tilde{\sigma}_j M\tilde{P}S\Big]d\ln R
\end{aligned} \tag{1.86}
$$

□

7.5 Solution method

As 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, Bardoczy, 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.[70]

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). 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.

[70]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, Bardoczy, 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.

[71]See Carroll (2006).

An essential contribution of Auclert, Bardoczy, 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. Exploiting the linearized structure of the heterogeneous agent problem around the steady-state provides a critical speed improvement related to the typically used method (Direct method) by a factor of about T, where T is usually about 300. For instance, Auclert, Bardoczy, 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.

Chapter 2

Exchange Rate Pass-Through and Invoicing Currency: Different Patterns at the Border and the Store

1. Introduction

Understanding the impact of the exchange rates on consumer inflation is a centerpiece of international economics and first-order interest for policymakers in open economies. The relationship between exchange rate fluctuations and international prices depends on the currency in which prices are rigid (Gopinath, 2016). In recent years, three competing hypotheses have governed the debate: PCP, LCP, and DCP (Gopinath, et al., 2020).[1] Given the predominance of the US dollar in international transactions, DCP has gained an enormous interest (Gopinath and Itskhoki, 2022).

[1]Under Producer Currency Pricing (PCP), prices are sticky in the currency of the producing country. Local Currency Pricing (LCP) assumes prices are sticky in the currency of the destination market. More recently, the Dominant Currency Paradigm (DCP) questions the validity of the previous hypotheses by stating that firms set export prices in dominant currencies, mainly the US dollar.

The debate around what currency of invoicing governs international prices is associated with import and export prices at the border, and it is independent of the category of goods, which raises some concerns. First, one of the consensus hypotheses is that exchange rate pass-through (ERPT) is larger at the border than at the store (Burstein and Gopinath, 2014; Amiti, et al., 2019). Moreover, store prices are primarily set in local currency (Engel, 2016), so the role of currency of invoicing related to exchange rate shocks at the store should be muted.[2]

Secondly, many internationally traded goods are not final consumer goods; they are intermediate and capital goods used to produce final goods (Engel, 2016). Recent literature shows that ERPT at the border changes across industries (Chen, et al., 2022; Giuliano and Luttini, 2020). However, if capital goods and intermediate inputs are used in the production process, then ERPT will also be impacted by the ERPT and currency of invoicing of intermediate and capital goods.

In this paper, we study the relevance of the currency of invoicing for ERPT at the border and at the store. First, we evaluate how prices respond to exchange rate movements at the border in imports and exports. Importantly, we assess the role of currency of invoicing on ERPT by explicitly distinguishing between final consumption goods and non-consumption goods (intermediate goods and capital goods). To study this at the border, we exploit detailed customs of imports and exports data for Chile at the transaction level. Then, we evaluate how prices respond to exchange rate movements at the store. We employ disaggregated product-level data used for constructing the Consumer Price Index (CPI). To assess the role of the currency of the invoice, we match export and import prices to every product, and we develop a new instrumental variable to estimate ERPT that leverages on customs data.

[2]Exceptions are Yang (2023) that studies the role of input-output linkages in determining ERPT in final consumer prices and the role of the currencies of invoicing, and Auer, et al. (2021) that uses the sudden Swiss Franc exchange rate appreciation in 2015 in Switzerland as a case study to study ERPT at the border and the store.

To guide our empirical assessment, we develop an open economy model that extends the one presented in (Gopinath, et al., 2020) by including a distribution sector that involves all the additional costs in domestic currency, such as distribution services, to make the imported product available at the store. From the model, we obtain a set of testable implications. In the short run, where prices are sticky, exchange rate fluctuations affect prices at the border (under PCP, bilateral is relevant; under DCP, the dollar is relevant) but do not affect prices at the store. In the long run, where prices are flexible, the ERPT at the border corresponds to the impact over marginal costs. This impact is not fully passed to the store price, where the incompleteness's magnitude depends on the distribution sector's share.

We then turn to empirically analyze the role of currency of invoicing for exchange rate pass-through (ERPT) at the border and the store at different time horizons. At the border, consistent with the dominant currency paradigm, we find a predominant role for the USD for ERPT; however, bilateral exchange rate fluctuations also matter for longer time horizons, providing support to PCP. Specifically, for USD-invoiced imports from non-USD countries, the short-run ERPT from a depreciation in the USD exchange rate is high (around 90 percent). It remains relatively high after eight quarters (around 60 percent). On the other hand, the ERPT from a depreciation in the bilateral exchange rate is close to zero on impact for USD invoiced imports but increases, reaching a peak of 28 percent after four quarters. Furthermore, it is higher for consumption goods than non-consumption goods (42 percent vs. 20 percent) and exceptionally high for food (57 percent). For non-USD countries invoicing Chilean products in USD, we find similar patterns. However, there are some noticeable differences: a more important role for bilateral exchange rates in the long run and ERPT to export prices are higher for consumption goods than non-consumption goods.

An essential challenge to estimating ERPT at the store is related to endogeneity concerns.[3]

[3] The first endogeneity concern is related to double causality for an endogenous monetary policy response to expected inflation, which affects exchange rates through interest rate parity conditions. The second

To overcome this challenge, we develop a new instrumental variable approach to estimate ERPT at the store by leveraging at-the-border regressions. We use the ERPT results at the border for imports and exports, exogenously estimated due to differences in the invoicing currency, to construct instruments to estimate retail prices. The instrument corresponds to the weighted average across varieties of a product of the predicted value of price changes for imports and exports.

Consistent with sticky prices in the consumer's currency, we find an ERPT over-impact close to zero at the store. As predicted by our model, for longer time horizons, as nominal rigidities ease, determinants of import and export prices at the border echo at the store, however, in a lower magnitude. We find an ERPT of around 25 percent after eight quarters. We show that considering only bilateral rates or dollar fluctuations as a determinant of retail prices produces biased estimations, highlighting the relevance of the currency of invoices at the store.

These results carry significant implications for monetary policy. First, at the border, if we distinguish consumption from non-consumption goods, the currency of invoicing is still relevant. What is not trivial is the level of ERPT when we compare them at the border. The relevance of this result is that intermediate inputs won't underestimate or overestimate the role of invoice currency at the store. Second, at the store, the low sensitivity of ERPT in the short term contrasts with the results at the border. This result points out the Engel (2016) idea that all consumer prices are invoiced in local currency. However, as we show empirically and with our model, this result is valid only in the short term due to price rigidities. Invoice currency is relevant at the store in the medium and long term. Finally, those results carry important implications for expenditure switching. In the short run, at the border, important effects on quantities derived from exchange shocks are expected, but at the store, they should

endogeneity concern we show in our empirical analysis at the border is related to omitted variable bias caused by the lack of adequate accounting for different currencies of invoicing that interact at the store.

be more muted.

Related literature. This paper is related to the literature on ERPT and the currency of invoicing. In the presence of market power and price rigidities, exchange rate fluctuations can affect economic activity (Dornbusch, 1987), where a key variable to evaluate the impact of those fluctuations is the ERPT. An abundant amount of literature has estimated ERPT in different periods and countries (Feenstra, 1989; Knetter, 1989; Goldberg and Knetter, 1997). More recent literature estimates different ERPTs according to the currency of invoicing.[4] For example, Gopinath, et al. (2010) show very low long-run pass-through for dollar-priced goods and complete pass-through for non-dollar-priced goods. Gopinath (2016) finds that ERPT depends on foreign currency invoicing shares, providing evidence of the US dollar as a dominant currency. Developing a modeling framework with dominant currency pricing, pricing complementarities, and imported inputs in production, called the "dominant currency paradigm," Gopinath, et al. (2020) shows that changes in the dominant currency should drive the pass-through of import prices.[5] Giuliano and Luttini (2020) and De Gregorio, et al. (2023) closely relate to our work. Using a comprehensive dataset for Chile, the former shows that even though most Chilean imports are invoiced in dollars, bilateral exchange rates to exporter currencies matter in the medium term. At the same time, the latter finds that bilateral exchange rate fluctuations don't affect export prices in the short run, supporting DCP, but do affect export prices in the long run, supporting PCP. We go one step further by studying how prices respond to exchange rate movements at the border in imports and exports, distinguishing between final consumption goods and non-consumption goods. Moreover, we decompose final consumption goods into food, transportation, and other manufactured goods.

[4] See Burstein and Gopinath (2014) and Auer, et al. (2021).

[5] Amiti, et al. (2022) finds that currency choice is an active firm-level decision that can impact ERPT. For our analysis, we abstracted from this discussion and assumed currency choice as given.

The main part of the literature on ERPT and invoicing currency concerns the effect of exchange rate fluctuations on border prices. Burstein, et al. (2003) find that distribution costs are relevant to explaining exchange rate dynamics, and they impact pass-through at the store. To the best of our knowledge, the only paper connecting invoice currency's role to exchange rate changes and the store is Auer, et al. (2021). Focusing on a natural experiment in Switzerland, they find a lower pass-through to retail than at the border. More recently, Yang (2023) adds to this literature by incorporating a rich input-output network with imported inputs. In the context of an emerging economy like Chile and based on distributed lag regressions, we contribute to this literature by comparing the role of invoicing currency for imports and exports for consumption and non-consumption goods. We also provide a new instrumental variable to estimate the role of invoicing currency on ERPT at the store and develop a simple model to explain the mechanisms based on sticky prices and distribution costs.

The paper is organized as follows. Section 2. develops an open economy model incorporating distribution costs to the DCP model, providing a theoretical framework to benchmark our empirical results. Section 3. provides our empirical methodology to test the implications derived in Section 2.. Section 4. explains the main features of the dataset and provides descriptive statistics. Section 5. presents the empirical results of the paper. Section 6. concludes.

2. Theoretical Framework and Testable Implications

We build a simple model to describe the evolution of prices at the border and the store depending on nominal rigidities and invoicing currency. Consider a small economy j that trades goods and assets with the rest of the world. Consistent with the evidence for Chile,[6] we assume that the dominant currency is the dollar. Households consume a bundle of imported and exported final goods and have access to foreign currency-denominated bonds. Producer firms adjust prices infrequently a la Calvo. Moreover, the producer sector uses imported intermediate inputs, and their prices are affected by exchange rate fluctuations. The main departure of this model in comparison with Gopinath, et al. (2020) is the inclusion of a distribution sector that involves all the additional costs in domestic currency, such as transportation services, to make the imported product available at the store. Firms in the distribution sector also adjust prices infrequently a la Calvo.[7]

Producer-level import price inflation in country j for goods produced in country i is[8]

$$\Delta p_{ij} = \theta^i_{ij}\underbrace{(\Delta p^i_{ij} + \Delta e_{ij})}_{\text{PCP}} + \theta^j_{ij}\underbrace{(\Delta p^j_{ij} + \Delta e_{jj})}_{\text{LCP}} + \theta^\$_{ij}\underbrace{(\Delta p^\$_{ij} + \Delta e_{\$j})}_{\text{DCP}},$$

where we assume there are three potential invoicing currencies, producer-priced (PCP), locally-priced (LCP), or dominant currency-priced (DCP), with the fraction of each invoicing currency k given by θ^k_{ij} and $\theta^i_{i,j} + \theta^j_{i,j} + \theta^\$_{i,j} = 1$.

Under Calvo pricing $\Delta p^k_{ij,t} = (1-\delta_p)(\bar{p}^k_{ij} - p^k_{ij,t-1})$.[9] $1-\delta_p$ firms randomly reset prices every period. Then, import price changes are as follows[10]

$$\Delta p_{ij} = \theta^i_{ij}\Delta e_{ij} + \theta^\$_{ij}\Delta e_{\$j} + (1-\delta_p)\sum_{k\in\{i,j,\$\}}\theta^k_{ij}(\bar{p}^k_{ij,t} - p^k_{ij,t-1})$$

[6]Section 4. provides evidence of the US dollar as a dominant currency.

[7]Details of the model are in Appendix 7.1.

[8]Log-level variables are denoted with lower case such that $p \equiv \log P$.

[9]The optimal reset price $\bar{p}^k_{ij,t}$ comes from the producer problem (see Appendix 7.1). The presence of a distribution sector modifies the optimal reset price. For instance, assuming flexible prices $\bar{P}_{ji} = \frac{(1-\gamma)\sigma}{(1-\gamma)\sigma-1}MC_j$, where $1-\gamma$ corresponds to the share of imported consumption goods used by the retail firm.

[10]Note that we assume the convention $\mathcal{E}_{jj} = 1$.

Assuming fully rigid prices ($\delta_p \to 1$), then, under PCP $\Delta p_{ij} = \Delta e_{ij}$ and import prices are directly affected by bilateral exchange rates. Under LCP, $\Delta p_{ij} = 0$, and import prices are not sensitive to bilateral exchange rate fluctuations. Finally, under DCP $\Delta p_{ij} = \Delta e_{\$j}$ and import prices are directly affected by the dollar.

We also evaluate how prices evolve at the store. Retail-level price inflation is

$$\Delta p_j^r = \theta^j(\Delta p_j + \Delta e_{jj})$$

where $\theta^j = 1$, and $\mathcal{E}_{jj} = 1$ implies that $\Delta p_j^r = \Delta p_j$. Then, retail prices are not directly affected by the exchange rate and are only impacted through import prices on marginal costs. As shown in Appendix 7.1, retail prices are in local currency and subject to price rigidities. Under Calvo pricing assumption in the distribution sector, retail price changes can be expressed as

$$\Delta p_j^r = (1 - \delta_r)(\bar{p}_j^r - p_{j,t-1}^r).$$

Assuming fully rigid prices ($\delta_r \to 1$), the exchange rate does not affect retail prices. This result contrasts with border prices, where the exchange rate plays a first-order role in determining prices. In the long run, price rigidities ease. The exchange rate fluctuations are fully passed through marginal costs at the border (see Appendix 7.1). However, the ERPT at the store is incomplete, even under fully flexible prices. Under the assumption of a Cobb-Douglas production function in the distribution sector, the incompleteness depends on the share of the distribution sector determined by $\gamma \in (0, 1)$.

In our empirical section, we test the following implications derived from the previous analysis: in the short run (rigid prices), exchange rate fluctuations affect prices at the border (under PCP, bilateral is relevant; under DCP, the dollar is relevant), but does not affect prices at the store. In the long run (flexible prices), the ERPT at the border corresponds to the impact over marginal costs, while the ERPT at the store is lower than at the border in magnitude $1-\gamma$.

3. Empirical Strategy

3.1 Exchange Rate Pass-Through at the Border

We adopt dynamic-lag regressions of the type surveyed by Burstein and Gopinath (2014) to estimate exchange rate pass-through at the border. Pass-through regressions estimate the sensitivity of import or export prices to exchange rates. We homogenize our estimation approach for the importer and exporter pricing perspectives to make both of them comparable and evaluate the relevance of the currency of the invoice.[11] Then, we move to evaluate the relevance of the currency of the invoice across consumption and non-consumption goods (intermediate and capital goods). Due to its preponderance in the household consumption bundle, food, transportation, and manufactured goods are examined in our analysis. As discussed in the next section, the currency of invoice shares in dollars and trade partners changes across good categories, so we expect a differential impact across goods. We use the same models to compare goods categories.

We study short and long-run ERPT for import and export prices. As we discussed in Section 2., in the short run, given nominal price rigidities, the ERPT from USD depreciation to import (export) prices for goods shipped from (to) non-USD origins (destinations) invoiced in USD should be higher than the ERPT from the bilateral exchange rate. In the long run, the ERPT for the USD should moderate as nominal rigidities ease, but it should be

[11] Our empirical models closely follow recent literature of ERPT for the Chilean case (De Gregorio, et al., 2023; Giuliano and Luttini, 2020).

more relevant for the exporter currency. For the cumulative USD ERPT, our hypothesis anticipates a decreasing magnitude over time, and for the cumulative bilateral ERPT, we anticipate an increasing pattern as prices freely adjust.

Imported ERPT

First, we consider pass-through regressions for imports over bilateral exchange rates. The relevant variable we evaluate is log changes in import prices of a variety v, invoiced in currency k, imported from country i denoted by ΔP_{vkit}. The empirical model considers changes in contemporaneous and 8-period ($L = 8$) lagged bilateral exchange rates $\mathcal{E}_{CL,i}$, between Chilean pesos and the exporter country's currency[12]

$$\Delta P_{vkit} = \sum_{s=0}^{L} \beta_s \Delta \mathcal{E}_{CL,i,t-s} + \gamma \mathbf{z}_{it} + \alpha_{vki} + \lambda_t + \epsilon_{vkit}, \tag{2.1}$$

where z is a set of control variables, including the exporter country's inflation. α is a set of fixed effects at variety-currency-country level, and λ is a time fixed effect. Δ is the first difference quarterly operator. $\Sigma_{s=0}^{L}\beta_s$ captures the L-periods cumulative ERPT of an exchange rate movement at time 0.

We then gauge the degree of imports ERPT according to invoice currency. As discussed in the previous section, with nominal price stickiness, the currency of invoices in international trade transactions is a key determinant of the degree of ERPT and monetary policy transmission in the short and medium term. An important assumption is that the currency in which prices of goods are set is given, which is the relevant case for a small open economy. We measure the degree of ERPT of transactions invoiced in the exporter country's currency and those invoiced in USD. We do this by interacting the invoice currency with the associated

[12] As we defined in the previous section an increase in the bilateral exchange rate $\mathcal{E}_{CL,i}$ corresponds to a depreciation of the Chilean peso.

exchange rate and measuring the ERPT for each currency of the invoice:

$$\begin{aligned}\Delta P_{vkit} =& \sum_{s=0}^{L} \beta_s^B \Delta \mathcal{E}_{CL,i,t-s} D_{\text{invoice}=i} + \sum_{s=0}^{L} \beta_s^{\$} \Delta \mathcal{E}_{CL,\$,t-s} D_{\text{invoice}=\$} \\ &+ \gamma \mathbf{z}_i + \alpha_{vki} + \lambda_t + \epsilon_{vkit},\end{aligned} \tag{2.2}$$

where $D_{\text{invoice}=i}$ indexes transactions invoiced in the exporter country's currency, and $D_{\text{invoice}=\$}$ indexes transactions invoiced in USD.[13] Cumulative ERPT of transactions invoiced in the currency of country i is $\Sigma_{s=0}^{L} \beta_s^B$ and $\Sigma_{s=0}^{L} \beta_s^{\$}$ for transactions invoiced in USD.

The model in Equation (2.2) allows us to evaluate the relative relevance between bilateral and USD but does not consider the potential impact of the bilateral exchange rate when the currency of the invoice is in the USD. Then, we quantify the role of the exporter currency's exchange rate from non-dollar origins for those transactions invoiced in USD, which comprise the bulk of Chilean imports. To measure the interaction, we add a third term to the previous specification between transactions invoiced in USD and the bilateral exchange rate

$$\begin{aligned}\Delta P_{vkit} =& \sum_{s=0}^{L} \beta_s^{B;B} \Delta \mathcal{E}_{CL,i,t-s} D_{\text{invoice}=i} + \sum_{s=0}^{L} \beta_s^{\$;\$} \Delta \mathcal{E}_{CL,\$,t-s} D_{\text{invoice}=\$} \\ &+ \sum_{s=0}^{L} \beta_s^{B;\$} \Delta \mathcal{E}_{CL,i,t-s} D_{\text{invoice}=\$} + \gamma \mathbf{z}_{it} + \alpha_{vki} + \lambda_t + \epsilon_{vkit}\end{aligned} \tag{2.3}$$

where $\Sigma_{s=0}^{L} \beta_s^{B;\$}$ is the cumulative ERPT for the exporter bilateral currency for transactions invoiced in USD.

Exported ERPT

Regarding export prices, the modeling approach parallels the one for import prices. An important assumption is to consider the nominal value of the transactions in the destination currency to compare export price pass-through with import prices.[14]

[13] For dollarized countries such as the U.S. or Ecuador, we assume that if they invoice in USD, it corresponds to exporter country's currency.

[14] This assumption allows the transformation of exports into the recipient country's imports to make it comparable with the Chilean import results.

First, we consider pass-through regressions for export prices over bilateral exchange rates:

$$\Delta P_{vkit} = \sum_{s=0}^{L} \mathcal{B}_s \Delta \mathcal{E}_{i,CL,t-s} + \gamma \mathbf{z}_{it} + \alpha_{vki} + \epsilon_{vkit}, \tag{2.4}$$

where ΔP_{vkit} is log changes in export prices of a variety v denominated in the destination currency, invoiced in currency k, exported to the country i, and $\mathcal{E}_{i,CL}$ is the bilateral exchange rate between recipient country's currency and Chilean pesos. An increase in $\mathcal{E}_{i,CL}$ is a Chilean peso's appreciation.

Then, we evaluate the degree of ERPT of transactions invoiced in the local currency versus those invoiced in USD. The model is similar to the one evaluating producer currency pricing from the import perspective.

$$\begin{aligned} \Delta P_{vkit} = & \sum_{s=0}^{L} \mathcal{B}_s^B \Delta \mathcal{E}_{i,CL,t-s} D_{\text{invoice}=i} + \sum_{s=0}^{L} \mathcal{B}_s^{\$} \Delta \mathcal{E}_{i,\$,t-s} D_{\text{invoice}=\$} \\ & + \gamma \mathbf{z}_{it} + \alpha_{vki} + \epsilon_{vkit}, \end{aligned} \tag{2.5}$$

where $D_{\text{invoice}=i}$ indexes transactions invoiced in the local country's currency, and $D_{\text{invoice}=\$}$ indexes transactions invoiced in USD.[15] Cumulative ERPT of transactions invoiced in the currency of country i is $\Sigma_{s=0}^{L} \mathcal{B}_s^B$ and for transactions invoiced in USD $\Sigma_{s=0}^{L} \mathcal{B}_s^{\$}$.

The model in Equation (2.5) allows us to evaluate the relative importance between bilateral and USD. However, the differential impact of the bilateral exchange rate is still missing when the currency of the invoice is the USD. Next, we gauge this interaction in Equation (2.6),

$$\begin{aligned} \Delta P_{vkit} = & \sum_{s=0}^{L} \mathcal{B}_s^{B;B} \Delta \mathcal{E}_{i,CL,t-s} D_{\text{invoice}=i} + \sum_{s=0}^{L} \mathcal{B}_s^{\$;\$} \Delta \mathcal{E}_{i,\$,t-s} D_{\text{invoice}=\$} \\ & + \sum_{s=0}^{L} \mathcal{B}_s^{B;\$} \Delta \mathcal{E}_{i,CL,t-s} D_{\text{invoice}=\$} + \gamma \mathbf{z}_{it} + \alpha_{vki} + \epsilon_{vkit} \end{aligned} \tag{2.6}$$

where $\Sigma_{s=0}^{L} \mathcal{B}_s^{B;\$}$ is the cumulative ERPT for the importer bilateral currency for transactions invoiced in USD.

---

[15] As we did for imports, for dollarized countries such as the U.S. or Ecuador, we assume that if they invoice in USD, it corresponds to local country's currency.

3.2 Exchange Rate Pass-Through at the store

We aim to make a consistent estimation of ERPT at the store. One estimation approach uses bilateral or multilateral exchange rates as a regressor over product-level retail prices. However, using only bilateral or multilateral rates presents an omitted variable bias.[16] Our unique dataset used for estimations at the border allows us to go a step further by using the information from at-the-border regressions to produce a new instrumental variable for consistent estimations.[17]

By assuming the exogenous currency of invoice decisions, our regressions at the border produced a consistent identification of ERPT due to differential changes in invoicing currency vis-a-vis bilateral rates for import and export prices. Therefore, we use these regression results as a first stage for every retail product in our dataset.[18] As we have imports and exports, we repeat the exercise for both of them.[19] Our instrumental variable z_{gt} for every product g and time t is obtained as follows

$$z_{gt} = \sum_{v(g),k,i} \omega_{vkit} \Delta \hat{p}_{vkit},$$

where $\Delta \hat{p}_{vkit}$ is estimated from border regressions, and weights ω_{vkit} is computed as

[16]Official multilateral exchange rates are estimated as a weighted exchange rate where the weight on each trading partner's bilateral exchange rate is given by the trade share for that country. This indicator is problematic because the currency of the invoice does not always coincide with the trading partner's currency. Moreover, consumption goods correspond to 34% of total imports and 21% of total exports, which is another reason why trading partner weights in trade do not necessarily coincide with trading partners' weights in consumption.

[17]An additional identification challenge in this literature is the double causality bias. Given the consistency of the first stage, we will evaluate this bias under our proposed instrument.

[18]Section 4. describes the merging procedure we followed to connect import and export prices at the transaction level for every product in the consumption basket. It implies that per every product, estimations for different varieties within a product are an instrument for each one of them.

[19]Given the concentration in food exports, comparing product-by-product imports and exports ERPT is impossible. Imports are more diversified across consumption baskets.

$$\omega_{vkit} = \frac{V_{vkit}}{\sum_{v(g),k,i} V_{vkit}},$$

where V_{vkit} is the total value of imports (or exports) for variety v invoice in currency k with origin (or destination) country i. Then, we use this instrumental variable to estimate ERPT at the store,

$$\Delta p_{gt} = \sum_{i=0}^{L} \beta_i^s z_{gt-i} + \alpha_g + \eta \chi_t + \varepsilon_{gt}, \tag{2.7}$$

where p_{gt} corresponds to log change retail prices of product g, α_g is fixed effects per product g, and χ_t is a domestic control variable that, in this case, is seasonally adjusted domestic Chilean output. The number of lags considered again is eight lags.

One concern related to the performance of our instrumental variable is how the performance is compared to a multilateral exchange rate estimated with the bilateral rates weighted by relevant trade partners at the product level. Then, to tackle this concern, we develop a new variable called nominal effective exchange rate at the product level (NEER product level). NEER product level $NEER_{gt}$ for every product g and time t is obtained as follows

$$NEER_{gt} = \sum_{v(g),k,i} \omega_{vkit} \Delta e_{it}, \tag{2.8}$$

where ω_{vkit} is the same weight as for the instrument. Then, we estimate ERPT in Equation (2.7) by using as control this new variable $NEER_{gt}$ instead of z_{gt}.[20]

[20] We have different alternatives to construct NEER product level using only import or export weights or both of them. Given the high concentration of exports in food, we evaluate both cases.

4. Data

4.1 Data Sources

We use four different data sources that inform us about import prices, export prices, bilateral exchange rates, retail prices, and domestic household expenditure bundles in Chile.

The first two datasets are the most important ones and contain customs data at the transaction level for imports and exports. Those datasets contain total values and quantities to calculate unit values used as our import prices. A key characteristic of this dataset is that it incorporates the currency of the invoice of every transaction. We aggregate it quarterly and focus on the 2009-2020 period. This transaction level data is coded at the firm, HS 8-digit level.[21] A novel procedure we developed is splitting import and export datasets at BEC codes to classify them as consumption, intermediate, or capital goods. Then, for consumption goods, we match every HS 8-digit variety with CCIF product categories used for CPI construction.

The third dataset contains monthly retail prices at the product level from 2009 to 2020. The Chilean Statistics Agency uses this data to construct the CPI. We match this data with import and export unit values. Note that import and export varieties have a higher level of disaggregation, so different varieties will serve as an instrument to estimate ERPT at the store. We aggregate them by using total value shares.

The fourth dataset contains bilateral exchange rates we use for pass-through regressions. We adopt quarterly-level data collected in a period-average fashion. Other variables are domestic Chilean output and foreign inflation for the counterpart country.

[21]Each pair of price and value records is based on a unique exporting firm ID, the original country where the firm is established, and the invoiced currency at trade.

4.2 Data Description

We use quarterly average bilateral exchange rates that are invoiced twofold: at the origin country and trade. First, we briefly describe the currency of the invoice for Chilean international trade. We observe that Chilean imports and exports are mainly invoiced in USD regardless of country of origin, except for countries in the Eurozone.

Table 2.1 displays the import share distribution and the export share distribution by currency for each major origin/destination for 2009-2020. Panel A of Table 2.1 decomposes imports/exports across consumption, non-consumption, capital, and intermediate goods. For exports and imports, the USD is the most important invoicing currency. However, there are slight differences between consumption and non-consumption goods across imports and exports. For imports, consumption goods are mainly invoiced in USD (93.8%), while for exports, non-consumption goods are invoiced primarily in USD (96.8%). Panel B of Table 2.1 displays import and export share distribution by currency but focuses on consumption goods only. Again, the USD is the most critical invoicing currency, and there are slight differences among the three categories defined by the first digit of CCIF encoding. For imports, food is invoiced primarily in USD (92.98%), while for exports, manufactured goods are invoiced primarily in USD (99.32%).

Table 2.2 displays the import share distribution by trading partner origin and the export share distribution by trading partner destination. For imports, the US (38.26%) and China (27.84%) are important trading partners at origin for consumption goods, LATAM (31.67%) is important for non-consumption goods, and Europe (29.98%) for capital goods. For exports, LATAM (43.00%) and Europe (24.68%) are important trading partners at destination for consumption goods, and China (34.07%) is important for non-consumption goods and LATAM (65.92%) for capital goods. When we focus on consumption goods only (Panel B of Table 2.2), for imports, LATAM (70.99%) is the most relevant trading partner at origin

Table 2.1: Share of Import Value and Export Value by Invoicing Currency (2009-2020)

	Dollar (1)	Euro (2)	Yen (3)	Pound (4)	Others (5)	Share (6)
Panel A. BEC						
Imports						
Total Imports	88.66	8.44	0.60	0.21	2.08	
Consumption	93.80	3.75	0.15	0.23	2.08	34.17
Non-consumption	86.50	8.69	2.43	0.18	2.20	65.83
Capital	77.47	16.78	1.96	0.31	3.48	20.95
Intermediate	91.22	7.37	0.22	0.14	1.05	44.88
Exports						
Total Exports	96.81	2.27	0.02	0.41	0.48	
Consumption	82.18	7.72	0.35	4.89	4.86	21.30
Non-consumption	96.83	2.21	0.47	0.17	0.32	78.70
Capital	96.77	1.19	0.00	0.11	1.93	0.63
Intermediate	97.88	1.88	0.00	0.09	0.15	78.08
Panel B. CCIF						
Imports						
Total	95.56	3.18	0.22	0.22	0.82	
Food	92.98	5.12	0.00	0.35	1.55	36.89
Manufactured	94.99	3.62	0.18	0.31	0.89	33.83
Transportation	98.69	0.79	0.49	0.01	0.02	29.29
Exports						
Total	96.15	1.88	0.78	0.65	0.55	
Food	89.13	5.01	2.33	1.93	1.60	96.80
Manufactured	99.32	0.62	0.00	0.00	0.05	2.03
Transportation	99.99	0.01	0.00	0.00	0.00	1.17

Notes: The table shows the import share distribution and the export share distribution by currency for each major origin/destination. Panel A decomposes imports/exports across consumption, non-consumption, capital, and intermediate goods. Panel B decomposes imports/exports across three categories defined by the first digit from 1 to 9 of CCIF encoding: food (divisions 1 and 2), transportation (division 7), and manufactured (other divisions 3, 4, 5, 6, 8, and 9 combined). Column share is the ratio of each category over all of them. The shares are computed using nominal values and correspond to the annual average for 2009-2020.

for food, Asia without China (70.76%) is important for manufactured goods, and the US (85.73%) for transportation. For exports, Asia without China (30.37%) is the most important trading partner at destination for food, and LATAM is important for both manufactured goods (83.09%) and transportation (90.50%).

Consistent with previous studies for emerging economies (Goldberg and Tille, 2008; Gopinath, 2016), we have documented that most Chilean international trade is conducted in US dollars. Around 90 percent of Chilean imports and exports are invoiced in USD, even though only 23 percent of Chilean imports come from the US, and only 10 percent of Chilean exports go to the US. This predominance of the US dollar remains across good types, with some differences in the magnitudes. Finally, there is a significant heterogeneity in the import and export share distribution by origin/destination across good types.

Table 2.2: Share of Import Value by Origin and Share of Export Value by Destination

	U.S.	**China**	**Asia** (w/o China)	**Europe**	**America** (w/o U.S.)	**Others**	**Africa**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A. BEC							
Imports							
Total Imports	23.02	15.57	12.83	16.52	31.07	0.86	0.13
Consumption	38.26	27.84	6.54	8.25	18.98	0.07	0.07
Non-consumption	18.21	12.17	16.13	20.73	31.67	0.92	0.16
Capital	22.83	12.07	12.43	29.98	21.93	0.63	0.13
Intermediate	18.22	13.79	9.08	16.51	40.90	1.27	0.22
Exports							
Total Exports	10.08	32.22	25.43	16.10	14.98	0.97	0.23
Consumption	15.03	6.09	10.64	24.68	43.00	0.43	0.13
Non-consumption	9.72	34.07	26.47	15.48	13.01	1.01	0.24
Capital	23.23	1.15	1.83	5.07	65.92	1.95	0.85
Intermediate	9.61	34.34	26.67	15.57	12.58	1.00	0.23
Panel B. CCIF							
Imports							
Total Imports	34.13	0.57	28.63	5.94	29.93	0.73	0.06
Food	11.94	1.44	5.28	8.14	70.99	2.13	0.07
Manufactured	4.73	0.24	70.76	7.31	16.79	0.07	0.10
Transportation	85.73	0.03	9.83	2.39	2.01	0.01	0.00
Exports							
Total Exports	13.04	1.92	11.67	8.28	64.72	0.21	0.15
Food	24.63	1.91	30.37	22.11	20.58	0.23	0.16
Manufactured	8.02	3.85	1.69	2.68	83.09	0.39	0.29
Transportation	6.47	0.00	2.97	0.04	90.50	0.02	0.00

Notes: The table shows the import share distribution by trading partner origin and the export share distribution by trading partner destination. Panel A decomposes imports/exports across consumption, non-consumption, capital, and intermediate goods. Panel B decomposes imports/exports across three categories defined by the first digit from 1 to 9 of CCIF encoding: food (divisions 1 and 2), transportation (division 7), and manufactured (other divisions 3, 4, 5, 6, 8, and 9 combined). The shares are computed using nominal values and correspond to the annual average for 2009-2020.

5. Regression Results

5.1 Results at the border

This section presents our regression results at the border for import and export prices at different horizons.[22] We evaluate the hypothesis described in the previous section for different invoice currencies among goods categories. We first compare those hypotheses for consumption goods with non-consumption goods (intermediate and capital goods). Then, we open up consumption goods in the most relevant consumption divisions for the Chilean case.

Table 2.3 reports regression results of ERPT to import prices.[23] Panel A of Table 2.3 shows results from a panel regression of import prices on bilateral exchange rates (see Equation 2.1). Consistent with Giuliano and Luttini (2020), the ERPT from a depreciation in the bilateral exchange rate is 55 percent on impact and then increases slightly in the medium (69 percent) and long run (68 percent). When we decompose import goods into consumption and non-consumption goods, the ERPT is higher in the first quarter for consumption goods (63 percent vs. 51 percent). Moreover, the ERPT increases slightly in the medium run for consumption goods, while for non-consumption goods, the ERPT remains relatively stable for longer horizons.[24] As consumption goods are intended for final sale, its ERPT has a higher impact over CPI than non-consumption goods that support production. So, we dig deeper into consumption goods by decomposing them into three categories: food, transportation,

[22] $\sum_{i=0}^{Q} \beta_i$ is the cumulative ERPT for the Q-periods. For the exposition, the short run refers to $Q = 0$, the medium run refers to $Q = 4$, and the long run refers to $Q = 8$.

[23] To understand the role of currency of invoice in the ERPT, we follow Giuliano and Luttini (2020).

[24] Table 2.7 in Appendix 2.7 shows ERPT to border results decomposing non-consumption goods into intermediate and capital goods. When we decompose non-consumption goods into intermediate and capital goods, the ERPT is higher for intermediate goods (52 percent vs. 41 percent).

and manufacturing. The three categories follow an increasing bilateral ERPT over time, although it is lower for transportation goods on impact (36 percent vs. 68-69 percent).

As well stated by Giuliano and Luttini (2020), the above results have two shortcomings: (1) the coefficient on the bilateral exchange rate could be capturing movements in the CLP-USD parity, and (2) the coefficient on the bilateral exchange rate is an average of potentially heterogeneous ERPT to import prices which depend on the currency of the invoice. We then measure the degree of ERPT of transactions invoiced in the exporter country's currency and those invoiced in USD. Panel B of Table 2.3 shows results for ERPT regression distinguishing among transactions invoiced in the exporter country's currency *vis a vis* those that invoice in USD (see Equation 2.2). The ERPT is high and similar in impact for both types of exporters (around 90 percent). However, the ERPT from exporters that invoice their products in their country's currency is higher after eight quarters (100 percent vs 60 percent).

When we decompose import goods into consumption and non-consumption goods, for both types of exporters, there are no significant differences in the ERPT to import prices on the impact between good types; however, in the long run, we find different patterns across currency of invoice. After eight quarters, the ERPT from exporters that invoiced in their domestic currency is higher for consumption goods than non-consumption goods (135 percent vs. 85 percent) and similar across good types for exporters that invoiced in USD (around 60 percent). We find noticeable differences across good types when decomposing final consumption goods into food, transportation, and manufacturing. For food and manufacturers, the ERPT has a high impact (more than 90 percent); it increases for exporters that invoice in their country's currency and decreases for exporters that invoice in USD. In contrast, for transportation, the ERPT is relatively lower (48 percent bilateral and 62 percent USD) but increases over time for both types of exporters.

The previous analysis allowed us to evaluate the ERPT depending on the currency of the invoice. Still, it did not consider the potential impact of the bilateral exchange rate when the currency of the invoice is in the USD, which is the corresponding case for mainly all the Chilean imports originating outside the US. To understand the role of bilateral exchange rates to non-USD countries that invoice their exports in USD, Panel C of Table 2.3 shows results from ERPT regression adding an interaction term between transaction invoice in USD and the CLP-X exchange rate (see Equation 2.3). For USD-invoiced imports from non-USD countries, the short-run ERPT from a depreciation in the USD exchange rate is high (around 90 percent). In the medium and long run, the ERPT decreases but remains relatively high (around 60 percent). There are no quantitatively large differences across good types. On the other hand, the ERPT from a depreciation in the bilateral exchange rate is close to zero on impact for USD invoiced imports but increases, reaching a peak of 28 percent after four quarters. Moreover, consumption goods are higher than non-consumption goods (42 percent vs. 20 percent). Finally, for the three categories of final consumption goods, the ERPT from a depreciation in the USD exchange rate is high on impact (around 90 percent) and decreases over time but remains relatively high. Instead, the ERPT in the bilateral exchange rate is significantly greater than zero on impact only for food (25 percent) and for food and manufactures in the medium run (57 and 46 percent, respectively).

The previous results support the dominant currency paradigm in imports in the short run. However, bilateral exchange rate fluctuations also matter for longer time horizons, supporting PCP. Although consumption and non-consumption goods exhibit similar currency of invoicing patterns, imported consumption goods experience a higher ERPT. These results are meaningful for the expected ERPT at the store. ERPT at the border is an upper bound for consumption goods.

Table 2.4 reports regression results of ERPT to export prices. Panel A of Table 2.4 shows results from a panel regression of export prices on bilateral exchange rates (see Equation

Table 2.3: Invoice Currency and Bilateral ERPT to Import Prices

		BEC		CCIF		
	All	Consumption	Non-cons.	Food	Transportation	Manufactures
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. ERPT Bilateral						
β_0	0.553***	0.633***	0.507***	0.694***	0.356*	0.682***
$\sum_{s=0}^{4} \beta_s$	0.685***	0.840***	0.579***	0.847***	1.048*	0.869***
$\sum_{s=0}^{8} \beta_s$	0.679***	0.845***	0.560***	0.946***	1.124**	0.842***
R2	0.067	0.067	0.068	0.066	0.069	0.066
Adj. R2	-0.0271	-0.0275	-0.0261	-0.0386	-0.0222	-0.0238
Panel B. ERPT by invoice currency						
β_0^B	0.911***	0.959***	0.881***	0.922***	0.480	1.125***
$\sum_{s=0}^{4} \beta_s^B$	1.114***	1.231***	1.034***	0.848***	0.674	1.775***
$\sum_{s=0}^{8} \beta_s^B$	1.033***	1.348***	0.850***	1.101***	0.704	2.009***
$\beta_0^{\$}$	0.885***	0.905***	0.865***	0.952***	0.618**	0.911***
$\sum_{s=0}^{4} \beta_s^{\$}$	0.700***	0.766***	0.644***	0.815***	1.089*	0.695***
$\sum_{s=0}^{8} \beta_s^{\$}$	0.597***	0.601***	0.574***	0.670**	1.094	0.478**
R2	0.074	0.072	0.077	0.074	0.074	0.071
Adj. R2	-0.0190	-0.0215	-0.0169	-0.0315	-0.0242	-0.0190
Panel C. Invoice currency and bilateral ERPT.						
$\beta_0^{B;B}$	0.926***	0.981***	0.892***	0.940***	0.515	1.155***
$\sum_{s=0}^{4} \beta_s^{B;B}$	1.153***	1.286***	1.063***	0.889***	0.758	1.851***
$\sum_{s=0}^{8} \beta_s^{B;B}$	1.080***	1.414***	0.886***	1.152***	0.796	2.104***
$\beta_0^{\$;\$}$	0.907***	0.895***	0.901***	0.910***	0.943**	0.869***
$\sum_{s=0}^{4} \beta_s^{\$;\$}$	0.605***	0.618***	0.579***	0.715**	0.731	0.516**
$\sum_{s=0}^{8} \beta_s^{\$;\$}$	0.585***	0.594***	0.568***	0.713**	0.854	0.428*
$\beta_0^{B;\$}$	-0.003	0.067	-0.035	0.249**	-0.359	0.112
$\sum_{s=0}^{4} \beta_s^{B;\$}$	0.280***	0.415***	0.200*	0.569**	0.709	0.459**
$\sum_{s=0}^{8} \beta_s^{B;\$}$	0.185	0.250	0.142	0.366	0.741	0.341
R2	0.075	0.073	0.077	0.077	0.087	0.072
Adj. R2	-0.0186	-0.0208	-0.0168	-0.0299	-0.0192	-0.0180
Obs.	91,307	32,235	59,072	7,721	1,206	19,239

Notes: The table shows the results of ERPT to import price regressions. Panel A shows the regression results (2.1). Panel B shows the regression results (2.2). Panel C shows the regression results (2.3). Column (1) reports estimates for all import products. Columns (2) and (3) report estimates for consumption goods and non-consumption goods (intermediate and capital goods) according to BEC classification. Columns (4)-(6) report estimates decomposing final consumption goods into food, transportation, and manufacturing according to CCIF classification. ***, **, * denote statistical significance at 1, 5, and 10 percent levels.

2.4). Regardless of the good type, the ERPT to export prices from a depreciation in the bilateral exchange rate is much lower than the ERPT to import prices. Moreover, there are no large differences in the magnitude of ERPT across good types. Panel B of Table 2.4 shows results for ERPT by invoice currency regression (see Equation 2.5). Again, we can see noticeable differences in ERPT compared to import prices. Regardless of the time horizon, the ERPT is nearly zero and insignificant for trading partners that invoice their imports in their local currency. In contrast, the ERPT is high on impact (87 percent) and remains relatively high (around 55 percent) over the medium and long run for importers invoicing in USD. This dynamic is similar across good types. However, there are some differences in the magnitudes. In the long run, it is higher for consumption goods than for non-consumption goods (65 percent vs. 46 percent), and the ERPT is higher for manufacturers than for food (102 percent vs. 71 percent).

Finally, to understand the role of bilateral exchange rates to non-USD countries that invoice their Chilean imports in USD, Panel C of Table 2.4 shows results from ERPT regression adding an interaction term between transaction invoice in USD and the CLP-X exchange rate (see Equation 2.6). For USD-invoiced exports going to non-USD countries, the short-run ERPT from a depreciation in the USD exchange rate is high (82 percent). In the medium and long run, the ERPT decreases but remains relatively high (35-40 percent). There are some remarkable differences across good types. In the long run, the ERPT to export prices are higher for consumption goods than non-consumption goods (50 percent vs. 20 percent). When we decompose final consumption goods into food and manufactures, the ERPT is higher for the latter on impact (116 percent vs. 85 percent) and after eight quarters (124 percent vs. 48 percent). On the other hand, the ERPT from a depreciation in the bilateral exchange rate is close to zero on impact for USD invoiced transactions but increases over time, reaching 45 percent after eight quarters. As opposed to the imports case, it is higher for non-consumption goods than consumption goods (57 percent vs. 36 percent). Moreover, the

ERPT is higher for food than for manufacturers (44 percent vs. 17 percent). These results imply a more important role for bilateral exchange rates when transactions are invoiced in dollars in the case of exports.

5.2 Results at the store

This section presents our regression results at the store's product level. We evaluate how ERPT depends on the currency of invoicing associated with import and export goods. As a benchmark, we first estimate ERPT for consumption goods with the traditionally used nominal effective exchange rates (NEER) and bilateral dollar rates. Then, we estimate ERPT with the new NEER weighted at the product level described in Section 3.2. Finally, we compare those previous results with our new instrumental variable approach.

Table 2.5 reports ERPT regression results for the store's NEER and bilateral dollar rates. Panel A of Table 2.5 shows the results for ERPT for products at the store that are only related to imports.[25] We find that the official NEER has a higher ERPT than the bilateral dollar (see columns (1)-(3)).[26] This result is valid in the short and medium term, and in both cases, ERPT increases with the time horizon. Panel B shows results for ERPT for products at the store that are only related to exports. As expected, the results are qualitatively similar to those of imports.

However, the official NEER is an aggregate index calculated using almost all traded goods. As discussed in previous sections, goods are traded with different countries, so assuming the same weight for all goods is misleading. Then, to tackle this concern, we develop a new

[25] As described in Section 4., imported goods are more diversified than exported goods, so we have a different number of observations per each part of the trade balance.

[26] NEER official considers the bilateral exchange rate of all trading partners. In comparison, NEER-5 considers bilateral rates of only the five trading partners: the U.S., Japan, the UK, Canada, and the Euro Zone.

Table 2.4: Invoice Currency and Bilateral ERPT to Export Prices

		BEC		CCIF	
	All	Consumption	Non-consump.	Food	Manufactures
	(1)	(2)	(3)	(4)	(5)
Panel A. ERPT Bilateral					
$\mathcal{B}_0$	0.046***	0.027***	0.088***	0.099	0.058
$\sum_{s=0}^{4} \mathcal{B}_s$	0.108***	0.072**	0.184***	0.180***	0.282*
$\sum_{s=0}^{8} \mathcal{B}_s$	0.127***	0.089*	0.206***	-0.016***	0.173
R2	0.052	0.046	0.064	0.065	0.063
Adj. R2	-0.0256	-0.0352	-0.00867	-0.0117	-0.0491
Panel B. ERPT by invoice currency					
$\mathcal{B}_0^B$	-0.005	-0.013	0.011	0.072***	0.067*
$\sum_{s=0}^{4} \mathcal{B}_s^B$	0.042	0.024	0.081	0.090**	0.413**
$\sum_{s=0}^{8} \mathcal{B}_s^B$	0.093*	0.063	0.157**	-0.153**	0.373
$\mathcal{B}_0^{\$}$	0.865***	0.858***	0.876***	0.911***	1.050***
$\sum_{s=0}^{4} \mathcal{B}_s^{\$}$	0.588***	0.628***	0.539***	0.696***	0.970***
$\sum_{s=0}^{8} \mathcal{B}_s^{\$}$	0.566***	0.647***	0.463***	0.709***	1.022**
R2	0.075	0.066	0.092	0.087	0.073
Adj. R2	-0.0012	-0.0139	0.0215	0.0117	-0.0403
Panel C. Invoice currency and bilateral ERPT					
$\mathcal{B}_0^{B;B}$	-0.003	-0.011	0.015	0.074***	0.065*
$\sum_{s=0}^{4} \mathcal{B}_s^{B;B}$	0.055	0.030	0.104**	0.097**	0.404*
$\sum_{s=0}^{8} \mathcal{B}_s^{B;B}$	0.113**	0.0725	0.193**	-0.142**	0.360
$\mathcal{B}_0^{\$;\$}$	0.822***	0.841***	0.792***	0.851***	1.165***
$\sum_{s=0}^{4} \mathcal{B}_s^{\$;\$}$	0.413***	0.504***	0.288***	0.490***	1.118***
$\sum_{s=0}^{8} \mathcal{B}_s^{\$;\$}$	0.368***	0.499***	0.195**	0.481***	1.239***
$\mathcal{B}_0^{B;\$}$	0.079***	0.036	0.147***	0.095**	-0.217
$\sum_{s=0}^{4} \mathcal{B}_s^{B;\$}$	0.374***	0.292***	0.496***	0.398***	0.0766
$\sum_{s=0}^{8} \mathcal{B}_s^{B;\$}$	0.446***	0.361***	0.567***	0.444***	0.168
R2	0.076	0.067	0.094	0.089	0.078
Adj. R2	-0.0004	-0.0133	0.0229	0.0130	-0.0363
Obs.	86,925	50,060	36,865	42,045	4,697

Notes: The table shows the results of ERPT to import price regressions. Panel A shows the regression results (2.4). Panel B shows the regression results (2.5). Panel C shows the regression results (2.6). Column (1) reports estimates for all import products. Columns (2) and (3) report estimates for consumption goods and non-consumption goods (intermediate and capital goods) according to BEC classification. Columns (4) and (5) report estimates decomposing final consumption goods into food and manufacturing according to CCIF classification. ***, **, * denote statistical significance at 1, 5, and 10 percent levels.

variable called nominal effective exchange rate at the product level (NEER product level), where bilateral rates are weighted by relevant trade partners at the product level. Column (4) in Panel A Table 2.5 reports the results for products related to imports. ERPT decreases and is closer to the bilateral USD rate. Even when we use a non-weighted average of the specific bilateral rates associated with imports, ERPT decreases (see column 5).[27] There is a clear contrast when we use retail products associated with exports in Panel B. ERPT, in this case, is no longer positively affecting retail prices. This is consistent with results from the previous section, which state that bilateral rates for export produce a small impact.

Three important results emerge from the previous analysis. First, independently of the exchange rate variable considered in-store regressions, ERPT is significantly lower at the store than at the border for imports and exports. This finding is consistent with our model and with a long body of literature that found a lower ERPT at the store than at the border (Burstein and Gopinath, 2014). Second, independently of the exchange rate variable considered in-store regression, ERPT over impact is close to zero and increases over time. This result is directly related to our theoretical results; in the short run, price rigidities play a determinant role, and as those rigidities ease, then exchange rate fluctuations become relevant. This result is similar to LCP but at lower levels of ERPT. Third, when we move to a more suitable exchange rate, such as the bilateral dollar (90% of consumption imports and 82% of consumption exports are invoiced in dollars) or NEER product-level (heterogeneous bilateral rates across products), ERPT at the store decreases. So, there is an upward bias when using NEER to measure ERPT at the store.

Next, we move to the instrumental variable approach described in Section 3.2. Column (1) in Panel A Table 2.6 shows results when we use Equation (2.1) as a first stage for imports. We find a lower ERPT at the store compared to the results obtained in Panel A Table 2.5,

[27] It implies that there is a country composition and a magnitude composition effects interacting. Future research will disentangle both effects.

Table 2.5: Tradable CPI at the Product Level. ERPT with Observed Exchange Rates for Imports and Exports

	NEER Official	NEER-5 Official	USD	NEER Product-level (weighted avg.)	NEER Product-level (simple avg.)
	(1)	(2)	(3)	(4)	(5)
Panel A. Imports					
β_0^s	0.071***	0.079***	0.027	0.007	0.018***
$\sum_{i=0}^{4} \beta_i^s$	0.349***	0.330***	0.241***	0.207***	0.214
$\sum_{i=0}^{8} \beta_i^s$	0.495***	0.461***	0.278***	0.321***	0.369***
Observations	3,017	3,017	3,017	3,017	3,017
R-squared	0.189	0.185	0.186	0.179	0.176
Adj. R-squared	0.149	0.145	0.147	0.139	0.136
Panel B. Exports					
β_0^s	0.100***	0.076***	0.049**	-0.067*	-0.031***
$\sum_{i=0}^{4} \beta_i^s$	0.352***	0.291***	0.226***	-0.291***	-0.188***
$\sum_{i=0}^{8} \beta_i^s$	0.479***	0.382***	0.263***	-0.399***	-0.274***
Observations	2,175	2,175	2,175	2,175	2,175
R-squared	0.151	0.143	0.144	0.131	0.134
Adj. R-squared	0.104	0.0959	0.0973	0.0829	0.0870

Notes: The table shows the results of ERPT to the store regression (2.7) controlling for different exchange rates. Column (1) controls for the official nominal effective exchange rate (NEER). Column (2) controls for the official NEER-5 (the US, Japan, the UK, Canada, and the Euro Zone). Column (3) controls for CLP-USD. Column (4) controls for NEER product level defined in Equation (2.8). Column (5) controls for a non-weighted NEER product level. Panel A shows results for imports, and Panel B shows results for exports. ***, **, * denote statistical significance at 1, 5, and 10 percent levels.

even though our instrument does not include dollar variation.[28] Specifically, compared to our benchmark results (columns 1 and 2 in Table 2.5), we find a lower ERPT for both the short and long run. This lower pass-through implies an upward bias in official NEER when calculating ERPT at the store. An important result is that over-impact ERPT is lower and closer to zero, which is consistent with our model. When we include dollar variation in our instrument (Equation 2.2) we find a lower ERPT in the short (0 percent) and long run (24 percent). Finally, we include bilateral rates for dollar invoices in our instrument (Equation 2.3). ERPT reduces slightly in the medium run to 14 percent and in the long run to 23 percent.

Contrasting the instrumental variables with and without bilateral dollars is important to account for the relevance of the currency of the invoice (columns 1 vs. 2 and 3). The level of ERPT is significantly lower when present, which points out that bilateral rates are not the only determinant.[29] Moreover, as both bilateral and dollar are relevant at the border, our econometric model would be misspecified without considering the dollar variation. The implication is that the currency of invoicing matters at the border and the store.[30]

Next, we move to exports in Panel B Table 2.6. As we previously discussed for border results, bilateral rates play a minor role in exports. Column (1) shows no statistically significant results for our instrumental variable that uses only bilateral exchange rate movements (Equation 2.4). This result echoes what we observed at the border. The incorporation of the dollar in our instrument dramatically changes the results in the long run. We find a

[28] Note that in column (1) we construct our instrument using bilateral rates only. As we discussed, the instrument in this case has an omitted relevant variable bias due to the dollar's relevance at the border, and so on; the results are more similar to those in the official NEER.

[29] Table 2.8 in Appendix 2.8 shows ERPT to store results when we consider at the border and at the store food and alcoholic beverages only. Panel A shows the results for imports and B for exports. The results are similar for imports and considerably lower for exports.

[30] A caveat for our results is that at the border, we find a similar impact for imports for a dollar and bilateral exchange rates, so huge differences at the store should not be observed. In column (4) Table 2.6, we consider only dollar variation, finding almost identical results to column (1).

larger long-term ERPT of 26 percent (column 2). When bilateral rates for dollar invoices are included (column 3), ERPT again loses significance, as when we use only fluctuations in bilateral exchange rates in the first step. Finally, in column (4), we use an instrument incorporating only dollar variation. This counterfactual exercise finds a high ERPT close to 1 in the long term.[31] This result of the high relevance of dollars related to exports is a reminiscence of the at-the-border exercise and points out the key role of the invoice currency at the store.

The previous results provide three key insights. First, over impact, ERPT is almost zero. This result was also present without considering instrumental variable analysis and is consistent with our model. Second, considering only bilateral rates or dollars as a determinant of retail prices is misleading and can produce biased estimations. Third, determinants of import and export prices at the border echo at the store, mainly in the medium and long term. We showed in Chile at the border for consumption goods, the currency of the invoice is an important determinant of ERPT on top of bilateral rates. Therefore, our second and third insights highlight the relevance of the currency of invoices at the border and the store.

[31]An ERPT close to 1 is unexpected, and we attribute it to misspecification bias due to bilateral rates omitted.

Table 2.6: Tradable CPI at a product level. Instrumental variables associated with imports and export prices

	IV Model 1 (1)	IV Model 2 (2)	IV Model 3 (3)	IV Model 1* (4)
Panel A. Imports				
β_0^s	-0.027***	-0.019	-0.020***	-0.008
$\sum_{i=0}^{4} \beta_i^s$	0.189	0.152***	0.143	0.181***
$\sum_{i=0}^{8} \beta_i^s$	0.271***	0.241***	0.231***	0.261***
Obs.	3,017	3,017	3,017	3,017
R2	0.181	0.184	0.185	0.187
Adj. R2	0.141	0.145	0.146	0.148
Panel B. Exports				
β_0^s	0.304	-0.017**	-0.041	0.101***
$\sum_{i=0}^{4} \beta_i^s$	0.263	0.181	0.0689	0.562
$\sum_{i=0}^{8} \beta_i^s$	-0.360	0.256**	0.162	1.123***
Obs.	2,175	2,175	2,175	2,175
R2	0.130	0.126	0.124	0.134
Adj. R2	0.0826	0.0783	0.0762	0.0868

Notes: The table shows the results of ERPT to the store regression (2.7) controlling for different instrumental variables. Each panel shows the sum of ERPT regression coefficients of no lags, lags 0 to 4, and lags 0 to 8. Column (1) considers the instrumental variable of the model in Equation (2.1) for imports and in (2.4) for exports. Column (2) considers the instrumental variable of the model in Equation (2.2) for imports and in (2.5) for exports. Column (3) considers the instrumental variable of the model in Equation (2.3) for imports and in (2.6) for exports. Finally, Column 4 considers the same model as in Column 1 but replaces the bilateral exchange rate with the CLP-USD exchange rate. ***, **, * denote statistical significance at 1, 5, and 10 percent levels.

6. Conclusion

This paper uses a comprehensive dataset from Chile to analyze the role of currency in invoicing for ERPT at the border and the store. At the border, consistent with the dominant currency paradigm, we find a predominant role for the USD for ERPT; however, bilateral exchange fluctuations display an important role in the medium and long run, providing support to PCP. Moreover, we find differences in the magnitude of ERPT when we distinguish between final consumption goods and non-consumption goods and when we decompose final consumption goods into food, transportation, and manufacturing.

Using a new instrumental variable approach that leverages at-the-border regressions, we find that exchange rate fluctuations do not affect retail prices on impact, consistent with sticky prices set in the consumer's currency. For longer time horizons, as nominal rigidities ease, determinants of import and export prices at the border echo at the store, however, in a lower magnitude. We show that considering only bilateral rates or dollar fluctuations as a determinant of retail prices produces biased estimations, highlighting the relevance of the currency of invoices at the store.

7. Appendix

7.1 Model

Households

We consider an economy populated by a continuum of symmetric households of measure 1. In country j, a representative household h consumes a bundle of traded goods C_{jt}.[32] Households own firms in this economy, and to simplify, we assume labor is inelastically supplied. Then, per period utility function is

$$U_t = \frac{1}{1-\sigma} C_{jt}^{1-\sigma} \tag{2.9}$$

where the coefficient of relative risk aversion is $\sigma > 0$. The consumption aggregator is defined by the homothetic CES[33]

$$C_{jt} = (w_x^{\frac{\eta-1}{\eta}} (C_t^x)^{\frac{\eta-1}{\eta}} + w_m^{\frac{\eta-1}{\eta}} (C_t^m)^{\frac{\eta-1}{\eta}})^{\frac{\eta}{\eta-1}} \tag{2.10}$$

where η is the relative preference parameter for exports to imports.

The following function describes household preferences,

$$\mathbb{E}_t \sum_t \beta^t U\Big(C_t\Big) \tag{2.11}$$

where U is a standard CRRA function with parameter σ. β is a subjective discount factor

[32] The notation closely follows the one in Gopinath, et al. (2020).

[33] Gopinath, et al. (2020) assumes Kimball homothetic demand aggregator. In our case, we omit this assumption to gain more economic intuition in the role of distribution costs.

within the interval $(0, 1)$.

It is assumed that the consumer divides expenditures between imported C^m and exported C^x consumption of final goods and has access to an internationally traded one-period, state non-contingent bond B_t denominated in foreign currency. Then, consumer budget constraint is,

$$P_t^m C_t^m + P_t^x C_t^x + \mathcal{E}_{jt}(1 + i_{jt-1})B_{jt} = W_t N_t + \Pi_t + \mathcal{E}_{jt} B_{jt+1} \tag{2.12}$$

where P_t^m is the price of imported goods, P_t^x is the price of exported goods. Households receive income from labor, where W_t is the nominal wage and N_t hours worked that are supplied inelastically.

Domestic retailer

As we previously discussed, an essential part of our analysis is related to retailers selling imported or domestically produced products to export combined with domestic distribution services. We assume the existence of a competitive retail sector. This sector combines tradable goods (imports and exported goods) with non-tradable distribution services that are ready to buy for final consumers. Production technology is[34]

$$f(Y_j^k, Y_d^k) = Y^r = \frac{1}{(1-\gamma)^{1-\gamma}(\gamma)^{\gamma}}(Y_j^k)^{1-\gamma}(Y_d^k)^{\gamma} \tag{2.13}$$

where Y_j^k is a bundle of consumption goods consumed in country j invoiced in currency k composed by imported goods Y_{ij}^k in country j of goods produced in country i, and domestically produced goods that can also be exported Y_{ji}^k produced in country j and potentially

[34]Leontief technology is a stylized assumption used in the literature that captures all the relevant elements for our analysis (Burstein, et al., 2003).

exported to country i.[35] Y_d^k is a distribution service denominated in currency k in the country j.

The cost minimization problem determines consumers' final retail price in product g invoiced in currency k. To simplify, we assume retailers sell in local currency $k = j$. The retail price index of good g is:

$$P_{gj}^r = (P_{gj})^{1-\gamma}(P_d^k)^\gamma \tag{2.14}$$

where producer price P_{gj} for product g in country j invoiced in currency local currency is obtained by aggregating import and export prices as:

$$P_{gj} = (w_m^{\eta-1}(P_{ij})^{1-\eta} + w_x^{\eta-1}(P_{ji})^{1-\eta})^{\frac{1}{1-\eta}} \tag{2.15}$$

where w_x is home bias parameter and η elasticity of substitution.

The per-period nominal profits of the firm in the distribution sector is

$$\Pi_j(\omega) = P_j^r(\omega)C_j(\omega) - MC_j^r Y^r(\omega) \tag{2.16}$$

Reset price in the firm in the distribution sector satisfies the optimality condition

$$\mathbb{E}\sum_{s=t}^{\infty}\delta_d^{s-t}\Theta_{js}Y_j\left(\bar{P}_j^r(1-\sigma) + \sigma MC_{js}^r\right) = 0 \tag{2.17}$$

In the case of fully flexible prices $\delta_d = 0$, the problem in Equation 2.17 collapses to the one-period firm problem.

[35] To simplify notation we skip subindex t. We only include it when it is necessary to avoid confusion.

Producers

Firms produce using imported intermediate inputs and labor with a Cobb-Douglas production function

$$Y_j = A_j L_j^{1-\alpha} X_j^{\alpha} \tag{2.18}$$

The minimization problem of the firm determines nominal marginal costs as

$$MC_j = \frac{1}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}} \frac{W_j^{1-\alpha} P_j^{\alpha}}{A_j} \tag{2.19}$$

The per-period nominal profits of the domestic firm producing is

$$\Pi_j(\omega) = \sum_{i,k} \mathcal{E}_{kj} P_{ji}^k(\omega)\Big(C_{ji}^k(\omega) + X_{ji}^k(\omega)\Big) - MC_j Y_j(\omega) \tag{2.20}$$

where a firm's output can be used as a consumption or intermediate good. Moreover, the convention is that $\mathcal{E}_{jj} = 1$. Producer price from country j invoiced in currency k sold in country i is P_{ji}^k.

The firm chooses prices to sell in the country j or i. As in previous literature, we consider a Calvo pricing where firms randomly reset prices with probability $1 - \delta_p$, such that price dynamic is given by

$$\Delta p_{ij,t}^k = (1 - \delta_p)(\bar{p}_{ij}^k - p_{ij,t-1}^c) \tag{2.21}$$

The demand schedule for this economy assumes a CES aggregator such that[36]

[36]This assumption produces constant markups. A potential extension to raise this assumption is defining a consumption aggregator C_j implicitly defined by a Kimball (1995) homothetic demand aggregator.

$$C_j(\omega) = \left(\frac{P^r_{gj}}{P_j}\right)^{-\sigma} C_t \tag{2.22}$$

The firm reset price satisfies the optimality condition

$$\mathbb{E}\sum_{s=t}^{\infty} \delta_p^{s-t}\Theta_{js}Y^k_{ji}\left(\mathcal{E}_{kjs}\bar{P}^k_{ji}(1-(1-\gamma)\sigma) + (1-\gamma)\sigma MC_{js}\right) = 0 \tag{2.23}$$

In the case of fully flexible prices $\delta_p = 0$, the problem in Equation (2.23) collapses to the one-period firm problem. Produce prices under flexible prices is

$$\mathcal{E}_{kjs}\bar{P}^k_{ji} = \bar{P}_{ji} = \frac{(1-\gamma)\sigma}{(1-\gamma)\sigma - 1} MC_j \tag{2.24}$$

We can use the producer price in 2.24 to produce the retail price P^r

$$P^r_g = \left(\frac{(1-\gamma)\sigma}{(1-\gamma)\sigma - 1}\right)^{1-\gamma} (MC_j)^{1-\gamma}(P_d)^{\gamma} \tag{2.25}$$

Then, we calculate the pass-through of costs to producer prices and retail prices, respectively:

$$\frac{d\log \bar{P}_{ji}}{d\log MC_j} = 1 \tag{2.26}$$

$$\frac{d\log P^r_g}{d\log MC_j} = 1-\gamma \tag{2.27}$$

Pass-through shows why it is different at the border and the store. Imported intermediate input prices are affected by ERPT, and then, in the long term, with flexible prices, ERPT at the border is higher than at the store since $\gamma \in (0,1)$.

7.2 Additional tables

Table 2.7: Invoice Currency and Bilateral ERPT for non-consumption goods

	Import		Export	
	Intermediate (1)	Capital (2)	Intermediate (3)	Capital (4)
Panel A. ERPT Bilateral				
β_0	0.517***	0.407***	0.080***	0.559***
$\sum_{s=0}^{4}\beta_s$	0.586***	0.443	0.167***	1.114**
$\sum_{s=0}^{8}\beta_s$	0.550***	0.490*	0.186***	1.787***
R-squared	0.067	0.072	0.063	0.149
Adj. R-squared	-0.0295	-0.0200	-0.00928	0.0515
Panel B. ERPT by invoice currency				
β_0^B	0.882***	0.839***	0.010	-0.633
$\sum_{s=0}^{4}\beta_s^B$	1.029***	1.028***	0.070	0.449
$\sum_{s=0}^{8}\beta_s^B$	0.751***	1.096**	0.138*	1.640*
$\beta_0^{\$}$	0.877***	0.808***	0.853***	1.192***
$\sum_{s=0}^{4}\beta_s^{\$}$	0.601***	0.797***	0.511***	0.716
$\sum_{s=0}^{8}\beta_s^{\$}$	0.562***	0.596*	0.458***	1.115*
R-squared	0.076	0.079	0.090	0.173
Adj. R-squared	-0.0195	-0.0140	0.0203	0.0682
Panel C. Invoice currency and bilateral ERPT				
$\beta_0^{B;B}$	0.895***	0.841***	0.015	-0.553
$\sum_{s=0}^{4}\beta_s^{B;B}$	1.064***	1.035***	0.092*	0.624
$\sum_{s=0}^{8}\beta_s^{B;B}$	0.793***	1.105**	0.174**	1.813*
$\beta_0^{\$;\$}$	0.906***	0.908***	0.757***	0.977***
$\sum_{s=0}^{4}\beta_s^{\$;\$}$	0.512***	0.940***	0.226***	0.459
$\sum_{s=0}^{8}\beta_s^{\$;\$}$	0.534***	0.775**	0.174**	0.648
$\beta_0^{B;\$}$	-0.009	-0.214	0.158***	0.361
$\sum_{s=0}^{4}\beta_s^{B;\$}$	0.252**	-0.175	0.531***	0.755
$\sum_{s=0}^{8}\beta_s^{B;\$}$	0.207	-0.340	0.571***	1.256
R-squared	0.076	0.079	0.092	0.178
Adj. R-squared	-0.0193	-0.0142	0.0219	0.0653
Observations	47,074	9,762	33,069	992

Notes: The table shows the results of ERPT to import and export price regressions for components of non-consumption goods. Panel A columns (1) and (2) show the results of regression (2.4), Panel B columns (1) and (2) show the results of regression (2.5), and Panel C columns (1) and (2) show the results of regression (2.6) for imports. Similarly, for exports in columns (3) and (4). Columns (1) and (3) report estimates for intermediate and (2) and (4) report estimates for capital. ***, **, * denote statistical significance at 1, 5, and 10 percent levels.

Table 2.8: Tradable CPI related to food and alcoholic beverages. Instrumental variables associated with imports and export prices

	IV Model 1 (1)	IV Model 2 (2)	IV Model 3 (3)
Panel A. Imports			
β_0^s	0.0217**	0.0772*	0.0406***
$\sum_{i=0}^{4} \beta_i^s$	0.272***	0.257***	0.225***
$\sum_{i=0}^{8} \beta_i^s$	0.342	0.342***	0.277
Obs.	1,216	1,216	1,216
R2	0.038	0.036	0.035
Adj. R2	-0.0173	-0.0191	-0.0201
Panel B. Exports			
β_0^s	1.023**	0.034**	0.0237
$\sum_{i=0}^{4} \beta_i^s$	1.588**	0.320**	0.187
$\sum_{i=0}^{8} \beta_i^s$	0.0608	0.436	0.306
Obs.	1,361	1,361	1,361
R2	0.042	0.028	0.026
Adj. R2	-0.00494	-0.0188	-0.0208

Notes: The table shows the results of ERPT to the store regression (2.7) controlling for different exchange rates. This table considers only divisions 1 and 2 of consumption related to food and alcoholic beverages Each panel shows the sum of ERPT regression coefficients of no lags, lags 0 to 4, and lags 0 to 8. Column (1) considers the instrumental variable of the model in Equation (2.1) for imports and in (2.4) for exports. Column (2) considers the instrumental variable of the model in Equation (2.2) for imports and in (2.5) for exports. Column (3) considers the instrumental variable of the model in Equation (2.3) for imports and in (2.6) for exports. ***, **, * denote statistical significance at 1, 5, and 10 percent levels.

Chapter 3

Firms price setting and market power during episodes of high inflation

1. Introduction

During 2021 and 2022, the OECD countries registered inflation spikes not seen in decades. In tandem with inflation, firms' profits soared, generating concern in policy and academic circles about the role of market competitiveness as a driver of inflation. A particular channel by which competition may have fueled the last global inflation episode, emphasized by policymakers and academic circles, is that inflation itself may have reduced market competition, increasing firms' markups.[1] Because markup increases directly affect inflation and imply a higher passthrough of cost shocks to prices, this channel entails a reinforcement mechanism that could explain persistent inflation levels even after cost pressures are normalized. So far, the effect of unanticipated inflation shocks on market competition, particularly in the

[1] See, for example, the 2022 OECD's report on competition and inflation (OECD, 2022).

post-pandemic episode, has received little attention in the academic literature.[2]

In this paper, we study how firms' markups react to episodes of high inflation. In particular, we are interested in studying whether part of this reaction is partially explained by changes in the competitive environment in which firms operate that are not related to changes in demand. Disentangling the competition and the demand channels is a challenging empirical task because these two variables likely comove during an inflation episode: positive demand shocks are expected to induce inflation pressures and higher markups even if there is no change in the competitive environment that firms face. In turn, an inflationary environment may reduce market competition and increase markups, such as strategic complementary pricing, tacit collusion, or lower consumer price sensitivity.[3] To so, we use detailed firm-level data from the ORBIS database and compare the reaction of firms' markups to unanticipated inflation episodes in countries with different degrees of strictness in their antitrust regulation, as proposed by Besley, et al. (2021). Moreover, we consider an instrumental variable approach to control for endogenous changes in demand. Using this approach, we compare the post-pandemic inflation episode with other inflation episodes in the last two decades for OECD countries.

Our results show that the post-pandemic inflation episode was different. Although markups positively correlate with inflation shocks in all episodes, they increased significantly this time. In contrast, supply and demand shocks appear less relevant in explaining the markup increase in the last episode. These results hold when instrumenting demand shocks with different sources of exogenous variations, such as fiscal shocks and COVID-19 aid measures to households. Finally, we find that firm markups increased significantly in more concentrated sectors and significantly less in jurisdictions with tighter antitrust regulations during the last inflation episode.

[2] Chirinko and Fazzari (2000) and Acharya, et al. (2023) are notable exceptions.

[3] See for instance, Amiti, et al. (2019); Afrouzi and Caloi (2022); Acharya, et al. (2023).

2. Related literature

This paper is related to three strands of literature: the literature that studies the recent inflation episode post-pandemics, the literature that studies markups across time and their cyclicality, and the literature that studies strategic behavior related to markups.

There is an increasing interest in understanding the determinant factors of inflation after pandemics.[4] In the United States, different policy reports have evaluated the evolution of markups. A common view is related to a high spike in markup in 2021, which is higher than in previous decades. However, the determinants of the spike are less clear (Andler and Kovner, 2022; Glover, et al., 2023).[5] In the Euro Area, high inflation levels have been unobserved for decades. A leading explanation relates to the propagation of supply-chain disruptions to inflation expectations (Acharya, et al., 2023). They found that markup increases complemented household inflation expectations to produce higher inflation. In Canada, a rise in inflation not seen in two decades was also present. However, the markup increase was mild in this case, especially in sectors associated with final consumption goods (Faryaar, et al., 2023). We focus on disentangling the role of reduced demand from the demand shocks. Moreover, we are interested in markups for a broad set of countries and the comparison with previous inflation episodes.

A growing body of research has focused on markup cyclicality. Nekarda and Ramey (2020) show that markup cyclicality depends on the nature of macroeconomic shocks. Under demand shocks, they find that markups are procyclical.[6] Anderson, et al. (2018) go a step

[4]There is a long literature that studies inflation episodes. Recently, Blanco, et al. (2023) found those episodes are larger and more persistent when policy responses depart from textbook policy rules.

[5]Wage spirals is another important determinant of inflation studied. In the U.S., Bernanke and Blanchard (2023) find that the wage spiral did not play a key role; aggregate demand and commodity prices were more relevant.

[6]Markup cyclicality is a relevant property for new-Keynesian literature as it is a transmission mechanism for demand shocks.

forward to study markup dispersion across time and space. Over time, markup evolves mildly, but across space, there are large variations. From a theory perspective, Burstein, et al. (2023) characterize, through an oligopolistic model, the comovement of firm, sector, and economy-wide markups with sectoral and aggregate output, and they help to disentangle previous conflicting stylized facts. Our contribution to this literature is showing that aggregate shocks are important markup determinants across time. Moreover, we provide evidence that under exogenous demand shocks, markups are less sensitive.

Strategic behavior plays a central role in determining markups. Vast evidence of strategic complementarity in price setting has been found. Pitschner (2020) finds in corporate filings that this type of real rigidity is common in public companies. Amiti, et al. (2019) develop a general framework and show empirically that firms' prices respond to competitors' prices, which is more relevant for large firms.[7] Under a different market structure, Afrouzi and Caloi (2022) show implicit collusion models carry a relationship between markup and expected future sales growth and find empirical support for this model. We depart from this literature to assess how industry-level markups respond during an inflation episode and how firms react to aggregate and sector-level prices.

3. Theoretical framework and data

3.1 Theoretical framework: Firm price setting

Assume an invertible demand system $q_{it} = q_i(p_t; \xi_t)$ in a given industry s where $i \in \{1, ..., N\}$, vector of prices p_t, and demand shifters ξ_t.[8] Then, assuming flexible prices, the firm's profits

[7] A recent contribution to the study of strategic complementarity and price rigidities in a theoretical model is Alvarez, et al. (2022).

[8] To simplify notation we skip s corresponding to sector.

$$\pi_{it} = P_{i,t}(Q_{i,t})Q_{i,t} - MC_{it}Q_{i,t} \tag{3.1}$$

After solving the firm problem and applying logs, we define markups as

$$\mu_{it} \equiv p_{it} - mc_{it} = \log\left(\frac{\sigma_{it}}{\sigma_{it}-1}\right) \tag{3.2}$$

where $\sigma_{it} \equiv \frac{d\log Q_{it}}{d\log P_{it}}$. Markup μ_{it} is an equilibrium object determined by the firm's price, marginal cost, demand elasticities, demand shifters, and competitors' prices.[9]

From Equation (3.2), an increase in markup is not only associated with reduced competition. Marginal costs and market demand also play determinant roles.[10] Then, an identification problem appears as we can not separate the role of reduced demand without accounting for the role of market demand during an inflation episode.

To interpret the right-hand side in Equation (3.2), we need to assign market structure and/or functional forms to the demand. Arkolakis and Morlacco (2017) find for a broad set of demand structures, σ_{it} decreases and markup increases in market share. A commonly used market structure that provides time-varying markups is assuming Atkeson and Burstein (2008) nested CES with oligopolistic competition. Under quantity competition, it produces the following markup

$$\mu_{it} = \log\left(\frac{\sigma_{it}}{\sigma_{it}-1}\right) = -\log\left(\left(1-\frac{1}{\rho}\right) + s_{it}\left(\frac{1}{\rho}-\frac{1}{\eta}\right)\right) ;\, 1 < \eta < \rho \tag{3.3}$$

where η and ρ are the elasticity of substitution such that $1 < \eta < \rho$, and market share s_{it} depends positively on demand shifters and negatively on relative prices (its own price relative to market price).

From this stylized framework, we expect a positive relationship between markups and market

[9] A simplifying assumption in our analysis corresponds to medium-term analysis, and then price rigidities are less binding. This assumption is related to the structure of our dataset, which is annual.

[10] An inflation episode is usually associated with an increase in marginal costs, but the role of demand is less clear. If the marginal cost role overcomes demand or market power, we expect to observe declining markups during an inflation episode.

prices. Given our focus on unexpected inflation episodes, a stronger relationship should be expected in industries with higher price increases. Moreover, the previous framework also points out the relevance of accounting for demand shifters simultaneously affecting relative prices to identify the inflation episode on a firm's markups.

3.2 Data

The most relevant dataset for our analysis is Orbis, which standardized the firm's balance sheet across countries and sectors. We employ data from 2000-2022 for OECD countries. The focus is on medium and large firms that can exert market power.[11] From this dataset, we use profit margin as a proxy for markup, operating revenue, costs of goods sold, material costs, wages, employment, and NACE firm sector. We aggregate data at the industry level using the revenue share as a weight.

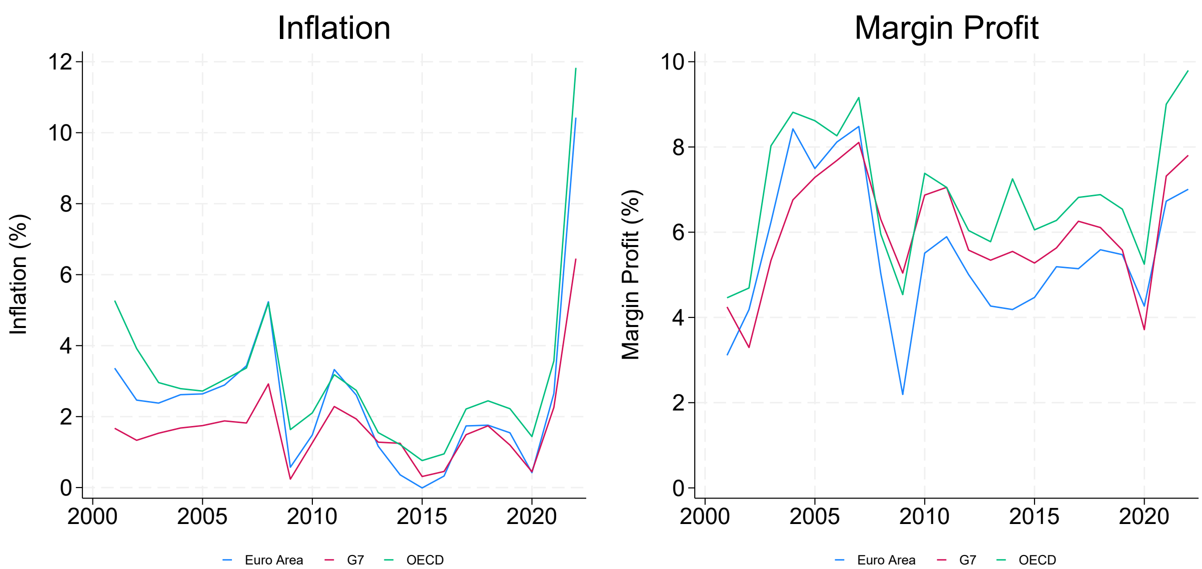
We use the methodology of Blanco, et al. (2023) to estimate inflation episodes. It evaluates observed inflation for every country against a rolling 10-year average plus 1.65 standard deviations. We consider the World Bank dataset for CPI headline, core, energy, and food. Finally, we obtain the GDP deflator from the OECD as sector-level inflation. This variable is constructed as the ratio between nominal and real GDP, and then we obtain a price index per NACE sector.

Figure 3.1 shows aggregate headline inflation and average margin profits for OECD countries, Euro Area, and G7 between 2001-2022. The left panel of the figure clearly reflects the last inflation episode. Until 2020 inflation was moderate and close to 2%, but then skyrocketed until 12% for OECD countries. This Figure also shows that previous to the Global Financial Crisis, there was an inflation episode. More moderated is the episode post Global Financial Crisis, which rapidly declined by the middle of the decade.

[11] Cleaning procedure follows Besley, et al. (2021); Diez, et al. (2020); Kalemli-Ozcan, et al. (2024).

The left panel of Figure 3.1 shows the evolution of margin profits. The recent increase in inflation coincides with markup increases, although for the three groups of countries, it is more moderate than the spike in inflation. Margin increases were also present before the global financial crisis, which was more persistent than the last one.

Figure 3.1: Inflation and margin profit over time



Note: This figure shows inflation and margin profit between 2001-2022. Groups of countries are Euro Area (blue), G7 (red), and OECD (green). Source: World Bank and ORBIS.

To estimate demand shocks, we consider a broad set of aggregate variables. From the World Bank and IMF, we use real GDP growth, real consumption growth, social expenditures, military expenditures, and domestic interest rates. Finally, we use the Antitrust index in Besley, et al. (2021) to evaluate market power. This index codes antitrust laws and policies worldwide and involves all OECD countries except Japan.

3.3 Measuring Markups: Accounting vs. Production approach

We consider two approaches to measure markups: Accounting and production. The accounting approach $\tilde{M}$ identifies net profit $p_t y_t - p_{xt} x_t$ over total sales $p_t y_t$ as a proxy for markups. From Orbis, we consider the variable margin profit to be the key variable for our analysis.[12] Under the accounting approach, markup is

$$\tilde{M}_t = \frac{p_t y_t - p_{xt} x_t}{p_t y_t} = 1 - \frac{p_{xt} x_t}{p_t y_t} \tag{3.4}$$

where $p_{xt} x_t$ is the total value of variable inputs, and we identify in the data with costs of goods sold, and $\frac{p_{xt} x_t}{p_t y_t}$ is the expenditure share of the inputs.

The production approach is based on De Loecker and Warzynski (2012) method to obtain the markup $\tilde{\mu}$ from the firm's cost minimization problem. The solution to this problem is

$$\tilde{\mu}_t = \theta_t \frac{p_t y_t}{p_{xt} x_t} \tag{3.5}$$

where $\theta_t = \frac{\partial \log f}{\partial \log x}$ is the output elasticity of variable input x_t. As a simplifying assumption, we assume f is a cobb-douglas production function, so θ is constant over time. Under this assumption, we can connect both approaches as follows

$$\tilde{M}_t = 1 - \frac{\theta}{\tilde{\mu}_t} \tag{3.6}$$

$$\tilde{\mu}_t = \theta(1 - \tilde{M}_t)^{-1} \tag{3.7}$$

We use profit margins $\tilde{M}_t$ as our main proxy for markups, as accounting and production approaches are similar under our assumptions.

4. Empirical Results

The baseline regression model considered is

[12] Besley, et al. (2021) use the same variable as the main key component in their analysis.

$$\Delta\tilde{M}_{cs,t} = \delta_{cs} + \delta_t + \beta_0 X_{cst} + \varepsilon_{cs,t} \tag{3.8}$$

where $\Delta\tilde{M}_{cs,t}$ is the log-difference of profit margin as it was defined in the previous sections in the country c, sector s, and period t. The variable is standardized. δ_{cs}, δ_t are country-sector, and time fixed effects. Finally, X_{cst} is the inflation episode as defined with CPI at country c level or standardized value of sector-level inflation per country c in sector s and period t.[13]

Table 3.1 Panel A reports regression results from markups on inflation episodes for different periods characterized by surges in inflation (see Equation 3.8). Column (1) Shows a positive relationship of 0.083 standard deviations when those episodes exist. Columns (2) and (3) indicate that before and after the global financial crisis in 2008, there was no strong relationship between those episodes and markups. Finally, column (4) confirms the view that inflation post-pandemics was related to markup increases. This result contrasts with columns (2) and (3), where inflation episodes did not play significant roles on markups.

To understand the nature of column (4), we use diff-in-diff event-study estimators introduced by De Chaisemartin and D'Haultfoeuille (2023). Figure 3.2 shows that there is a sudden spike in markup after the event, then it declines and moderates after two years in about 0.4 standard deviations.

Table 3.1 Panel B reports regression results from sector-level inflation on markups. In this case, for a more granular level of inflation at the sector level, again, we observe a positive relationship for the entire period between 2003-2022. Then, the period post-global financial crisis gained relevance, but it is still lower in magnitude than the period post-pandemic (see Columns (3) and (4)).

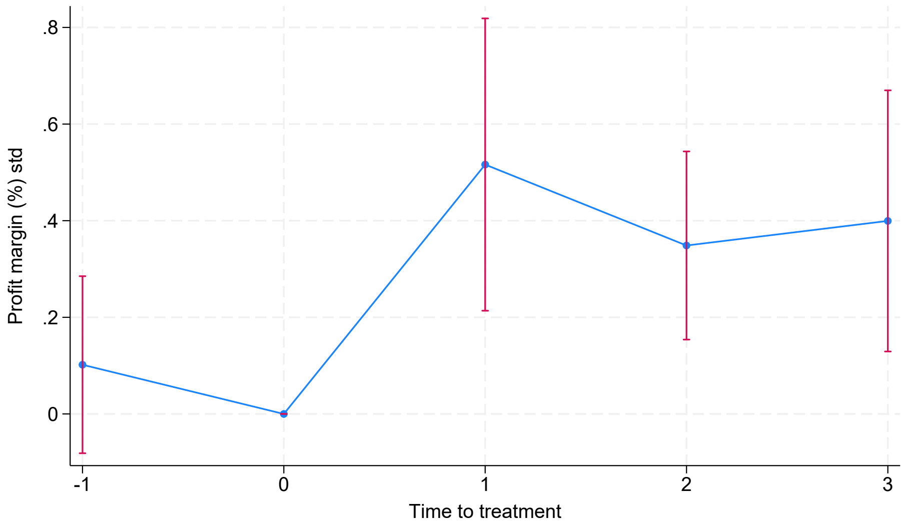
[13] Inflation episode was defined previously considering the change in inflation. For inflation, we use headline inflation as our benchmark variable, and as a comparison, we consider core, energy, and food inflation as a proxy for a supply shock.

Table 3.1: Estimation results for inflation episodes

Time	2003-22 (1)	2003-09 (2)	2010-19 (3)	2018-22 (4)
Panel A. Inflation episode				
Epis. π	0.083**	0.059	0.028	0.374***
	(0.038)	(0.058)	(0.038)	(0.118)
Observations	7,297	1,961	4,083	2,229
R-squared	0.096	0.130	0.107	0.208
Adj. R-squared	0.0243	-0.0457	-0.0247	-0.0226
Panel B. GDP deflator				
GDP deflator growth	0.057**	0.022	0.048***	0.092*
	(0.022)	(0.028)	(0.016)	(0.045)
Observations	6,463	1,744	3,652	1,946
R-squared	0.107	0.146	0.114	0.236
Adj. R-squared	0.0346	-0.0262	-0.0177	0.00292

Notes: The table shows the results for estimations using the model in Equation (3.8) for different periods. The change in margin profits is the dependent variable. Panel A uses as a regressor inflation episode as defined in the main text considering headline CPI, and Panel B is the GDP deflator in levels. This table incorporates country-sector and time-fixed effects. The sample considers country-sector combinations with more than 20 observations. Standard errors are clustered at a country level.

Figure 3.2: Event study for inflation episode



Note: This figure is based on Equation (3.8) for 2017-2022. It follows the diff-in-diff event-study estimators introduced by De Chaisemartin and D'Haultfoeuille (2023).

4.1 Supply shocks

The next exercise is to evaluate proxy variables for a supply shock. We consider energy and food prices as indicative of supply shocks.[14] We also consider core inflation as a comparison. Table 3.2 reports our results across different periods. Panel A indicates inflation episodes defined by the core inflation are not associated with increased markups. Panel B considers inflation energy to inflation episodes, which determine markups for the most recent period. Finally, Panel C considers food inflation; similarly to Panel A, there is no significant association with markups. Going back to Equation (3.2), the results in Table 3.2 are aligned with the negative direct association between marginal costs and markups. The result of energy inflation can be associated with a change in expectation about marginal costs (Acharya, et al., 2023).

[14]Shapiro (2022) shows there is a relationship between food and energy prices and supply-driven components of inflation. In contrast, demand-driven inflation is associated with monetary policy or recessions.

Table 3.2: Estimation results for supply channel

Time	2003-22	2003-09	2010-19	2018-22
	(1)	(2)	(3)	(4)
Panel A. Core CPI				
Epis. π: Core	0.020	0.034	0.022	0.018
	(0.034)	(0.063)	(0.039)	(0.080)
R-squared	0.095	0.129	0.107	0.200
Adj. R-squared	0.0234	-0.0461	-0.0246	-0.0332
Panel B. Energy CPI				
Epis. π: Energy	0.029	0.001	0.017	0.149*
	(0.026)	(0.069)	(0.029)	(0.078)
R-squared	0.095	0.129	0.107	0.203
Adj. R-squared	0.0235	-0.0464	-0.0247	-0.0293
Panel C. Food CPI				
Epis. π: Food	-0.008	0.010	-0.019	-0.095
	(0.029)	(0.041)	(0.036)	(0.082)
R-squared	0.095	0.129	0.107	0.201
Adj. R-squared	0.0233	-0.0463	-0.0247	-0.0315
Observations	7,297	1,961	4,083	2,229

Notes: The table shows the results for estimations using the model in Equation (3.8) for different periods. The change in margin profits is the dependent variable. Panel A uses as a regressor inflation episode as defined in the main text, considering core CPI to define inflation episode, Panel B considers energy CPI, and Panel C considers food CPI. This table incorporates country-sector and time-fixed effects. The sample considers country-sector combinations with more than 20 observations. Standard errors are clustered at a country level.

4.2 The role of demand

We also evaluate the role of demand in explaining markup increases during the last inflation episode post-pandemics. We consider the following regression model that extends the model in Equation (3.9),

$$\Delta \tilde{M}_{cs,t} = \delta_{cs} + \delta_t + \beta_0 X_{ct} + \beta_1 C_{ct} + \beta_2 X_{ct} C_{ct} + \varepsilon_{cs,t} \tag{3.9}$$

where X_{ct} is the inflation episode using headline inflation for country c, period t, C_{ct} is consumption growth for country c, period t, and $X_{ct}C_{ct}$ is the interaction between both of them. We consider that consumption growth is potentially affected by simultaneous shocks affecting inflation episodes. Then, we use the instrumental variables policy rates, military expenditure, and social and subsidy expenditure for X_{ct} and C_{ct}, not for the interaction.

Table 3.3 Panel A evaluates the relationship between consumption growth and markups. Columns (1)-(3) show OLS estimations. Demand played a role in markups before the Global Financial Crisis. A fundamental role is present after the Pandemic with a coefficient of 0.163 standard deviations over markups. Then, Columns (1)-(3) show 2SLS estimation results. The period 2003-2009 lost significance when we instrumented demand. The coefficient over the post-pandemics period is still significant and slightly decreases its impact. Those results suggest a relevant role for demand in determining markup increases after pandemics.

Then, in Table 3.3 Panel B, we jointly estimate inflation episodes and consumption as determinants of markups. We find in Columns (1) and (2) that neither inflation episode nor consumption is related to markups; only the interaction is. In contrast with Column (3), both variables are statistically significant for the last inflation episode. Previous results change when we incorporate our instruments for demand. Results for Columns (4) and (5) are qualitatively similar. However, Column (6) loses significance, and only the inflation episode is still significant. This result points out the relevance of appropriate instrument demand, as the increase in markups is more associated with the inflation surge rather than the demand.

4.3 Market power

We assess the role of market power from different perspectives. This section considers the relevance of HHI and antitrust regulation across jurisdictions and firm size.

First, we evaluate the role of sector-level concentration on industry markups. Table 3.4 evaluates the relationship between inflation episode, HHI index, and markup. We find in columns (1)-(2) no relationship between markup and the HHI index in the periods before and after the Global Financial Crisis. This result is replicated in level variables and the interactive term. Those results contrast with column (3). We found higher markups in more concentrated industries during the most recent episode.

Next, Table 3.5 evaluates the relationship between inflation episode, antitrust index, and markup. Columns (1)-(3) incorporate country-sector and time-fixed effects for the sample of medium and large firms. Our results show that, from 2003 to 2009, countries with tighter antitrust regulations increased markups more during inflation episodes. After the Global Financial Crisis, there is no relationship between inflation and antitrust. The previous results contrast with the most recent inflation episode; we find higher markups during this episode, and this effect is lower as regulation increases.

Then, we move to evaluate the same exercise in the subset of large firms. When our sample is split, large firms carry the main part of the effect of the last inflation episode, so we focus only on large firms.[15] We find for large firms qualitatively the same results as for medium and large firms. The main difference is in the magnitude of the coefficients. For instance, in column (6), both estimated coefficients are higher in absolute terms.

[15] This result is not presented in this document.

Table 3.3: Estimation results for demand channel

Time	2003-09 OLS (1)	2010-19 OLS (2)	2018-22 OLS (3)	2003-09 2SLS (4)	2010-19 2SLS (5)	2018-22 2 SLS (6)
Panel A: Demand						
Cons g.	0.076*	0.017	0.163***	0.030	-0.045	0.158***
	(0.039)	(0.018)	(0.020)	(0.053)	(0.062)	(0.036)
Observations	1,972	4,086	2,199	1,707	3,669	1,978
N. of cty-sector	333	518	499	286	463	446
R-squared	0.048	0.002	0.104	0.059	-0.001	0.103
Adj. R-squared	0.0466	0.00127	0.104	-0.132	-0.146	-0.160
Panel B: Inflation Episode and Demand						
Epis. π	-0.057	0.043	0.506***	-0.503	0.233	0.625*
	(0.051)	(0.047)	(0.154)	(0.601)	(0.258)	(0.338)
Cons g.	0.034	-0.000	0.083**	0.100	-0.066	0.056
	(0.024)	(0.018)	(0.031)	(0.144)	(0.070)	(0.067)
Epis. π x Cons g.	0.247**	0.171	0.030	0.239	0.185	0.027
	(0.092)	(0.106)	(0.052)	(0.148)	(0.186)	(0.052)
Observations	1,972	4,086	2,199	1,707	3,669	1,978
N. of cty-sector	333	518	499	286	463	446
R-squared	0.060	0.004	0.127	0.040	-0.002	0.120
Adj. R-squared	0.0584	0.00314	0.125	-0.157	-0.148	-0.139

Notes: The table shows the results for estimations using an extension to the model in Equation (3.8) that also considers an interactive term for different periods. The change in margin profits is the dependent variable. Panel (A) uses as a regressor aggregate consumption growth, and Panel (B) considers considers also the interaction of aggregate consumption growth and inflation episode using headline CPI. Columns (4)-(6) use policy rates, military expenditure, and social and subsidy expenditure as instrumental variables. This table incorporates country-sector and time-fixed effects. The sample considers country-sector combinations with more than 20 observations. Standard errors are clustered at a country level.

Table 3.4: Estimation results considering the role of competition

Time	2003-09	2010-19	2018-22
	(1)	(2)	(3)
Epis. π	0.091	0.086	0.334**
	(0.076)	(0.068)	(0.090)
Epis. π x HHI	-0.081	-0.323	0.596**
	(0.288)	(0.300)	(0.296)
Observations	1,931	3,638	2,229
R-squared	0.130	0.105	0.210
Adj. R-squared	-0.0402	-0.0191	-0.0202

Notes: The table shows the results for estimations using an extension to the model in Equation (3.8) that also considers an interactive term between inflation episode and HHI for different periods. The change in margin profits is the dependent variable. This table incorporates country-sector and time-fixed effects. HHI corresponds to the index in 2003, 2010, and 2018, in columns (1), (2), and (3), respectively. The sample considers country-sector combinations with more than 20 observations.

Two additional implications are derived from those results. First, large firms led the increase in markups in the last inflation episode. This is important as large firms can exert market power. Second, Markup increased less in jurisdictions with tighter antitrust regulation which is also related to market power

Table 3.5: Estimation results considering the role of competition

	Medium and large firms			Large firms		
Time	2003-09	2010-19	2018-22	2003-09	2010-19	2018-22
	(1)	(2)	(3)	(4)	(5)	(6)
Epis. π	-0.049	0.015	0.448***	-0.063	0.006	0.564**
	(0.058)	(0.121)	(0.135)	(0.070)	(0.163)	(0.205)
Epis. π x Antitrust	0.150**	0.016	-0.204**	0.223***	0.035	-0.235*
	(0.068)	(0.183)	(0.094)	(0.072)	(0.248)	(0.119)
Observations	1,836	3,906	2,139	1,820	3,857	2,120
R-squared	0.138	0.108	0.214	0.139	0.106	0.208
Adj. R-squared	-0.0381	-0.0249	-0.0171	-0.0376	-0.0289	-0.0257

Notes: The table shows the results for estimations using an extension to the model in Equation (3.8) that also considers an interactive term for different periods. The change in margin profits is the dependent variable. Antitrust index corresponds to the variable defined in Besley, et al. (2021) Columns (1)-(3) consider medium and large firms, and Columns (4)-(6) large firms. This table incorporates country-sector and time-fixed effects. The sample considers country-sector combinations with more than 20 observations. Standard errors are clustered at a country level.

5. Conclusion

In this paper, we investigated the role of market power in firms' price setting during episodes of high inflation for OECD countries, the set of countries more affected by the recent inflation surge. The main focus is the last inflation episode after the pandemic. We find a series of results that shed light on the recent inflation episode and the firms' price-setting behavior. This time was different, as some firms could increase markups more than in previous episodes. Large companies mainly led this result. Moreover, those markup increases are more related to demand than supply shocks, even when we use instrumental variables for demand, which points out the role that competition may have in fueling inflation episodes. Consistently with this narrative, we show that markups increase more in more concentrated sectors and countries with less tight antitrust regulations.

From a policy perspective, the previous results have relevant implications. First, although the markup increase does not explain the entire post-pandemic inflation surge, it played an important role. This real rigidity is in addition to traditional nominal rigidities, so future research should investigate the role of monetary policy when this happens. Second, there is an important role for increased competition, where tighter regulations can be determinant. Third, this analysis does not incorporate household expectations or other measures of markups. Future research should evaluate these and other related topics.

Bibliography

Acharya, V. V., M. Crosignani, T. Eisert, and C. Eufinger (2023). How Do Supply Shocks to Inflation Generalize? Evidence from the Pandemic Era in Europe. NBER Working Paper No. 31790.

Afrouzi, J., and L. Caloi (2022). Endogenous Firm Competition and the Cyclicality of Markups. Manuscript.

Aguiar, M., and M. Bils (2015). Has Consumption Inequality Mirrored Income Inequality? *American Economic Review*, 105: 2725-2756.

Ahn, S., G. Kaplan, B. Moll, T. Winberry, and C. Wolf (2018). When Inequality Matters for Macro and Macro Matters for Inequality. *NBER Macroeconomics Annual*, 32, Issue 1: 1-75.

Alvarez, F. E., F. Lippi, and T. Souganidis (2022). Price Setting with Strategic Complementarities as a Mean Field Game. Becker Friedman Institute Working Paper No. 2022-90.

Amiti, M., O. Itskhoki, and J. Konings (2019). International Shocks, Variable Markups, and Domestic Prices. *Review of Economic Studies*, 86(6): 2356-2402.

Amiti, M., O. Itskhoki, and J. Konings (2022). Dominant Currencies: How firms choose currency invoicing and why it matters. *Quarterly Journal of Economics* 137(3): 1435-93.

Anderson, E., S. Rebelo, and A. Wong (2018). Markups Across Space and Time. NBER Working Paper No. 24434.

Andler, M., and A. Kovner (2022). Do Corporate Profits Increase When Inflation Increases? Liberty Street Economics, Federal Reserve Bank of New York, July 13.

Arce, F., and M. Tran-Xuan (2022). Sudden Stops and Consumption Inequality with Non-homothetic Preferences. Manuscript.

Arkolakis, C., and M. Morlacco (2017). Variable Demand Elasticity, Markups, and Pass-Through. Technical Report, Yale University 2017.

Atkeson, A., and A. Burstein (2008). Pricing-to-Market, Trade Costs, and International Relative Prices. *American Economic Review*, 98(5): 1998-2031.

Auclert, A. (2019). Monetary Policy and the Redistribution Channel. *American Economic Review*, 109(6): 2333-67.

Auclert, A., M. Rognlie, M. Souchier, and L. Straub (2021). Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel. Manuscript.

Auclert, A., B. Bardoczy, M. Rognlie, and L. Straub (2021). Using the Sequence-Space Jacobian to Solve and Estimate Heterogeneous-Agent Models. *Econometrica*, 89(5): 2375-2408.

Auer, R., A. Burstein, and S. M. Lein (2021). Exchange Rates and Prices: Evidence from the 2015 Swiss Franc Appreciation. *American Economic Review* 111(2): 652-686.

Auer, R., A. Burstein, S. Lein, and J. Vogel (2022). Unequal Expenditure Switching: Evidence from Switzerland. Manuscript.

Bems, R., and J. Di Giovanni (2016). Income-Induced Expenditure Switching. *American Economic Review*, 106(12): 3898-3931.

Bernanke, B., and O. Blanchard (2023). What caused the US pandemic-era inflation? NBER Working Papers 31417.

Besley, T., N. Fontana, and N. Limodio (2021). Antitrust Policies and Profitability in Non-tradable Sectors. *American Economic Review: Insights*, 3(2): 251-65.

Bianchi, J., and E. Mendoza (2020). A Fisherian Approach to Financial Crises: Lessons from the Sudden Stops Literature. *Review of Economic Dynamics*, 37: 254-283.

Blanco, A., A. Drenik and E. Zaratiegui (2019). Nominal Devaluations and Inequality. Manuscript.

Blanco, A., P. Ottonello, and T. Ranosova (2023). The Dynamics of Large Inflation Surges. Manuscript.

Blaum, J. (2022). Global Firms in Large Devaluations. Manuscript.

Boppart, T., P. Krusell, and K. Mitman (2018). Exploiting MIT Shocks in Heterogeneous-Agent Economies: The Impulse Response as a Numerical Derivative. *Journal of Economic Dynamics and Control*, 89: 68-92.

Borusyak, K., and X. Jaravel (2021). The Distributional Effects of Trade: Theory and Evidence from the U.S. Manuscript.

Burstein, A. T., J. C. Neves, and S. Rebelo (2003). Distribution Costs and Real Exchange Rate Dynamics during Exchange-Rate-Based-Stabilizations. *Journal of monetary Economics*, 50(6): 1189-1214.

Burstein, A., M. Eichenbaum, and S. Rebelo (2007). Modeling Exchange Rate Passthrough After Large Devaluations. *Journal of Monetary Economics*, 54(2): 346-368

Burstein, A., and G. Gopinath (2014). International Prices and Exchange Rates. *Handbook of International Economics*, 4: 391-451.

Burstein, A., V. M. Carvalho, and B. Grassi (2023). Bottom-up Markup Fluctuations. Manuscript.

Calvo, G., and C. M. Reinhart (2002). Fear of floating. *The Quarterly Journal of Economics*, 117(2): 379-408.

Calvo, G. A., and E. G. Mendoza (1996). Petty Crime and Cruel Punishment: Lessons from the Mexican Debacle. *American Economic Review*, Papers and Proceedings, 86(2): 170-175.

Candia, B., and M. Pedemonte (2023). Export-Led Decay: The Trade Channel in the Gold Standard Era. Manuscript.

Carroll, C. (2006). The Method of Endogenous Gridpoints for Solving Dynamic Stochastic Optimization Problems. *Economics Letters*, 91(3): 312-320.

Cespedes, L., R. Chang, and A. Velasco (2004). Balance sheets and exchange rate policy. *American Economic Review*, 94(4): 1183-1193.

Chang, R., and A. Fernandez (2013). On the Sources of Aggregate Fluctuations in Emerging Economies. *International Economic Review*, 54(4): 1267-1295.

Chen, N., W. Chung, and D. Novy (2022). Vehicle Currency Pricing and Exchange Rate Pass-Through. *Journal of the European Economic Association* 20(1): 312-351.

Chirinko, R. S., and S. M. Fazzari (2000). Market Power and Inflation. *Review of Economics and Statistics*, 82(3): 509-513.

Clayton, C., X. Jaravel, and A. Schaab (2018). Heterogeneous price rigidities and monetary policy. Manuscript.

Comin, D., D. Lashkari, and M. Mestieri (2021). Structural change with long-run income and price effects. *Econometrica*, 89(1): 311-374.

Cravino, J., and A. A. Levchenko (2017). The distributional consequences of large devaluations. *American Economic Review*, 107(11): 3477-3509.

Cravino, J. and S. Sotelo (2019). Trade Induced Structural Change and the Skill Premium. *AEJ: Macroeconomics*, 11(3): 289-326.

Cugat, G. (2018). Emerging markets, household heterogeneity, and exchange rate policy. Manuscript.

Davis, J. S., M. B. Devereux, and C. Yu (2022). Fed's 1994 rate aggressiveness led to emerging-market turmoil; is this time different? Dallas FED Economics, July 12, 2022.

Dedola, L., G. Rivolta, and L. Stracca (2017). If the Fed sneezes, who catches a cold? *Journal of International Economics*, 108: 23-41.

De Chaisemartin, C., and X. D'Haultfoeuille (2023). Difference-in-Differences Estimators of Intertemporal Treatment Effects. Manuscript.

De Ferra, S., K. Mitman, and F. Romei (2020). Household heterogeneity and the transmission of foreign shocks. *Journal of International Economics*, 124, 103303.

De Gregorio, J., P. Garcia-Silva, E. Luttini, and M. Rojas (2023). From Dominant to Producer Currency Pricing: Dynamics of Chilean Exports.

De Loecker, J., and F. Warzynski (2012). Markups and Firm-Level Export Status. *American Economic Review*, 102(6): 2437-2471.

Diez, F. J., J. Fana, and C. Villegas-Sanchez (2021). Global declining competition? *Journal of International Economics*, 132.

Dornbusch, R. (1987). Exchange Rates and Prices. *American Economic Review*, 77(1): 93-106.

Edwards, S. (2010). Left Behind: Latin America and the False Promise of Populism. The University of Chicago Press.

Engel, C. (2016) Commentary: The International Price System.

Faryaar, H., D. Leung, and A. Fortier-Labonte (2023). Markups and inflation: Evidence from firm-level data. Economic and Social Reports Statistics Canada, 3(6).

Feenstra, R. C. (1989). Symmetric Pass-Through of Tariffs and Exchange Rates under Imperfect Competition: An Empirical Test. *Journal of International Economics*, 27(1): 25-45.

Ferrante, F., and N. Gornemann (2022). Devaluations, Deposit Dollarization, and Household Heterogeneity. Manuscript.

Fujiwara, I, and K. Matsuyama (2022). A Technology-Gap Model of Premature Deindustrialization. CEPR-DP15530.

Gagnon, E. (2009). Price Setting during Low and High Inflation: Evidence from Mexico. *Quarterly Journal of Economics*, 124(3): 1221-63.

Gali, J., and T. Monacelli (2005). Monetary policy and exchange rate volatility in a small open economy. *Review of Economic Studies*, 72: 707-734.

Garcia, B., C. Lizama, M. Giarda, and D. Romero (2023). Time-Varying Expenditure Shares and Macroeconomic Dynamics. Working Paper Central Bank of Chile 1000.

Giagheddu, M. (2020). The Distributional Implications of Fiscal Devaluations. Working Paper 3651258, Social Science Research Network.

Giuliano, F., and E. Luttini (2020). Import Prices and Invoice Currency: Evidence from Chile. *Journal of International Money and Finance*, 106: 102-183.

Glover, A., J. Mustre-del-Rio, and A. von Ende-Becker (2023). How much have record corporate profits contributed to recent inflation? *The Federal Reserve Bank of Kansas City Economic Review*, 108(1): 23-35.

Goldberg, P. K., and M. M. Knetter (1997). "Goods Prices and Exchange Rates: What Have We Learned?" *Journal of Economic Literature*, 35(3): 1243-1272.

Goldberg, L. S., and C. Tille (2008). Vehicle Currency Use in International Trade. *Journal of International Economics*, 76(2): 177-192.

Gopinath, G., O. Itskhoki, and R. Rigobon (2010). Currency Choice and Exchange Rate Pass-Through. *American Economic Review*, 100(1): 306-336.

Gopinath, G. (2016). The International Price System. Jackson Hole Symposium Proceedings.

Gopinath, G., E. Boz, C. Casas, F. J. Diez, P. O. Gourinchas, and M. Plagborg-Moller (2020). Dominant Currency Paradigm.*American Economic Review*, 110(3): 677-719.

Gopinath, G., and O. Itskhoki (2022). Dominant Currency Paradigm: A Review. *Handbook of International Economics.*

Guerrieri, V., G. Lorenzoni, L. Straub, and I. Werning (2022). Macroeconomic Implications of COVID-19: Can Negative Supply Shocks Cause Demand Shortages? *American Economic Review*, 112(5): 1437-1474.

Guntin, R., P. Ottonello, and D. Perez (2023). The micro anatomy of macro consumption adjustments. *American Economic Review*, 81(8).

Guo, X., P. Ottonello, and D. Perez (2023). Monetary Policy and Redistribution in Open Economies. *Journal of Political Economy Macroeconomics*, 1(1): 191-241.

Gyongyosi, G., J. Rariga, and E. Verner (2022). The Anatomy of Consumption in a Household Foreign Currency Debt Crisis. SAFE Working Paper No. 332.

Herrendorf, B., R. Rogerson, and A. Valentinyi (2013). Two Perspectives on Preferences and Structural Transformation. *American Economic Review*, 103: 2752-2789.

Hong, S. (2020). Emerging Market Business Cycles with Heterogeneous Agents. Manuscript

Hong, S. (2023). MPCs in an Emerging Economy: Evidence from Peru. *Journal of International Economics*, 140.

Iacoviello, M., and G. Navarro (2019). Foreign effects of higher U.S. interest rates. *Journal of International Money and Finance*, 95: 232-250.

Kalemli-Ozcan, S., B. E. Sorensen, C. Villegas-Sanchez, V. Volosovych, and S. Yesiltas (2024). How to Construct Nationally Representative Firm-Level Data from the Orbis Global Database: New Facts on SMEs and Aggregate Implications for Industry Concentration. *American Economic Journal: Macroeconomics*, 16(2): 1-22.

Kaplan, G., B. Moll, and G. L. Violante (2018). Monetary policy according to HANK. *American Economic Review*, 108(3): 697-743.

Kaplan, G., G. L. Violante, and J. Weidner (2014). The Wealthy Hand-to-Mouth. *Brookings Papers on Economic Activity*, 48: 77-153.

Kimball, M. S. (1995). The Quantitative Analytics of the Basic Neomonetarist Model. *Journal of Money, Credit and Banking*, 27 (4): 1241-77.

Knetter, M. M. (1989). Price Discrimination by U.S. and German Exporters. *American Economic Review*, 79 (1): 198-210.

Korinek, A., and E. Mendoza (2014). From Sudden Stops to Fisherian Deflation: Quantitative Theory and Policy Implications. *Annual Review of Economics* 6.

Krusell, P., and A. Smith (1998). Income and Wealth Heterogeneity in the Macroeconomy. *Journal of Political Economy*, 106(5): 867-896.

Matsuyama, K. (2023). Non-CES Aggregators: A Guided Tour. *Annual Review of Economics*, 15: 235-265.

McKay, A., E. Nakamura, and J. Steinsson (2016). The Power of Forward Guidance Revisited. *American Economic Review*, 106(10): 3133-3158.

Meyer, B. D., and J. X. Sullivan (2013). Consumption and Income Inequality and the Great Recession. *American Economic Review*, 103 (3): 178-83.

Nekarda, C., and V. A. Ramey (2020). The Cyclical Behavior of the Price-Cost Markup. *Journal of Money, Credit and Banking*, 52(S2): 319-353.

Neumeyer, P., and F. Perri (2005). Business Cycles in Emerging Economies: the Role of Interest Rates. *Journal of Monetary Economics*, 52(2): 345-380.

OECD (2022). Competition and Inflation. OECD Competition Policy Roundtable Background. Organization for Economic Co-operation and Development.

Oskolkov, A. (2023). Exchange rate policy and heterogeneity in small open economies. *Journal of International Economics*, 142.

Pitschner, S., (2020). How do firms set prices? Narrative evidence from corporate filings. *European Economic Review*, 124.

Reiter, M. (2009). Solving Heterogeneous-Agent Models by Projection and Perturbation. *Journal of Economic Dynamics and Control*, 33(3): 649-665.

Rojas, E., and F. Saffie (2022). Non-Homothetic Sudden Stops. *Journal of International Economics*, 139.

Rotemberg, J. (1982). Sticky prices in the United States. *Journal of Political Economy*, 90(6): 1187-1211.

Shapiro, A. H. (2022). Decomposing Supply and Demand Driven Inflation. Federal Reserve Bank of San Francisco Working Paper, 18.

Schaab, A., and S. Y. Tan (2023). Monetary and Fiscal Policy According to HANK-IO. Manuscript.

Schmitt-Grohe, S., and M. Uribe (2016). Downward Nominal Wage Rigidity, Currency Pegs, and Involuntary Unemployment. *Journal of Political Economy*, 124: 1466-1514.

Uribe, M. and V. Z. Yue (2006). Country Spreads and Emerging Countries: Who Drives Whom? *Journal of International Economics*, 69(1): 6-36.

Winberry, T. (2018). A Method for Solving and Estimating Heterogeneous Agent Macro Models. *Quantitative Economics*, 9(3): 1123-1151.

Yang, S. (2023). Dominant Currency Paradigm with Input-Output Linkages. Manuscript.

Zhou, H. (2022). Open economy, redistribution, and the aggregate impact of external shocks. Manuscript.