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Gabriela Cugat

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Gabriela Cugat *

International Monetary Fund

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Abstract

I argue that household heterogeneity plays a key role in the transmission of aggregate shocks in emerging market economies. Using Mexico's 1995 crisis as a case study, I first document empirically that working in the tradable versus non-tradable sector is a crucial determinant of the income and consumption losses of different types of households. Specifically, households in the non-tradable sector suffered much larger income and consumption losses, regardless of other household characteristics. To account for the effect of this observation on macroeconomic dynamics, I construct a New Keynesian small open economy model with household heterogeneity along two dimensions: uninsurable sector-specific income and limited financial-market participation. I find that the propagation of shocks in this economy is affected by both dimensions of heterogeneity. In terms of policy, a managed exchange rate policy is more costly overall when households are heterogeneous; however, households in the non-tradable sector benefit from it.

Keywords: Exchange rate policy; Fear of floating; Inequality; Emerging markets; Small open economy; Household heterogeneity.

JEL Classification Numbers: E21, E32, E52, F31, F41, F61

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1 Introduction

In recent years, there has been heightened concern about the exposure of emerging markets to sudden stops, characterized by an abrupt decline in capital inflows and a sharp drop in output.[1] A large literature in economics has developed to analyze the causes and consequences of sudden stops. Typically, baseline models to analyze this phenomenon adopt a representative agent approach, bypassing household heterogeneity and distributional issues. In this paper, I argue that accounting for household heterogeneity is particularly important for understanding these episodes since it reflects other dimensions of market incompleteness relevant for emerging markets. I consider a heterogeneous agents model consistent with micro evidence and find that household heterogeneity can account for 65% of the drop in consumption and 60% of the fall in output during a sudden stop. In terms of policy, flexible exchange rates might not benefit all types of households, despite providing aggregate stabilization for the economy.

I organize my study of household heterogeneity in emerging market economies and its role in the transmission of aggregate shocks by focusing on two questions: 1. How are different types of households affected by external shocks?; and 2. How do different household-level responses drive macroeconomic dynamics? To answer these questions, I use Mexico's 1995 crisis as a case study. My empirical analysis suggests that households do not have diversified income across sectors and their possibilities to smooth consumption are limited. Based on these observations, I construct a New Keynesian small open economy model with household heterogeneity along two dimensions: uninsurable sector-specific income and limited financial-market participation. The first dimension, uninsurable sector-specific income, refers to households receiving income exclusively from the tradable or the non-tradable sector and being unable to write contracts to share income across sectors. The second dimension, limited financial-market participation, refers to some households not having access to financial markets. Emerging markets, then, differ from advanced economies in that they have more incomplete markets.

In the first part of the paper, I study the effects of Mexico's 1995 crisis at the household level to identify which dimensions of heterogeneity are more likely to play a distinctive role during sudden stops. I focus on this case for two reasons. First, this event has been extensively studied at the macroeconomic level and can be characterized as a sudden stop

[1] Recently, U.S. Federal Reserve Bank Chairman Jerome Powell declared *''we're raising rates, that puts upward pressure on interest rates around the world and can affect countries, particularly countries that have significant external dollar borrowing. (...) There are some countries that are – that are undergoing severe stress, a handful of them, and – but not most emerging market countries.*" on his Sept. 26th, 2018 opening statement. See also the Wall Street Journal article from June 3rd, 2018, "Dollar's Strength Adds Stress to Emerging Market Currencies". Argentina, Brazil and Turkey were experiencing turbulences that evoked late 1990s sudden stops.

crisis.[2] Second, there is high-quality household data available for the time period of the crisis, both for income and consumption outcomes. Using microdata from the Mexican household income and expenditure survey, I document that there are heterogeneous responses of income and consumption across different types of households. In particular, these losses are not significantly different across education levels or age cohorts, but they do differ according to the household sector of employment. Households in the non-tradable sector experienced a larger income loss than households in the tradable sector. Moreover, this pattern is also observed for consumption losses.

In the second part of the paper, I develop a model with household heterogeneity and I use it to perform two exercises. First, I consider a crisis episode triggered by external factors. I find that household heterogeneity amplifies the effects of external shocks on output and consumption, and this channel is more important under a fixed exchange rate regime. Second, I compute the welfare cost of monetary policies that display "fear of floating", i.e. that limit the fluctuations of the nominal exchange rate. This type of policy becomes more costly when households are heterogeneous, but the asymmetric income responses make such a policy beneficial for some households at the expense of others.

The crisis exercise consists of analyzing the dynamic adjustment, with and without household heterogeneity, of an economy that experiences a sudden stop given by an international interest rate shock and a productivity shock in the tradable sector.[3] The model with household heterogeneity produces amplification of output and consumption responses through two channels. First, heterogeneity within the tradable sector and the lack of income sharing with non-tradable households mute the response of tradable output to the interest rate shock and amplify the recession generated by the productivity shock. Second, the fall in non-tradable output is larger since hand-to-mouth households in the non-tradable sector reduce their demand for non-tradable goods by more than the rest of the economy. The combined effect of these two channels results in a larger fall in both output and consumption compared to the representative household case.

The second exercise consists of evaluating the welfare costs of monetary policy with "fear of floating". The central bank commits to let the exchange rate float and follow an interest rate rule that responds to inflation, but for reasons outside the model, it is reluctant to let the nominal exchange rate fluctuate excessively. As documented by Calvo & Reinhart (2002), many emerging markets' central banks behave in this way, particularly

[2] Calvo & Mendoza (1996*a*), Cole & Kehoe (2000), Mendoza (2002), Aguiar & Gopinath (2007), Kehoe & Ruhl (2009) focus on different aspects of Mexico's 1995 crisis.

[3] The interest rate shock can be interpreted as a sudden stop of capital inflows, while the productivity shock in the tradable sector represents in a reduced-form the real effects of the credit crunch in the tradable sector.

after experiencing sudden stop crises. I compute the welfare cost of different degrees of "fear of floating" by comparing lifetime welfare under a policy with "fear of floating" and lifetime welfare under an exchange rate policy that replicates the flexible-price allocation. I find that for the economy as a whole, a monetary policy with "fear of floating" is worse than letting the exchange rate float freely. In addition, the cost is at least twice as large in the economy with household heterogeneity than in the representative household case. As the strength of "fear of floating" increases the policy becomes relatively more costly in the economy with heterogeneous households. The interaction of both types of market incompleteness explains the increase in the welfare cost of such policies. In terms of the distribution of welfare costs, households in the non-tradable sector that can access financial markets actually prefer policies that limit exchange rate fluctuations, even though this increases aggregate volatility. "Fear of floating" can then arise if this type of household has more weight in the economy.

Related Literature. This paper is related to several strands of the literature. First, it builds upon the international macroeconomics literature on emerging markets business cycles and sudden stops. Some related contributions in this literature include Mendoza (2002) and Kehoe & Ruhl (2009) that study sudden stops and business cycles in two-sector real models of emerging markets, and Gertler, Gilchrist & Natalucci (2007), Schmitt-Grohé & Uribe (2016), Burstein, Eichenbaum & Rebelo (2007), and Gopinath, Boz, Casas, Diez, Gourinchas & Plagborg-Moller (2019) that incorporate different types of nominal rigidities. My main contribution to this strand of literature is including heterogeneous households. By including household heterogeneity, I can identify a demand-side channel that helps explain the large fall in output and consumption that takes place during sudden stops. Additionally, I can study the distributional effects of different exchange rate regimes.

This paper also contributes to a growing literature on household heterogeneity in New Keynesian models, such as Kaplan, Moll & Violante (2018), McKay, Nakamura & Steinsson (2016) and Guerrieri & Lorenzoni (2017), with a full distribution of agents, and Galí, López-Salido & Vallés (2007), Bilbiie (2008), and Galí & Debortoli (2018) with limited heterogeneity — two types of agents, one that has access to financial markets or that can accumulate capital, and another that is hand-to-mouth as in Campbell & Mankiw (1989). In this paper, I extend the framework with limited heterogeneity to a two-sector small open economy model. I consider the effect of uninsurable sector-specific income in addition to marginal propensity to consume heterogeneity arising from limited financial-market participation. I show that, for emerging markets, the lack of sectoral income sharing plays a central role in the transmission of aggregate shocks and the ability of the model to match consumption differentials observed in the data. This is due to sectoral incomes behaving very differently after external shocks.

Finally, this paper is related to the study of the redistribution effects of monetary policy, such as Doepke & Schneider (2006), Auclert (2019) and Gornemann, Kuester & Nakajima (2016) that consider different channels affecting redistribution in closed economies. For open economies, Drenik (2015) considers the case of a small open economy with tradable and non-tradable sectors and downwardly rigid nominal wages. When not all wages are equally rigid, nominal devaluations have redistribution effects across workers according to the degree of nominal wage rigidity in their sector of work. Prasad & Zhang (2015) examine the distributional effects of exchange rate policies in a model with limited heterogeneity and lack of sectoral income sharing. They find that the short-run and long-run distributional effects of exchange rate policy can be very different. Cravino & Levchenko (2017) analyze empirically the redistribution effects of nominal devaluations through their effects on prices for the case of Mexico in 1995. They find devaluations are anti-poor. Poor households face a higher inflation rate since they consume more tradable goods and tradable prices increase by more than non-tradable ones after a devaluation. Wieland, Hausman & Rhode (2019) study the role of the dollar devaluation in the U.S. 1933 recovery through the redistribution of resources to constrained farmers. They find that this channel can account for a large portion of the output recovery in 1933. In terms of redistribution effects, my paper highlights the role of the income channel in determining who benefit and who lose from exchange rate fluctuations. Individual income dynamics under alternative exchange rate policies can be very different from aggregate dynamics once there is no income sharing across sectors, creating a distributional conflict across households.

Layout. In the following section I present empirical evidence on the household level effects of an external crisis, using Mexico's 1995 Tequila crisis as a case study. In section 3, I construct a New Keynesian small open economy model with household heterogeneity. I compare the benchmark model with the traditional representative agent model in section 4. In section 5, I evaluate the welfare cost of monetary policy that limits nominal exchange rate fluctuations, i.e. that exhibit "fear of floating". Finally, section 6 concludes.

2 Mexico's 1995 Tequila crisis

In this section, I lay out the macroeconomic behavior during the Mexican 1995 crisis and the effects on different types of households that motivate the inclusion of household heterogeneity in the model in section 3. First, I describe the macroeconomic facts of the crisis, while in the second part of the section I study the distribution of income and consumption losses during the crisis for different types of households.

The Mexican 1995 crisis, also known as the "peso crisis" or "Tequila crisis", refers to the sudden stop episode that started at the end of 1994 in Mexico. This event has been extensively studied at the aggregate level since it was the first in a succession of major international crisis to hit emerging markets in the 1990s.[4] A sudden stop, as characterized by Calvo (1998) and Calvo & Reinhart (2000), represents an unexpected loss of access to international markets, through a negative swing in capital inflows, a corresponding current account reversal, and a sharp contraction in domestic output and expenditure. During such episodes, there are collapses in asset prices, the real exchange rate and the relative price on non-tradable goods. These events also tend to exhibit larger volatility in emerging markets than balance-of-payment crises in advanced economies (Calvo & Reinhart 2000). Tornell & Westermann (2002) characterize sudden stop events and boom-bust cycles after the liberalization of financial markets in middle-income countries. One of the characteristics they identify is the asymmetric evolution of tradable and non-tradable sectors: while the tradable sector experiences a quick recovery after a mild recession, the non-tradable one experiences a sharp fall and a sluggish recovery.

Figure 1 presents the growth rates of Mexican GDP, private consumption, GDP in the tradable sector and GDP in the non-tradable sector for 1991:Q1 to 2001:Q4, using quarterly national accounts data. The events that triggered Mexico's sudden stop started at the end of 1994, while the full impact of the crisis was felt in 1995:Q2.[5] Both output and consumption display the large contraction characteristic of sudden stop episodes. While tradable GDP experienced a large fall during 1995:Q2 and quickly recovered, non-tradable GDP experienced a longer recession with a more pronounced output contraction. Figure 2 presents a similar picture when considering detrended variables.

The top panel of Figure 3 presents the trade balance to GDP ratio, which shows a reversal from -4% of GDP in 1994:Q4 to 2% in 1995:Q1 and continues improving while output and consumption remained depressed. The bottom panel of Figure 3 presents the evolution of the nominal and real exchange rates at a quarterly frequency. The nominal exchange rate was under control until the end of 1994, when the government announced a 15% devaluation, after a speculative attack against the Mexican peso in November, and lost a massive amount of reserves. By January 1995, the government had completely abandoned any notion of a fixed or managed nominal exchange rate and was letting the

[4]For different studies on the Mexican crisis, see for example Cole & Kehoe (2000), Calvo & Mendoza (1996*a*) Mendoza (2002), Kehoe & Ruhl (2009), Meza & Quintin (2007), Aguiar & Gopinath (2007), Chari, Kehoe & McGrattan (2005)

[5]See Mussachio (2012), Whitt (1996), Sachs, Tornell & Velasco (1996) Calvo & Mendoza (1996*a*), and Calvo & Mendoza (1996*b*) for more detailed accounts of the events leading up to the crisis and its evolution.

currency float freely. The nominal depreciation between December 1994 and January 1995 was 75%. The real exchange rate also depreciated following the nominal depreciation and the collapse of non-tradable relative prices, as documented by Burstein, Eichenbaum & Rebelo (2005) for the case of Mexico and other sudden stop episodes that featured large devaluations. Figure 4 shows that consumer price inflation increased by less than the nominal devaluation, as in the other episodes analyzed by Burstein et al. (2005).

As shown in Figure 5, the unemployment rate peaked in 1995:Q2 for all education levels, with unemployment rates being higher for more skilled workers. In terms of shocks related to the external sector, Figure 6 shows the evolution of productivity in the tradable sector (top panel) and international and domestic interest rates (bottom panel). During the sudden stop, productivity in the tradable sector dropped significantly for the duration of the crisis. This is in line with Meza & Quintin (2007), who point out that conventionally measured TFP falls by unusual amounts during financial crises. After the speculative attacks against the Mexican peso in 1994 and the capital flight at end of December 1994, the international interest rate faced by Mexico (measured as the 90-day U.S. T-bill rate plus the EMBI index for Mexico, adjusted by U.S. inflation) increased at the end of 1994 and shot up in the first quarter of 1995. Domestic rates for 90-day CETES (Mexican Treasury bonds) also increased in 1995:Q1, displaying the government's inability to borrow at low rates.

2.1 Household level effects of the crisis: the role of the sector of work

The household level effects of the Mexican crisis can be studied using two alternative household-level surveys: ENEU, a labor market survey, and ENIGH, an income and expenditure survey. Both surveys are conducted by INEGI, the national statistical institute of Mexico. In my empirical analysis, I will use ENIGH (National Household Income and Expenditure Survey), a repeated cross-section survey with a two-year frequency and interviews taking place from August to October. It is similar in structure to the Family Expenditure Survey (FES) from the UK. Data is comparable from 1992 onward. ENIGH is representative at the national level, both for urban and rural areas. The survey includes very detailed demographic information of all household members, as well as in-depth income information from different sources, not only labor income. Households also keep an expenditures diary including product, price and quantity purchased of non-durable goods and some durable goods and services. In terms of the distributional effects of the Mexican crisis, my main contribution consists of re-examining the income and consumption losses experienced by different types of households, taking into account their sector of work (tradable or non-tradable). I will first summarize the existing empirical findings to motivate my empirical analysis.

Binelli & Attanasio (2010) find that real wages dropped significantly between 1994 and 1996. This fall in income is also reflected in consumption, which indicates that households were not able to smooth out the negative shock of the crisis. Maloney, Cunningham & Bosch (2004) study the distribution of income shocks during the Mexican crisis using quantile regressions. They find that households with lower education experienced smaller income losses. This difference across education levels becomes more pronounced when considering extreme negative shocks.

Similarly, McKenzie (2003) finds that less-educated, rural and agricultural workers experienced smaller drops in income (around 20%), while households in metropolitan areas, highly educated, and workers in financial services and construction suffered larger reductions in income and consumption (around 40%). Despite these large income changes, household structure and labor market participation did not change much during the episode. In a related work, McKenzie (2006) finds that households adjusted mainly through a reduction in durable consumption.

Attanasio & Székely (2004) find that for all cohorts and education levels, the 1994 crisis induced a decline in real wages, but lower educated households experienced smaller income losses as a percentage of their wage in 1994. In terms of consumption, they also find that households with lower educated heads experienced a smaller loss. Lopez-Acevedo & Salinas (2000) find that labor earnings is the most important source of inequality in Mexico during the 1990s. Even though the top income decile had access to financial assets, they were not able to protect their labor income during the crisis and experienced a larger income loss, leading to a reduction in income inequality.

The empirical literature has highlighted the correlation between education and the size of income and consumption losses during the Mexican crisis, however, this relationship is at odds with the findings of other studies, such as Halac & Schmukler (2004) and Fallon & Lucas (2002), that examined the distributional effects of financial crises (including sudden stops) and found that poor low-educated households with less access to financial markets suffered more during crises. Lopez-Acevedo & Salinas (2000) suggest the flipped correlation in the case of the Mexican crisis is due to the highly educated working mainly in the non-tradable sector which was more heavily affected by the crisis.

Defining agriculture, mining, and manufacturing as tradable industries, Figure 7 shows that while 53% of households with primary education or less had a household head working in the non-tradable sector during 1992-1998, almost 83% of high-educated households did. On top of this, most households received income from only one of these two broad sectors, as I show in Figure 8. Considering that labor mobility costs are high in developing countries and emerging markets, as shown by Artuc, Lederman & Porto (2015), and the asymmetric response of tradable and non-tradable sectors during sudden stop episodes, I re-examine the distribution of income and consumption losses during the Mexican crisis in order to take into account the effect of sector of work. Figure 9 shows that when grouping households according to the sector of work of their household head, income and consumption losses were larger for households in the non-tradable sector.

I estimate the relative impact of the crisis for different types of households using a difference-in-differences design, by comparing the outcomes of households more exposed to the crisis (the ones working in the non-tradable sector) to households less exposed to it (those working in the tradable sector). Households in the non-tradable sector are treated by the crisis with higher intensity than those in the tradable sector. I use the data from the income and expenditure survey ENIGH to study the effects in both income and consumption. Since this survey is a repeated cross-section, I estimate the difference-in-differences using a pooled specification with survey data from the 1994 and the 1996 waves. Even if the same individual household cannot be followed over time, it is possible to compute the average effect over similar households since each survey wave contains a random sample of the population.

For a given outcome, Y, my difference-in-differences specification controls for pre-existing differences between households working in each sector, such as education or gender, and for labor market choices, such as working in the informal sector:

$$\begin{aligned}\ln Y_{it} = \alpha + \beta \text{NT}_{it} + \gamma \text{Post}_t + \delta \text{NT}_{it} \times \text{Post}_t \\ + \mu_1 \text{Controls}_{it} + \mu_2 \text{Controls}_{it} \times \text{Post}_t + \eta \text{Controls}_i^{FE} + \varepsilon_{it}\end{aligned} \tag{1}$$

where NT_{it} is a dummy variable that indicates whether the household head works at the non-tradable sector, Post_t is a dummy that represents the timing of the crisis, it assumes a value of zero in 1994 and one in 1996, Controls_{it} include the household head education level (primary education or less, middle or high school, and college or more), the household head gender, the household head age group (less than 35, 35-50 or more than 50 year old), whether the household head is a government worker, and whether it works in the informal sector. $\text{Controls}_{it}^{FE}$ represent household level variables that proxy household fixed effects to improve efficiency of the estimation using repeated cross-sectional data, but that would not be present in a panel estimation; here I include location variables, such as rural area or whether a state is in the border with the US, and household composition characteristics, such as the share of household members of age 12 or less, and whether the household is nuclear, extended or single-headed.

The coefficient of interest, δ, is interpreted as the difference in outcomes between households working in the non-tradable sector and those working in the tradable one, during the crisis period. Given the log-linear specification, it is approximately equal to the differential percentage change in outcome during the crisis between households in each sector.

In my main specification, I consider as treated households those that have a household head working in the non-tradable sector. I define as tradable any industry in agriculture, mining or manufacturing, and consider the rest as non-tradable. The results are robust to considering an alternative definition of tradable industries based on trade data, considering the sector of work of the maximum income earner or considering a household weighted measure of exposure to non-tradable industries.[6]

I consider two outcome variables: household income and household consumption. Both outcomes are measured at per-capita household level, deflated by the domestic consumer price index.[7] In the main specification, I use as a measure of income the sum of earnings (wages, profits or self-employed income) of all household members working, and as a measure of consumption I use total household consumption in goods and services, which includes expenditures in both non-durable and semi-durable goods, but not transfers to other households or purchase of financial assets.

In table 1 I present the estimation results for the crisis period, 1994 to 1996, for both income and consumption. After controlling for compositional differences between households in each sector, households in the non-tradable sector still experienced a larger income and consumption loss than those in the tradable one. During the crisis, households in the non-tradable sector experienced a income loss 13.61 log points larger than the loss experienced by similar households working in the tradable sector. In terms of consumption, they experienced a loss 7.92 log points larger than households in the tradable sector.

As noted by Lopez-Acevedo & Salinas (2000), low-skilled workers in Mexico worked mostly in the low-tech manufacturing industry, while high-educated workers worked in services, such as finance. Table 2 presents the results separating sub-sectors within the non-tradable sector: construction, finance, and the rest of non-tradable industries, while in Table 3 the results are separated by sub-sectors in the tradable sector: agriculture, mining, and manufacturing. In the first disaggregation, both workers in construction and in finance

[6]See appendix A for more details on the data cleaning process and alternative definitions of the sector of employment variable.

[7]To consider the effects on price indexes found by Cravino & Levchenko (2017), i.e. lower-income households faced a larger inflation rate during this episode, I also repeat the analysis deflating household level variables using an income-specific CPI constructed by INEGI according to the number of minimum wages the household receives as income. Results are similar to those of Table 1.

lost more income on average than other workers in the non-tradable sector, with workers in finance losing the most. This decomposition sheds light on the nature of the crisis, that was linked to the financial sector, and on the propagation of the shock to domestic demand. In terms of the tradable sector, both workers in agriculture and manufacturing-related industries did better than non-tradable households, with households working in agriculture outperforming those in manufacturing.

Finally, I estimate (1) as a placebo for the pre-crisis and the post-crisis periods. In both cases, employment in the non-tradable sector has a small and not significantly different from zero effect on consumption, as presented in Table 4, while it has a large and significant effect in income during the pre-crisis period. This effect on income during the pre-crisis would imply that the actual fall for households employed in the non-tradable sector is even larger than the 13.6 log points from Table 1. During non-crisis periods, tradable and non-tradable sectors were not displaying such stark differences as in the crisis, so there was no differential effect from employment in one or the other. Figure 10 summarizes the results for the crisis, pre- and post-crisis periods for the coefficient of interest: sector of work affects households differentially particularly during the crisis period.

3 A New Keynesian Small Open Economy model with household heterogeneity

The baseline economy is a New Keynesian small open economy with tradable and non-tradable goods and incomplete asset markets. The economy faces external shocks in the form of tradable productivity and foreign interest rate shocks. The model combines the sectoral structure from the small open economy real business cycles literature such as Mendoza (2002) and Kehoe & Ruhl (2009), with nominal rigidities as in Burstein et al. (2007), Gertler et al. (2007), and Schmitt-Grohé & Uribe (2016). The key modifications I make are in the household side. First, households can only work in one of the two sectors, so their income is not diversified. Second, a subset of households has limited access to financial markets, as in Campbell & Mankiw (1989), Galí & Debortoli (2018) and Bilbiie (2008). These two modifications are meant to capture, in a stylized form, the observations from the previous section. To highlight how far these modifications can go, I keep the rest of the model simple. There is no physical capital and no financial frictions other than the lack of access to financial markets for some households.

Time is discrete and goes on forever. The economy is a small open economy, in which S_t denotes the nominal exchange rate in units of local currency (pesos) per unit of foreign currency (dollars). The only financial asset available is one-period uncontingent debt denominated in foreign currency, at an exogenous interest rate r_t^*.[8] The economy has two sectors: tradable and non-tradable. Prices are sticky in the non-tradable sector, while the law of one price holds in the tradable sector.

3.1 Households

The economy is populated by a large number of households that value leisure and consumption. Households are heterogeneous in two dimensions: first, some households have perfect access to financial markets, while some others have no access to financial markets; second, households can only work in one of the two sectors of the economy (tradable or non-tradable). I will refer to households that have perfect access to financial markets as "Ricardian" or "unconstrained", while I will refer to households that have no access to financial markets or other means to move resources across time as "hand-to-mouth" or "constrained".

In the benchmark setup there are then four types of households: an unconstrained household that works in the tradable sector, a constrained household that works in the tradable sector, an unconstrained household that works in the non-tradable sector, and a constrained household that works in the non-tradable sector. The representative agent setup of this economy corresponds to a Lucas household in which all types of households pool their income and maximize aggregate household welfare. Since some members have perfect access to financial markets, the household as a whole does too. In subsection 4.2, I consider other types of Lucas households to assess the effect of each of the two dimensions of heterogeneity present in the benchmark case.

Let the household type $m = (j, f)$ be determined by the combination of sector of work $j \in T, NT$ and access to financial markets $f \in R, H$. Household m values leisure and consumption according to:

$$U^m = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{m\,1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{N_t^{m\,1+\phi}}{1+\phi} \right) \tag{2}$$

where C_t^m is the consumption of household m in period t, N_t^m represents the amount of time worked by household m at their corresponding sector in period t, β is the subjective discount factor common to all types of households, σ is the inverse of the intertemporal elasticity of substitution of consumption, ϕ is the inverse of the Frisch elasticity of labor, and κ^j is a scale parameter on the disutility of labor, common within sector of work.

There are λ households with no access to financial markets, distributed across tradable

[8] This type of debt has been used in the literature to capture the inability of emerging markets to issue debt at long horizons in domestic currency, due to past default or hyperinflation episodes.

and non-tradable sectors according to $s^{j,H}$, while the remaining $1-\lambda$ households have perfect access to financial markets and are distributed across sectors according to $s^{j,R}$.

Each type of household maximizes U^m subject to their corresponding budget constraint. For unconstrained households in sector j this is given by:

$$P_t C_t^{j,R} + S_t \frac{d_t^{j,R}}{1-\lambda^j} = W_t^j N_t^{j,R} + (1-\tau^j)\frac{\Pi_t^j}{s^{j,R}} + \frac{S_t}{1+r_t^j}\frac{d_{t+1}^{j,R}}{1-\lambda^j} \tag{3}$$

where P_t is the price of final composite consumption, $d_t^{j,R}$ is the debt household $m=(j,R)$ acquired in $t-1$ and repays at t, W_t^j is the nominal wage in sector j, Π_t^j are nominal profits from firms in sector j, τ^j represents the distribution of profits across sector j households, and λ^j is the share of constrained households in sector j.[9]

Since small open economy models with incomplete markets are non-stationary (see Schmitt-Grohé & Uribe 2003), I introduce a debt elastic interest rate, without internalization of this effect, for each household that has access to financial markets. The interest rate elasticity is small enough so as to not alter the high frequency dynamics of the model, but big enough to make the model stationary.

$$r_t^j = r_t^* + \psi\left(\exp(d_t^{j,R} - \bar{d}^{j,R}) - 1\right) \tag{4}$$

where r_t^* is the exogenous interest rate faced by the country, ψ is the interest rate elasticity to domestic debt, and $\bar{d}^{j,R}$ is steady state debt of household j, R.

Hand-to-mouth households working in sector j face the budget constraint:

$$P_t C_t^{j,H} = W_t^j N_t^{j,H} + \frac{\tau^j \Pi_t^j}{s^{j,H}} \tag{5}$$

3.2 Tradable sector

There is a single tradable good produced by the economy. Any domestic excess supply or demand is traded with the rest of the world without affecting the international price of the tradable good. The law of one price holds:

$$P_t^T = S_t P_t^{T*} \tag{6}$$

where P_t^{T*} is the price of tradable goods in foreign currency. Without loss of generality, I normalize $P_t^{T*} = 1$.

[9]For example, the total measure of households in the tradable sector is given by $s^{TR} + s^{TH}$, then $\lambda^T = \frac{s^{TH}}{s^{TR}+s^{TH}}$.

A competitive representative firm produces the tradable good using only labor:

$$Y_t^T = z_t^T \left(H_t^T\right)^{\alpha_T} \tag{7}$$

where z_t^T can be interpreted as both a productivity shock in tradable goods' production or a shock to the terms of trade.

Profits in the tradable sector are given by:

$$\Pi_t^T = P_t^T Y_t^T - W_t^T H_t^T \tag{8}$$

The representative tradable firm behaves competitively, considering the tradable price and wage as given:

$$W_t^T = \alpha_T P_t^T A_t^T \left(H_t^T\right)^{\alpha_T - 1} \tag{9}$$

3.3 Non-Tradable sector

There is a final non-tradable good and a continuum of non-tradable intermediate varieties. The final non-tradable good is produced by perfectly competitive firms using only the intermediate non-tradable varieties as inputs with a Dixit-Stigliz aggregator production function:

$$Y_t^N = \left[\int_0^1 \left(a_{it}^N\right)^{\frac{\mu-1}{\mu}} di\right]^{\frac{\mu}{\mu-1}} \tag{10}$$

in which Y_t^N denotes total production of the final non-tradable good, a_{it}^N is the quantity of intermediate non-tradable variety $i \in [0,1]$ demanded for final good production, and $\mu > 1$ is the elasticity of substitution across varieties in the production of the final non-tradable good.

Firms in the final non-tradable sector choose Y_t^N and a_{it}^N to maximize profits:

$$P_t^N Y_t^N - \int_0^1 P_{it}^N a_{it}^N di$$

taking into account the production function (10) and considering the price P_t^N as given. Taking FOC with respect to each variety, I find the demand for each intermediate non-tradable good:

$$a_{it}^N = Y_t^N \left(\frac{P_{it}^N}{P_t^N}\right)^{-\mu} \tag{11}$$

which is increasing in the level of final non-tradable output and has a price elasticity of $-\mu$ with respect to the relative price of variety i in terms of the final non-tradable good.

Combining the demand functions for intermediate inputs with the Dixit-Stiglitz aggregator for the final non-tradable good results in an expression for the price of the final non-tradable good in terms of the prices of intermediate non-tradable inputs:

$$P_t^N = \left[\int_0^1 \left(P_{it}^N\right)^{1-\mu} di\right]^{\frac{1}{1-\mu}} \tag{12}$$

The intermediate non-tradable varieties are produced by monopolistically competitive firms indexed by $i \in [0,1]$ using only labor as an input. Each firm operates a linear technology, common to all firms in the non-tradable sector:

$$y_{it}^N = H_{it}^N \tag{13}$$

Each firm faces demand for their intermediate variety given by (11), taking as given aggregate final non-tradable output Y_t^N and the final non-tradable price P_t^N. Firms are price-takers in the labor market, they receive a proportional labor subsidy τ from the government and they pay a lump-sum tax T_{it}^{Π}.[10] Period t profits are given by:

$$\pi_{it}^N = P_{it}^N a_{it}^N - (1-\tau) W_t^N N_{it}^N - T_{it}^{\Pi} \tag{14}$$

Market clearing in each variety's market requires:

$$y_{it}^N = a_{it}^N \tag{15}$$

Rewriting period t profits using the intermediate production function, the demand for variety i and the market clearing condition:

$$\pi_{it}^N = P_{it}^N Y_t^N \left(\frac{P_{it}^N}{P_t^N}\right)^{-\mu} - (1-\tau) W_t^N Y_t^N \left(\frac{P_{it}^N}{P_t^N}\right)^{-\mu} - T_{it}^{\Pi} \tag{16}$$

With flexible prices intermediate good firms choose their current price P_{it}^N to maximize current profits as expressed in (16). With sticky prices, an intermediate good firm must take into account that the price chosen today will affect its future profits since it might not be possible to change the price in the future. I will assume Calvo pricing, that is: with exogenous probability $\theta \in (0,1)$ a firm cannot reset its price in the current period and must charge the same price as it was charging in the period before, while with probability $1-\theta$ it can adjust its price, independently of the number of periods the firm has been unable

[10] I assume firms pay for the tax that finances the labor subsidy to keep the incidence of this tax tied to receiving profits from the NT sector. Traditionally, the tax is levied on households, but since there's a representative household it would be equivalent to firms paying for the tax.

to change prices. A firm that is able to adjust its price will choose the current price $\tilde{P}^N_{it}$ to maximize the present discounted value of expected profits generated while such price is in effect:

$$\mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s}\theta^s \left[\left(\tilde{P}^N_{it}\right)^{1-\mu} Y^N_{t+s} \left(P^N_{t+s}\right)^{\mu} - (1-\tau) W^N_{t+s} Y^N_{t+s} \left(\frac{\tilde{P}^N_{it}}{P^N_{t+s}}\right)^{-\mu} - T^{\Pi}_{it} \right] \tag{17}$$

where $Q_{t,t+s}$ is a nominal discount factor between periods t and $t+s$. Firms take the discount factor as given when choosing their price.

Taking the FOC with respect to $\tilde{P}^N_{it}$ and rearranging:

$$\mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s}\theta^s Y^N_{t+s} \left(\frac{\tilde{P}^N_{it}}{P^N_{t+s}}\right)^{-\mu} \left[\frac{\mu-1}{\mu}\tilde{P}^N_{it} - (1-\tau) W^N_{t+s}\right] = 0 \tag{18}$$

Every firm that gets to reoptimize in period t will choose the same price $\tilde{P}^N_t$, since there are no other idiosyncratic shocks in condition (18) and the time elapsed since the last price change is irrelevant. Calvo pricing and equation (12) imply that:

$$P^N_t = \left[\theta \; {P^N_{t-1}}^{1-\mu} + (1-\theta) \; {\tilde{P}^N_t}^{1-\mu}\right] \tag{19}$$

I will assume that firms discount profits at the international interest rate, as if they could directly borrow in foreign currency at rate r_t as unconstrained households do. The nominal discount factor they use is then:

$$Q_{t,t+s} = \Pi^s_{j=1} \left[(1 + r^*_{t+s-1})\epsilon_{t+s}\right]^{-1} \text{ for } s \geq 1 \tag{20}$$

where ϵ_{t+s} is the devaluation rate between $t+s-1$ and $t+s$. The discount factor is equal to 1 for $s = 0$.

Total demand for labor in the non-tradable sector is given by:

$$H^N_t = \int_0^1 H^N_{it} di \tag{21}$$

Using the demand for intermediate non-tradable varieties and the non-tradable production function in the previous expression, a relationship between aggregate demand for labor in the non-tradable sector and final non-tradable good output is obtained:

$$H^N_t = Y^N_t \int_0^1 \left(\frac{P^N_{it}}{P^N_t} di\right)^{-\mu} \tag{22}$$

Define s_t, a measure of price dispersion, as:

$$s_t = \int_0^1 \left(\frac{P_{it}^N}{P_t^N} di \right)^{-\mu} \tag{23}$$

Then, the non-tradable final good production can be written as:

$$Y_t^N = H_t^N s_t^{-1} \tag{24}$$

As in the New Keynesian literature, $s_t \geq 1$ and evolves according to:

$$s_t = \theta s_{t-1} \left(\frac{P_{t-1}^N}{P_t^N} \right)^{-\mu} + (1-\theta) \left(\frac{\tilde{P}_t^N}{P_t^N} \right)^{-\mu} \tag{25}$$

Aggregate profit income from the non-tradable sector, after taking taxes into account (see government subsection), is given by:

$$\Pi_t^N = P_t^N Y_t^N - W_N H_t^N \tag{26}$$

3.4 Composite consumption good

A competitive firm produces the final composite consumption good combining both tradable and non-tradable goods. Production of composite consumption takes place through an increasing, concave, and homogeneous of degree one Armington aggregator $A(C_t^T, C_t^N)$. In particular, I assume a CES aggregator:

$$A(C_t^T, C_t^N) = \left[\omega^{1/\eta} \, {C_t^T}^{1-1/\eta} + (1-\omega)^{1/\eta} \, {C_t^N}^{1-1/\eta} \right]^{\frac{1}{1-\frac{1}{\eta}}} \tag{27}$$

where ω is a weight on the relative importance of tradable goods, and η is the intratemporal elasticity of substitution between tradable and non-tradable goods.

Profits in this sector are given by:

$$P_t A(C_t^T, C_t^N) - P_t^T C_t^T - P_T^N C_t^N \tag{28}$$

Profit maximization implies the following conditions:

$$P_t A_1(C_t^T, C_t^N) = P_t^T \tag{29}$$
$$P_t A_2(C_t^T, C_t^N) = P_t^N \tag{30}$$

where $A_j(C_t^T, C_t^N)$ is the partial derivative of $A(C_t^T, C_t^N)$ with respect to its jth argument.

Combining these FOC, the allocative relative price of non-tradable goods is obtained:

$$\frac{P_t^N}{P_t^T} = \frac{A_2(C_t^T, C_t^N)}{A_1(C_t^T, C_t^N)} \tag{31}$$

The zero-profit condition implies that the unit price of the composite consumption good can also be written as:

$$P_t = \left(\omega\ P_t^{T\,1-\eta} + (1-\omega)\ P_t^{N\,1-\eta}\right)^{\frac{1}{1-\eta}} \tag{32}$$

3.5 Government

The government conducts monetary policy through an interest rate rule that will be specified with the nominal exchange rate regime.

In terms of fiscal policy, the government's only action is to correct the monopoly distortion in the market for non-tradable varieties by imposing a subsidy on labor that is financed through lump-sum taxes on non-tradable firms.

$$\int_0^1 T_{it}^{\Pi} di = \tau H_t^N \tag{33}$$

3.6 Market clearing

In the competitive equilibrium, all markets must clear. Labor markets, non-tradable varieties, non-tradable final good, and composite consumption good's markets must clear domestically, while the tradable good market does not.

Labor market for the tradable sector:

$$H_t^T = \sum_{m \in T} N_t^m dm \tag{34}$$

Labor market for the non-tradable sector:

$$H_t^N = \sum_{m \in N} N_t^m dm \tag{35}$$

Non-tradable varieties, for all i:

$$y_{it}^N = a_{it}^N \tag{36}$$

Final non-tradable market:

$$Y_t^N = C_t^N \tag{37}$$

Finally, for the composite consumption good,

$$C_t = \sum_m C_{m,t} dm \tag{38}$$

By Walras' law, the market clearing condition for the tradable good is redundant. This condition defines the current account equation: a relationship between domestic production and consumption of tradable goods, and the flow of funds from financial markets' transactions.

$$P_t^T C_t^T = P_t^T Y_t^T + S_t \left(\frac{d_{t+1}}{1 + r_t^*} - d_t \right) \tag{39}$$

in which d_t is aggregate debt from all unconstrained households.

3.7 Nominal exchange rate regime

The central bank follows an augmented Taylor rule where the domestic nominal interest rate reacts to domestic inflation (in terms of the composite consumption good) and to the depreciation rate:

$$(1 + i_t) = (1 + \bar{r}) \left(\frac{P_t}{P_{t-1}} \right)^{\phi_\pi} \epsilon_t^{\phi_e} \exp\left\{ \varepsilon_t^S \right\} \tag{40}$$

with $\phi_\pi > 1$, $\phi_e \geq 0$, $\bar{r}$ is the steady state real interest rate, and ε_t^S is a monetary policy shock.

The nominal exchange rate adjusts endogenously to satisfy the uncovered interest parity condition given by:

$$\sum_{m \in \{TR, NR\}} \frac{s^m}{s^{TR} + s^{NR}} \mathbb{E}_t \left\{ \left(\frac{C_{t+1}^m}{C_t^m} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \left((1 + r_t^j) - \frac{(1 + i_t)}{\epsilon_{t+1}} \right) \right\} = 0 \tag{41}$$

where j is the sector of work of household m.

The coefficient ϕ_e in (40) represents the central bank's degree of "fear of floating". When $\phi_e = 0$ the central bank lets the currency float freely, while when $\phi_e \to \infty$ the central bank keeps the exchange rate fixed.

The nominal exchange rate regime is a key ingredient of the economy, since it can alleviate the effects of nominal rigidities in the non-tradable sector. Schmitt-Grohé & Uribe (2016) prove, in a representative agent economy, that the exchange rate regime that stabilizes non-tradable inflation can reproduce the flexible-price allocation, which is Pareto optimal. This regime corresponds to a floating exchange rate that depreciates when the relative price of non-tradable goods goes down in the flexible-price allocation.

The monetary policy rule in (40) includes a reaction to the exchange rate depreciation in order to capture the phenomenon of "fear of floating". Calvo & Reinhart (2002) coined this expression in their analysis of monetary policy in emerging markets. They find that even if countries announce to be following a floating exchange rate regime, they limit the fluctuations in the nominal exchange rate. Lubik & Schorfheide (2007) examine empirically whether central banks in advanced economies react to the nominal exchange rate. They find that Canada and England do, but Australia and New Zeland do not. Best (2013) estimates a Bayesian NK-SOE model for the case of Mexico and finds that there is evidence of "fear of floating", as was suggested by Calvo & Reinhart (2002).

3.8 Exogenous shocks

There are three exogenous shocks that affect the economy: productivity in the tradable sector, the international interest rate, and monetary policy shocks. Interest rate shocks capture in a reduced form the fact that business cycles in emerging markets are correlated with the finance premium they face in international financial markets.

I will assume the tradable productivity shocks and the international interest rate shock follow independent AR(1) processes:

$$\ln(z_t^T) = \rho_{z^T} \ln(z_{t-1}^T) + \varepsilon_t^T \tag{42}$$

$$\ln\left(\frac{1+r_t^*}{1+\bar{r}}\right) = \rho_r \ln\left(\frac{1+r_{t-1}^*}{1+\bar{r}}\right) + \varepsilon_t^r \tag{43}$$

$\rho_{z^T}, \rho_r \in (-1, 1)$ are first-order auto-correlation parameters, ε_t^T and ε_t^r are independent white noise shocks, distributed normally with mean zero and standard deviation $\sigma_{\epsilon_{z^T}}$ and $\sigma_{\epsilon_{r^*}}$ respectively, and $\bar{r}$ is the steady state value of the international interest rate.

The monetary policy shock ε_t^S is a white noise process distributed normal with mean zero and standard deviation σ_{ϵ_S}.

3.9 Equilibrium

A competitive equilibrium in the benchmark model with heterogeneity is given by a set of processes: $\left\{C_t, C_t^j, C_t^m, N_t^m, d_t^m, W_t^j, P_t^j, \tilde{P}_t^N, Y_t^j, H_t^j, r_t^j, \epsilon_t, s_t, z_t^T, r_t^*\right\}$ for $j \in \{T, N\}$ and $m \in \{TR, TH, NR, NH\}$ such that households maximize their utility, firms maximize profits, and all markets clear, given initial conditions $s_0, d_0^{TR}, d_0^{NR}, z_0^T, r_0^*$, the stochastic processes $\varepsilon_t^T, \varepsilon_t^r$ and ε_t^S, a monetary policy rule (40) and a subsidy τ.

3.10 Calibration and solution method

The baseline calibration of the model is such that the steady state matches characteristics of the Mexican economy and the benchmark model with heterogeneity replicates the fall in consumption during the sudden stop episode. The central component is the calibration of household heterogeneity from available microdata. Table 5 summarizes all the calibrated parameters of the model. I calibrate the benchmark model with heterogeneity to have the same steady state, in terms of aggregate variables, as the model with a representative agent setup. The calibration is performed at a quarterly frequency.

I solve the model numerically using a perturbation approach. For the response to shocks in section 4, I compute the impulse-response functions from a first-order approximation, while for the welfare analysis in section 5 I compute a second-order approximation as in Schmitt-Grohé & Uribe (2004).

Preferences. I set the subjective discount rate β to 0.9758, to match the quarterly foreign interest rate faced by Mexico in the period 1994-2001. I set the inverse of the intertemporal elasticity of substitution, σ, to 2 as in Mendoza (2002), Kehoe & Ruhl (2009) and Schmitt-Grohé & Uribe (2016). For the intratemporal elasticity of substitution between tradable and non-tradable goods, η, I use a value of 1/2, which is slightly higher than Ostry & Reinhart (1992) estimate of 0.316 for Latin America or González-Rozada, Neumeyer, Clemente, Sasson & Trachter (2004) estimate of 0.40-0.48 for Argentina. I calibrate the weight of tradable goods in composite consumption ω and the aggregate level of debt $\bar{d}$ to jointly match the average ratio of tradable output to GDP (25%, 1990-2001) and the ratio of net foreign assets to GDP (-36%, 1980-2011, from Lane & Milesi-Ferretti (2007)).

In terms of parameters related to the labor market, there is little agreement on the literature about the value of ϕ, the inverse Frisch elasticity of labor supply. I calibrate this parameter to match the response of consumption during the Mexican crisis with the corresponding response in the benchmark model with heterogeneity. The corresponding value is 2.9, which corresponds to a Frisch elasticity of 0.35, which lies on the lower range used in the literature. The disutility of labor scale parameter κ^j for each sector j is set to match the share of labor in each sector and a total time spent working of $1/3$ in the representative household version of the model.

Household heterogeneity. I calibrate all the household heterogeneity parameters to match moments in the 1994 ENIGH survey described in section 2. I use the same classification of households into tradable and non-tradable sectors as in the previous empirical analysis. According to this classification, the share of households working in the tradable sector is given by $s^{TR} + s^{TH} = 0.38$ and the share working in the non-tradable sector is $s^{NR} + s^{NH} = 0.62$.

Identifying hand-to-mouth households from micro-data requires a serious analysis of what does it mean for a household to be "hand-to-mouth". In the model, these households have no access to financial markets and no other means of moving resources across time.

In the data, however, it's highly unlikely for this to be the case, since households can use informal storage technologies or informal financial markets. This last possibility is particularly relevant in emerging markets, where financial markets are underdeveloped. Since in the model financial markets refer to access to international markets, I consider as hand-to-mouth those households that have no access to "formal" financial markets.

The ENIGH survey includes three sections that I use to identify participation in formal financial markets: "capital expenditures", "capital income", and "income from rents". The first two refer to the same categories of financial transactions: savings accounts, loans, credit cards, foreign currency, jewelry, bequests, real state, mortgages, bonds and stocks, and patents. While the third section registers income from interest payments from savings, loans, bonds, and stocks perceived in the quarter of the interview. I then define access to financial markets by either receiving interest payments from formal bank accounts, bonds or stocks; making or receiving payments from financial transactions such as deposits or withdrawals from a bank account; loans to and from third parties; mortgage payments and new mortgages; sale or purchase of foreign currency, bonds, and stocks; or purchase or sale of real state.[11]

Under this definition, 58% of households are considered hand-to-mouth. Of the households working in the non-tradable sector, 56% are constrained, while 62% of those working in the tradable sector are. Since the ENIGH survey does not have a balance sheet approach, I can only measure current access to formal financial markets, but not past access. There is no register if a household has savings or debt with a financial institution that were acquired in a quarter other than the current one. Using the 2002 Mexican Family Life Survey, about 20% of Mexican households had some form of savings, 60% of households didn't know where they could get a loan, and about 12% of households borrowed money at least once in the past year. Similarly, the World Bank's Financial Inclusion survey from 2011 and 2014 indicate that about 30% of Mexican households have an account at a financial institution, and while 53% of households borrowed money from any source, only 10% of those who borrowed did so from a financial institution.

Finally, I use the ENIGH data to determine the distribution of profits in each sector. In Mexico, about 25% of household heads are self-employed, while less than 10% are business owners with employees. The stock market in Mexico, as in other emerging markets, lacks depth and has limited access (both for firms and investors).[12] Therefore it is more likely that firms' profits will be paid out directly, rather than through stocks' dividends. I then calibrate τ^T and τ^N to match the share of self employed and business income by sector.

[11] In appendix B, I detail the exact survey categories I consider for each case.

[12] Stock market depth index comparison: http://vif.com.mx/indice/anio/2017/

Supply side. For the tradable sector, I set $\alpha^T = 0.52$, the labor share estimated for the tradable sector in Mexico by Meza & Urrutia (2011). In the non-tradable sector, I set the Calvo parameter $\theta = 0.7$, as estimated by Gagnon (2009) from price duration data from Mexico, and I set the elasticity of substitution within non-tradable varieties, μ, to match a 20% mark-up.

I set the labor subsidy to non-tradable firms $\tau = 1/\mu$, in order to induce marginal cost pricing in steady state and eliminate the monopoly-induced distortion in the market of each non-tradable variety.

Exogenous processes. For the foreign interest rate process, I use the rate constructed by Neumeyer & Perri (2005) for the period 1994-2001. The international interest rate is given by:

$$1 + r_t^* = \frac{(1 + r_t^{USTBILL})(1 + EMBI_t)}{1 + \pi_t^{US}}$$

where $r_t^{USTBILL}$ is the 90-day U.S. T-bill interest rate, $EMBI_t$ is the J.P. Morgan EMBI global spread for Mexico, and π_t^{US} is a 4-period moving average of U.S. inflation. I construct productivity in the tradable sector as output per worker in the tradable sector. I estimate the AR(1) processes specified in (42) and (43) for each of the two shocks as independent processes.

For the monetary policy rule, I use a value of $\phi_\pi = 1.5$ and for the standard deviation of the monetary policy shock I use the value identified by Best (2013) for Mexico in the post-crisis period.

Finally, I calibrate the interest rate elasticity to domestic debt ψ, common to all households, to match the standard deviation of the trade balance to output ratio for the period 1990-2001.

4 Sudden stop crises with and without heterogeneity

In this section I compare the responses of the representative agent (RA) setup and the benchmark economy during a crisis episode. I assume that each economy starts in steady state and it is then hit by a one-time, unanticipated shock to the international interest rate and a productivity shock in the tradable sector. The interest rate shock can be interpreted as a sudden stop of capital inflows, while the productivity shock in the tradable sector represents in a reduced-form the real effects of the credit crunch in the tradable sector. I study the response of each economy under the same monetary policy regime, a fixed exchange rate. Finally, to asses the role of each dimension of heterogeneity, I repeat the exercise turning off one dimension of heterogeneity at a time.

Before looking at the crisis episode, consider the special case of $\sigma = 1/\eta$.[13] For a given exchange rate regime, inequality has two effects on the equilibrium conditions: first, it introduces a wedge on the intertemporal allocation of aggregate consumption, and second, it introduces a wedge on each sector intratemporal labor supply condition.

First, consider the intertemporal Euler equation of unconstrained households in sector j:

$$C_t^{jR\,-\sigma} = \beta\left(1 + r_t^j\right)\mathbb{E}_t\left\{C_{t+1}^{jR\;-\sigma}\,\frac{P_t/S_t}{P_{t+1}/S_{t+1}}\right\} \tag{44}$$

Since $r_t^j \approx r_t^*$ and (29) implies $P_t = P_t^T/\left(C_t^{1/\eta}\,C^{T\,-1/\eta}_t\,\omega^{1/\eta}\right)$, this equation can be used to write an aggregate Euler equation for tradable consumption:

$$C_t^{T\,-\sigma} = \beta(1 + r_t^*)\mathbb{E}_t\,C_{t+1}^{T\;-\sigma}\underbrace{\left(\frac{C_{t+1}^{jR}}{C_{t+1}}\right)^{-\sigma}\left(\frac{C_t^{jR}}{C_t}\right)^{\sigma}}_{\text{Intertemporal inequality wedge}} \tag{45}$$

In the representative household setup, every type of household has the same consumption, so the underbraced term is equal to 1 at every period. Heterogeneity, then, introduces a wedge on the intertemporal Euler equation, as noted by Galí & Debortoli (2018) and Werning (2015). This intertemporal inequality wedge operates as an interest rate shock for the aggregate economy. When the wedge is larger than one, it is as if the economy were facing an increase in the international interest rate.

Second, consider the intratemporal choice of labor and consumption for housheold m in sector j:

$$\kappa^j\;N_t^{m\,\phi} = W_t^j\;C_t^{m\,-\sigma} \tag{46}$$

Market clearing in the labor market for each type of labor and (29), imply a labor choice in each market given by:

$$\kappa^j\;H^{j\,\phi} = \frac{W_t^j}{S_t}\,C_t^{T\,-\sigma}\underbrace{\left[s^{jR}\left(\frac{C_t^{jR}}{C_t}\right)^{-\frac{\sigma}{\phi}} + s^{jH}\left(\frac{C_t^{jH}}{C_t}\right)^{-\frac{\sigma}{\phi}}\right]^{\phi}}_{\text{Intratemporal inequality wedge in sector j}} \tag{47}$$

Heterogeneity introduces an intratemporal wedge on the labor choice arising from the presence of income effects on individual labor choices. Since households of different

[13] The special case of equal intertemporal and intratemporal elasticity of substitution is a case of interest since in the representative household economy the tradable sector equilibrium is independent of the exchange rate regime. In this case, all the differences in welfare come through the dynamics of the NT sector, as shown by (Uribe & Schmitt-Grohé 2017).

types consume a different share of total consumption, they experience a different relative income effect. In section 4.2 I examine the role of these differential income effects in driving aggregate responses. For a given wage and tradable consumption level, intratemporal inequality over/underweights labor resources in sector j with respect to the measure of households in that sector $s^{jR} + s^{jH}$.

Note that equation (45) is independent of the exchange rate regime. However, the exchange rate regime does affect the determination of consumption distribution through its effect on the relative price of composite consumption and the value of output and wages in the non-tradable sector.

4.1 A sudden stop event

Both the benchmark and the RA economy start on steady state with a fixed exchange rate regime. I consider the sudden stop event as an unexpected increase in the quarterly foreign interest rate of 200 basis points and a tradable productivity shock of -500 basis points, similar to the one experienced by the Mexican economy in the first two quarters of 1995. In this exercise I keep the exchange rate regime unchanged, while in the Mexican episode the fixed exchange rate was abandoned after the start of the sudden stop. Given this difference, I will focus on matching the through of the Mexican crisis in 1995:Q2, and the differences on how the shock propagates in each type of economy.

Figure 11 presents the Impulse Response Functions for aggregate variables during the sudden stop episode for both economies. To gain intuition, it is useful to analyze the representative household model first (dashed lines). The IRF to the sudden stop combines the responses to the interest rate shock and the tradable productivity shock. When the sudden stop hits, the domestic interest rate increases by the same amount as the interest rate shock since the economy operates on a fixed nominal exchange rate. In the single representative household setup, the household has access to financial markets as unconstrained households do. Then, an increase in the international interest rate makes present consumption less attractive.

Given the specification in (2), the representative household would like to work more in both sectors due to the negative income effect generated by a higher interest rate. However, the negative productivity shock in the tradable sector decreases tradable labor supply. Tradable output decreases since the effect of the productivity shock dominates the income effect. Any domestic excess supply of tradable goods can be sold in international markets without affecting its price. Since domestic consumption of tradable goods falls by more than tradable output, there is an improvement on the trade balance to output ratio, although it is small compared to the current account reversal observed in the data.

In terms of non-tradable output, the fall in aggregate demand now acts as a constraint since price rigidities limit the fall on prices and non-tradable output must fall to clear the market. In turn, wages fall in both sectors (not pictured). Total output and hours decrease following the recession in both sectors. The recession in the non-tradable sector is larger than in the tradable one.

The IRFs of the benchmark model are given by the solid lines in Figure 11. Compared to the representative household responses, they display amplification of the impact response of all variables. Hand-to-mouth households are not directly affected by the interest rate shock since they do not have access to financial markets. However, they do respond to general equilibrium changes triggered by the response of unconstrained households and to the productivity shock in the tradable sector. As noted by Bilbiie (2008) and Werning (2015), including heterogeneous agents can amplify or dampen the responses of representative agent models, depending on the relationship between the income of hand-to-mouth agents and aggregate income.

The response of consumption and non-tradable output is amplified due to the combination of the two types of heterogeneity introduced. While hand-to-mouth households do not cut down consumption due to the increase in the interest rate, they do so due to the fall in real wages. In fact, Figure 12 shows that while hand-to-mouth households in the non-tradable sector reduce their consumption, hand-to-mouth households in the tradable sector actually increase their consumption since their real wage is actually increasing. The lack of income diversification across sectors makes the real income loss larger for households in the non-tradable sector (both current and in present value terms). In the representative household setup, household members in the tradable sector smooth out the shock received by non-tradable members by increasing their labor supply in the tradable sector so the household does not have to borrow as much to keep consumption smooth. Once the single household is separated, the income sharing and intra-household insurance are lost.

The response of tradable output is explained by the behavior of households within the tradable sector. For unconstrained households, the negative productivity shock in the tradable sector dampens the incentive to increase labor supply generated by the negative income effect triggered by the interest rate increase. Constrained households, on the other hand, do not experience this negative income effect and they respond more strongly to the productivity shock. This heterogeneity within the tradable sector dampens the response to income effects, amplifying the response to the negative productivity shock.

Since households in the non-tradable sector are richer than households in the tradable one and they cut down they consumption by more, the crisis reduces consumption inequality. Over time, this effect is reduced and in the absence of any more shocks, there is a permanent reduction in consumption inequality. The inequality wedge presents a positive deviation from steady state at first, meaning that it is larger than one in levels. This reflects the evolution of inequality over time measured as consumption of unconstrained households in the tradable sector relative to aggregate consumption, as presented in Figure 12. While inequality decreased (the ratio c^{TR}/c increased, since tradable households are poorer than the aggregate), its overshooting pattern makes inequality increasing over time. Through the lens of equation (45), the economy with heterogeneity displays an amplified response because the dynamics of inequality operate as an additional interest rate increase at first.

Finally, when grouping the responses of households in each sector, there is a differential effect against households in the non-tradable sector with respect to households in the tradable one. This differential against non-tradable households is in line with the empirical evidence from section 2, -13.9 percentage points on impact, but the increase in tradable households' consumption is counterfactual.

The benchmark model is calibrated to match the initial fall in consumption from Figure 2, by using a more inelastic labor supply. Since the model without heterogeneity uses this same elasticity, it is possible to determine how much of the fall in consumption can be accounted by heterogeneity. The single household model generates a fall in consumption of 3.7%, while the benchmark model matches the 10.5% fall from the data. Heterogeneity, then, accounts for 65% of the fall in consumption. The model with heterogeneity matches, without targeting it, the fall initial fall in output. Compared with the single household model, heterogeneity accounts for 60% of the fall in output. In the benchmark model, the non-tradable sector slightly overreacts compared to the data, while the response of tradable output falls short.

In terms of the welfare cost of the sudden stop, I compute the short-run cost as the proportion of steady state consumption each type of household would require to avoid the present discounted welfare loss during the first six quarters after the shock.[14] For each household I compute:

$$\Delta C^m = \frac{W^m_{crisis} - W^m_{ss}}{\lambda^m_{ss} C^m_{ss}} \tag{48}$$

where ΔC^m represents the percentage of steady state consumption household of type m requires to avoid the crisis, $W^m_{crisis} = \sum_{t=1}^{6} \beta^{t-1} U\left(C^m_t, N^m_t\right)$ is the present discounted value of utility during the crisis, W^m_{ss} is the corresponding value in terms of steady state consumption, $C^m_s s$ is steady state consumption for household m, and λ^m_{ss} is the marginal

[14]This is the time it took output in Mexico to get back on trend during the Tequila crisis, as in Figure 2.

utility of consumption for household of type m in steady state.

For the economy as a whole, the percentage of steady state consumption households would require to avoid the crisis is given by:

$$\Delta C = \sum_{m} s^m \frac{C^m_{ss}}{C_{ss}} \Delta C^m \tag{49}$$

where $m \in \{TR, TH, NR, NH\}$. The welfare cost for each household is weighted by the household's consumption share in order to keep the interpretation of ΔC as percentage of aggregate steady state consumption.

In Table 6 panel (a), I present the short-run welfare cost for each model. The welfare cost of the sudden stop is larger in the benchmark economy than in the representative household version. In the benchmark model, the crisis costs society about 17% of steady state consumption, while it costs 9.6% in the representative agent version. However, the distribution of welfare costs is very different across households, as shown in panel (b) of Table 6. The reallocation effects triggered by the sudden stop benefit all households in the tradable sector, while households in the non-tradable sector with access to financial markets benefit through the exchange rate remaining fixed. After the crisis, the economy moves to a new steady state in which non-tradable goods are relatively less valuable. This reallocation benefits tradable households that get to consume more on the new steady state, even if in level terms they are still poorer than households in the non-tradable sector.

Table 6 also presents what the welfare costs would have been in two alternative scenarios for the exchange rate regime: 1. the fixed exchange rate is abandoned one quarter after the sudden stop; 2. the exchange rate was always floating and the monetary authority follows a Taylor rule with no fear of floating. In the representative household case, the welfare cost is similar across all exchange rate regimes, about 9.5%. A flexible exchange rate reduces the impact on output and consumption, but it does not avoid the consumption loss during the sudden stop. For the benchmark model, the exchange rate regime does affect welfare costs more significantly. Facing a sudden stop with a flexible exchange rate reduces the aggregate welfare cost to 9.6%, while abandoning the fixed exchange rate one quarter after the shock only reduces the cost to 16.3%.

In terms of the distribution of welfare costs, the exchange rate regime affects households differently. Households in the tradable sector benefit from the sudden stop no matter the exchange rate regime, experiencing the largest benefits under a floating exchange rate. For hand-to-mouth households in the non-tradable sector, a floating exchange rate decreases their welfare cost by reducing the fall in aggregate demand and the fall in their income. Unconstrained households in the non-tradable sector benefit from the exchange rate being fixed when the sudden stop hits, but they are hurt if the exchange rate is always floating.

4.2 Mechanisms: access to financial markets and uninsurable sector-specific income

In this section I explore the role in driving short-run responses of each type of heterogeneity in the model. To asses the importance of each type of heterogeneity, I turn on each one at a time and repeat the crisis exercise.

Access to financial markets. Consider a version of the benchmark model in which there is only heterogeneity in access to financial markets, but not in terms of sectoral income. In this case, there are two households that receive income from both sectors. There is a hand-to-mouth household that pools households working in the tradable and non-tradable sector with no access to financial markets, of measure $\lambda = s^{TH} + s^{NH}$. There is also an unconstrained household that pools households in both sectors with access to financial markets, with measure $1-\lambda = s^{TR} + s^{NR}$. Both households receive diversified income, but the diversification is not necessarily the same since it depends on the original cross-sectional distribution of households.

Each household wants to maximize household utility given that every household member is provided with the same consumption level and each subtype inside a household is weighted by its relative share within the household. For example workers in the tradable sector in the hand-to-mouth household are weighted by s^{TH}/λ.

The budget constraint of the unconstrained household is given by:

$$P_tC_t^R + \frac{S_t d_t}{1-\lambda} = \frac{s^{TR}}{1-\lambda}W_t^T N_t^{TR} + \frac{(1-\tau^T)\Pi_t^T}{1-\lambda} + \frac{s^{NR}}{1-\lambda}W_t^N N_t^{NR} + \frac{(1-\tau^N)\Pi_t^N}{1-\lambda} + \frac{S_t d_{t+1}}{(1-\lambda)(1+r_t)}$$

While the hand-to-mouth household faces:

$$P_tC_t^H = \frac{s^{TH}}{\lambda}W_t^T N_t^{TH} + \frac{T_t^{TH}}{\lambda} + \frac{s^{NH}}{\lambda}W_t^N N_t^{NH} + \frac{T_t^{NH}}{\lambda}$$

The rest of the equilibrium operates as in the benchmark model. I use the same calibration as in the benchmark model, so all the differences in the impulse-response functions are due to changes in the model features and not in the calibration.

Figure 13 shows the crisis episode for the benchmark model, the representative agent version, and the model with only heterogeneity in access to financial markets (only MPC, dotted line). The IRFs display amplification for non-tradable output, consumption and total output, while it shows a dampened response on impact for tradable output. In terms of cross-sectional variables, shown in Figure 14, inequality goes up on impact, while there is no differential consumption response across households in the tradable and non-tradable sectors. Including only heterogeneity in access to financial markets does not explain the differential response observed empirically across households in each sector.

Uninsurable sector-specific income. Now consider a version of the model in which households are now pooled by their sector of work instead. Since in both cases there is a subset with access to financial markets, each type of household now has access to them. There is a tradable sector household, of measure $\nu = s^{TR} + s^{TH}$, and a non-tradable sector household of measure $1 - \nu = s^{NR} + s^{NH}$. Both households have access to financial markets, but they do not have their income diversified.

Budget constraints for each household are given by:

$$P_t C_t^{hT} + S_t d_t^{hT} = W_t^T N_t^{hT} + \frac{\Pi_t^T}{\nu} + \frac{S_t d_{t+1}^{hT}}{(1 + r_t^{hT})}$$
$$P_t C_t^{hN} + S_t d_t^{hN} = W_t^N N_t^{hN} + \frac{\Pi_t^N}{1 - \nu} + \frac{S_t d_{t+1}^{hN}}{(1 + r_t^{hN})}$$

As before, the rest of the equilibrium operates as in the benchmark model. I use the same calibration as in the benchmark model, so all the differences in the impulse-response functions are due to changes in the model features and not in the calibration.

Figure 15 shows the crisis episode for the benchmark model, the representative household version, and the model with only uninsurable sector-specific income (only sector, dotted line). The IRFs now closely track the ones for the representative agent model, except for the case of tradable output. However, in terms of cross-sectional variables, displayed on Figure 16, both inequality and the tradable to non-tradable differential in consumption move in the same direction as in the benchmark model and as in the data. The consumption differential between households in different sectors is weaker than in the benchmark case.

Taking stock, both dimensions of heterogeneity I introduced play a role in driving the responses of the benchmark model compared to the representative household version. While access to financial market helps explain amplification in the non-tradable sector, uninsurable sector-specific income helps explain the response in tradable output and it generates variation in cross-sectional variables in line with the data. Ultimately, it is the interaction of both frictions what has the largest impact on macroeconomic dynamics.

5 The welfare costs of fear of floating

In this section I compute the welfare costs of monetary policy that features "fear of floating". In the previous section, when the fixed exchange rate was abandoned, the central bank exhibited no "fear of floating", i.e. there was no constraint on how much the nominal exchange rate could fluctuate. However, this is not always the case, particularly in emerging market economies. Calvo & Reinhart (2002) document that many emerging market central banks behave in this way. They announce a freely floating exchange rate, but then they intervene to limit those fluctuations. Deviations from freely floating exchange rates are more common in countries that have previously experienced a sudden stop event.

As explained in section 3.7, "fear of floating" shows up on the Taylor rule as the nominal interest rate sensitivity to changes in the nominal exchange rate:

$$(1+i_t) = (1+\bar{r})\left(\frac{P_t}{P_{t-1}}\right)^{\phi_\pi} \epsilon_t^{\phi_e} \exp\left\{\varepsilon_t^S\right\} \tag{40}$$

The coefficient ϕ_e in (40) represents the central bank's degree of "fear of floating". When $\phi_e = 0$ the central bank lets the currency float freely, while when $\phi_e \to \infty$ the central bank keeps the nominal exchange rate fixed.

In the representative household specification, there exists a floating exchange rate that replicates the flexible-price allocation, which is Pareto optimal in this case.[15] This is achieved by fluctuations in the nominal exchange rate that exactly compensate any inflation within the non-tradable sector. I will compute the welfare costs of different degrees of "fear of floating" (alternative values of ϕ_e) with respect to this rule.

Note that in section 3.7, I specified $\phi_e \geq 0$ to represent "fear of floating" policies, but this coefficient could actually be negative and represent what could be denominated "love of floating", in which the central bank reacts to a nominal depreciation by making it even larger. The only limit to the value of ϕ_e lies in the conditions for equilibrium determinacy given that the monetary authority follows a Taylor rule as (40).[16] Given the calibrated value for ϕ_π, I consider some negative values compatible with a locally determinate equilibrium, but I will still refer as policies with "fear of floating" to the set of policies with $\phi_e \neq 0$.

I follow Schmitt-Grohé & Uribe (2007) and define the conditional welfare cost of a Taylor rule with "fear of floating" as the proportional change in the stream of consumption under the flexible-price policy that makes households indifferent between an economy with "fear of floating" and one where the exchange rate floats enough to replicate the flexible-price allocation.[17] The conditional welfare cost $\lambda_m(x_0, \sigma_\epsilon)$ for household m is

[15] See Appendix C for the proof.

[16] Galí, López-Salido & Vallés (2004) study the design of interest rate rules in a closed economy New Keynesian model with hand-to-mouth consumers and find that the existence of a unique equilibrium is no longer guaranteed by the satisfaction of the Taylor principle. By definition, hand-to-mouth households do not respond directly to changes in the real interest rate, which makes the Taylor principle less effective. I leave the analysis of stability of the equilibrium in the benchmark model for future work.

[17] See Kim, Kim, Schaumburg & Sims (2003) for a discussion on conditional versus unconditional welfare costs. Unconditional welfare costs are easier to compute since they do not consider the costs during the

defined as:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left(\left(1+\frac{\lambda_m(x_0,\sigma_\epsilon)}{100}\right) C_t^m\right)^{1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{{N_t^m}^{1+\phi}}{1+\phi} \right\} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{{\hat{C}_t^m}^{1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{{\hat{N}_t^m}^{1+\phi}}{1+\phi} \right\} \tag{50}$$

where $\{C_t^m, N_t^m\}_{t=0}^{\infty}$ corresponds to the economy with a floating exchange rate that replicates the flexible price allocation and $\left\{\hat{C}_t^m, \hat{N}_t^m\right\}_{t=0}^{\infty}$ to the economy with "fear of floating", x_0 represent initial conditions, and σ_ϵ is a volatility scale parameter. A positive value of $\lambda_m(x_0, \sigma_\epsilon)$ indicates that household m is better off under the rule with "fear of floating", while a negative value indicates the household is better off under the rule that replicates the flexible-price allocation.

I approximate $\lambda_m(x_0, \sigma_\epsilon)$ by taking a second-order Taylor expansion around the deterministic steady state (which is common to both models). Appendix D provides the details of this approximation. To obtain an accurate measure of the welfare cost, it is necessary to approximate the equilibrium to an order higher than one. Up to first order, lifetime utility is equal to the lifetime utility in the deterministic steady state. Since the alternative monetary policies considered all imply the same steady state, a first order approximation would not pick up any difference across rules. I approximate the welfare functions to second-order degree by solving a second order approximation of the policy functions.

For the economy as a whole, I compute the cost of the alternative rule as the uniform percentage change in consumption households would require under the flexible-price policy for the economy to achieve the same lifetime utility as in the economy that displays "fear of floating", when aggregate welfare is utilitarian. The uniform conditional welfare cost $\lambda(x_0, \sigma_\epsilon)$ satisfies:

$$\begin{aligned} &\sum_m s^m \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left(\left(1+\frac{\lambda(x_0,\sigma_\epsilon)}{100}\right) C_t^m\right)^{1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{{N_t^m}^{1+\phi}}{1+\phi} \right\} \\ &= \sum_m s^m \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{{\hat{C}_t^m}^{1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{{\hat{N}_t^m}^{1+\phi}}{1+\phi} \right\} \end{aligned} \tag{51}$$

Figure 17 presents the uniform welfare cost (panel a) for the benchmark economy and for the representative household specification. In terms of the uniform welfare cost, both economies show a monotonically increasing welfare cost for values of $\phi_e \geq 0$. Reducing exchange rate fluctuations becomes more costly when households have limited access to

transition back to steady state, however, unconditional welfare costs can produce paradoxical results.

financial markets and do not share sectoral income. For the values plotted, the welfare cost in the representative household economy is on average -0.04%, while it is -0.36% in the benchmark economy. These numbers are smaller than those of Uribe & Schmitt-Grohé (2017) and Schmitt-Grohé & Uribe (2016), but are in line with other studies for small open economies such as Drenik (2015) and De Paoli (2009). The main driver of the relatively small welfare costs I find compared to Schmitt-Grohé & Uribe (2016) is the degree of persistency of shocks. In their model, for example, the interest rate process is highly persistent with a first-order auto-correlation coefficient of 0.95, while in mine this coefficient is of 0.76 (which is in line with the estimates of Durdu, Mendoza & Terrones (2009) for Mexico in a similar time period).[18] Panel (b) in Figure 17 presents the uniform conditional welfare cost for the specifications with only heterogeneity in access to financial markets and only uninsurable sector-specific income. Both frictions increase the cost of reducing exchange rate fluctuations in a similar amount on its own, but most of the welfare cost in the benchmark model is explained by the interaction of both types of heterogeneity.

The key for understanding the increase in welfare cost lies in the distribution of welfare costs across different types of households, as presented in Figure 18 for the benchmark model. In the representative household version, since there is complete income sharing, all that matters for household welfare is aggregate dynamics. In this case, a floating exchange rate is better since it is closer to the flexible-price allocation which is Pareto optimal. In the benchmark model, on the other hand, households care about their specific income dynamics, which might differ from the aggregate one. Since each type of household has an endogenous labor supply, the effect of different exchange rate regimes on both consumption and leisure will determine which alternative they prefer. As pointed out by Cho, Cooley & Kim (2015) and Lester, Pries & Sims (2014), volatility has two effects on welfare: the fluctuations effect, related to households preferring smooth paths of consumption and leisure, and the means effect, related to the possibility of adjusting endogenous choices in their favor. In the representative agent economy, the fluctuations effect dominates and floating exchange rates are better than managed ones. In fact, even some "love of floating" gets the economy closer to the flexible price allocation. In the benchmark model, on the other hand, the effect that dominates will depend on the effect that dominates for each household and the weight of each type of household in the economy (in terms of their measure and their marginal utility).

[18]As an experiment, I changed both auto-correlation coefficients in my model to the values used in Schmitt-Grohé & Uribe (2016), keeping the variance of shocks as is, and found that the cost of the fixed exchange rate regime increased from -0.07% to -1.56% in the representative agent model, and from -0.46% to -7.39% in the benchmark model. This highlights the role of persistent shocks in the welfare cost of exchange rate policy.

In particular, households in the tradable sector prefer a flexible exchange rate since it reduces consumption and leisure volatility. Hand-to-mouth households in the non-tradable sector also prefer flexible exchange rates, since their other margin of adjustment (labor supply) is constrained by the fall in demand in the non-tradable sector. Households in the non-tradable sector with access to financial markets, on the other hand, prefer some degree of intervention in the nominal exchange rate, since they have two margins they can adjust: their labor supply and how much they borrow.

The aggregate welfare cost balances costs and benefits for each type of household. In the present case, tradable households are poorer and have a larger marginal utility of consumption, so the aggregate welfare cost follows their position. However, in an economy in which non-tradable households have more weight on aggregate welfare, an exchange rate regime with some degree of "fear of floating" might be preferred, even if it makes the aggregate economy more volatile.

Notice that the flexible-price allocation does not necessarily maximize aggregate welfare. On the one hand, it is not clear how to define aggregate welfare, since households could be given different weights than what utilitarian aggregate welfare would imply. Some degrees of "fear of floating" could be optimal under different assumptions in relation to aggregate welfare. On the other hand, even under utilitarian welfare, the flexible price allocation does not provide consumption smoothing to hand-to-mouth households so it is not necessarily optimal as it is in the representative household case. I leave both of these topics (political economy analysis and optimal policy) for future work.

One of the reasons a government might be interested in limiting nominal exchange rate fluctuations is the degree of exchange rate pass-through to consumer prices. As Cravino & Levchenko (2017) show for the case of Mexico, exchange rate depreciations tend to be anti-poor since lower-income households consume more goods that have a higher degree of exchange rate pass-through. My baseline specification does not feature this channel, since all households face the same price for composite consumption. In my model, any difference in the welfare cost of exchange rate policies originates on differences in income dynamics across households.

6 Conclusion

In this paper I presented the implications of household heterogeneity for the transmission of aggregate shocks during an emerging market crisis. First, I empirically identified a dimension of microeconomic heterogeneity that is relevant during this type of episodes. Not only households have difficulties smoothing income shocks, but they also receive non-diversified income. Given the aggregate asymmetries across tradable and non-tradable sectors during sudden stop episodes, this household-level heterogeneity creates very different income dynamics at the microeconomic level. Based on this observation, I constructed a two-sector New Keynesian small open economy model with two dimensions of household heterogeneity: uninsurable sector-specific income and limited financial-market participation. The interaction of both types of heterogeneity drives aggregate responses and results in amplification of the effects of the sudden stop in terms of output and consumption. Under the specified heterogeneity, the effect of the shock is larger under a fixed nominal exchange rate since this increases the importance of aggregate demand for macroeconomic dynamics. Finally, I studied the welfare cost of monetary policy with different degrees of "fear of floating", i.e. the monetary authority limits exchange rate fluctuations even though a floating exchange rate was announced. Limiting exchange rate fluctuations becomes more costly when households are heterogeneous, but the distributional effects driving this result show that certain households would prefer fixed exchange rates, even if it means more volatile aggregate fluctuations.

From an empirical point of view, this paper sheds light on the effects of sudden stop crises on inequality. The distribution of households across sectors of work is a key factor to take into account when analyzing inequality since aggregate differences can translate into very different household-level income dynamics. For the case of Mexico, the crisis resulted in a decrease in income and consumption inequality since poor households were more exposed to the sector that was hit less severely. A more comprehensive examination of household behavior during other sudden stop events would extend the analysis I performed in this paper. The main challenge arises from availability of micro-data in the precise time period around the crisis. More recent sudden stop episodes might provide a good starting point now that household level data is more commonly available.

There are a number of directions in which the model could be extended. I kept the model simple in terms of the two dimensions of heterogeneity I introduced. By reducing the number of moving parts and complexities in the model, I was able to capture the main effects of household heterogeneity. However, both dimensions are worth exploring in more depth. For example, micro-founding the reason why households do not diversify their income would provide insight into other policy interventions that could reduce the aggregate effect of sudden stop episodes. Labor market frictions that limit mobility across sectors could be addressed, as well as how households choose their sector of work given high labor mobility costs. In terms of access to financial markets, endogeneizing the share of hand-to-mouth households, by including occasionally binding borrowing constraints, would be useful to study how deleveraging takes place during a sudden stop since this type of episode consists precisely in a reduction of aggregate borrowing.

The model also included only debt in foreign currency with no default possibilities, which overlooks the fact that depreciations can deteriorate the balance sheet of households and firms in the presence of currency mismatch. This deterioration counterbalances the aggregate demand stimulus provided by nominal exchange rate fluctuations. Balance-sheet composition and uninsurable sector-specific income are likely to magnify the differences across households in different sectors. Finally, uninsurable sector-specific income is likely to play a role in the determination of macro-prudential policy and the prevention of sudden stops. Diverging income dynamics across households can generate overborrowing that originates in heterogeneity in financing needs. I plan to address several of these topics in future work.

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Appendix

A Empirical analysis: data description, cleaning, and definitions

I perform my empirical analysis in section 2 using household-level data from Mexico's National Income and Expenditure Survey (ENIGH) conducted every two years by Mexico's National Statistics Institute INEGI. The survey is available and comparable since 1992. In each survey, an independent sample is drawn and this sample is representative at the national level, urban area, and rural area.

The survey design for each year is stratified, multistage and clustered. The sampling unit is given by a household, and all members of the household are interviewed. The data is provided with probability weights that represent the inverse of the selection probability for each household. Sample sizes are 10530 households for 1992, 12815 for 1994, 14042 for 1996, and 10952 for 1998.

The survey includes information on household characteristics (number of members, dwelling characteristics, real state property, etc), individual characteristics of every household member (sex, age, education, position at work, sector of work, etc), and information on household consumption (disaggregated in 14 groups and over 500 categories), household income (by household member, labor income from each job, and income from other sources such as businesses, transfers, capital income), as well as information on financial transactions (credits or debits to savings accounts, loans, credit cards, foreign currency, jewelry, bequests, real state, mortgages, bonds and stocks, and patents).

Sample selection. In my analysis I consider households that are headed by individuals aged 25-64. I drop from the sample households in extreme poverty, that is, if they had a total consumption expenditure smaller than one third of the 1992 poverty line expressed in 1994 pesos. I also drop from the sample households that have extreme values of their earnings (labor, self-employed, and business income). I drop the top and bottom 1% earners by municipality.

Construction of outcome variables and controls. I define three levels of education for the educational attainment variable. The category "primary education or less" refers to a household member that has no education, incomplete primary education, or complete primary education. "Secondary education" refers to a household member that has incomplete secondary education (middle school or high school equivalents) or complete high school education. It includes vocational education (as alternative to high school). Finally, "college or more" refers to a household member that has incomplete or complete college education or a post-graduate degree.

I compute household earnings as the sum of labor income from every household member from income categories P001 to P015 in 1994 ENIGH, and the equivalent categories in the surveys from 1992, 1996 and 1998. This includes all types of income related to labor activities. As an alternative measure of income, I consider labor earnings plus transfers from all sources as labor earnings plus income from categories P023 to P028 in 1994 ENIGH. These transfers include income from retirement funds, severance payments, government subsidies, transfers from households in the country, and transfers from households outside of Mexico (remittances). I compute net financial income as the sum of income from real state leasing, interest payments from bonds and stocks, loans to third parties, and savings accounts (P018 to P022).

I construct several measures of household consumption. In the baseline specification, I consider total monetary household consumption, which is defined as monetary expenditures in all consumption categories, including non-durable goods (food and beverages, apparel, cleaning supplies, health care, transportation and communication, education, recreation), durable goods (vehicles, other durable goods), and housing expenditures. For robustness I consider only non-durable consumption, only durable consumption, only non-durable consumption plus housing, and total consumption including transfers to other households. Given the detailed data available for consumption there are many other consumption measures that could be constructed. I compute per-capita household variables by dividing total household income and consumption by the number of household members.

The ENIGH survey includes a variable "rama" with each household member's 4-digit sector of work, according to the Mexican classification CMAP 1994 (ClasificaciÃşn Mexicana de Actividad y Productos, Censos EconÃşmicos 1994). This classification can be matched to NAICS and SITC-4 classifications. I use two alternative for defining the sector of work of each household member. In the baseline specification, I consider a traditional approach in which I define any industry in agriculture, mining, or manufacturing as a tradable industry and the rest of the industries as non-tradable. Alternatively, I use trade data on exports and imports by industry from Feenstra et al (2005)[19] to identify tradable industries. I consider as tradable those industries with a combined value of exports and imports of $300 million US dollars in 1994. Using this classification, 70% of industries that participated in world trade are considered as tradable.

In the baseline specification, I classify households according to their household head sector of work. Alternatively, I consider two measures of household sector of work for robustness. In one of them, I consider the sector of work of the maximum income earner in the household. In the majority of cases (74%), this member coincides with the household head. In the second alternative measure, I consider an income weighted household index that indicates the share of household income that originates in tradable industries.

I repeat the analysis from (1) for alternative definitions of the sector of work variable (in terms of household level and tradable industries), and for alternative definitions of household income and consumption. Results are similar to those in Table 1 and are available upon request.

B Measuring access to financial markets from survey data

The ENIGH survey includes three sections that I use to identify participation in formal financial markets: "capital expenditures", "capital income", and "income from rents". The first two refer to the same categories of financial transactions: savings accounts, loans, credit cards, foreign currency, jewelry, bequests, real state, mortgages, bonds and stocks, and patents. While the third section registers income from interest payments from savings, loans, bonds, and stocks perceived in the quarter of the interview.

[19]Feenstra, R., R. Lipsey, H. Deng, A. Ma, and H. Mo, "World Trade Flows: 1962-2000", NBER Working Paper 11040.

I define access to financial markets by either receiving interest payments from formal bank accounts, bonds or stocks; making or receiving payments from financial transactions such as deposits or withdrawals from a bank account; loans to and from third parties; mortgage payments and new mortgages; sale or purchase of bonds, and stocks; or purchase or sale of real state.

Some of these variables represent more informal savings/borrowing instruments, than the ones that might be affected by fluctuations in the international interest rate. Taking this into account, I consider a household participated in formal financial markets if it has non-zero expenditures in operations in savings accounts, loans, credit cards, real state investment, mortgages, bonds, stocks, and patents. In all cases I consider both debits (expenditures) and credits (income). Additionally, I also consider a household participated in formal financial markets if it has non-zero net financial income. For example, in the expenditure categories in the previous table, Q005, Q006, Q007, Q012, and Q013 are not considered as participation in formal financial markets.

Variables in "capital expenditures"

Code	**Description**	**Code**	**Description**
Q001	Saving accounts, new deposits	Q009	Real state (for living)
Q002	Loans to third parties	Q010	Mortgage repayment
Q003	Credit card payment	Q011	Others
Q004	Loan payment to employer or to third parties	Q012	Purchase of capital goods for production
Q005	Purchase of foreign currency, gold, jewelry	Q013	Negative balance in own business
Q006	Life insurance	Q014	Purchase of bonds and stocks
Q007	Bequests	Q015	Purchase of patents
Q008	Real state (investment, not for living)		

Under this definition, 58% of households are considered hand-to-mouth. 56% of households working in the non-tradable sector are constrained, while 62% of those working in the tradable sector are.

C Optimal exchange rate in the representative household economy

In this section I prove that the optimal policy in the representative household setup consists of replicating the flexible-price allocation and it features a floating exchange rate with complete stabilization of non-tradable inflation.

Claim 1: *The flexible-price allocation is Pareto optimal.*
Consider the setup with a representative household: there is a single household that pools income from all type of households and provides consumption insurance for them (they all get the same amount of consumption). The household chooses C_t, N_t^N N_t^T, and d_{t+1}. In the flexible-price equilibrium, $\theta = 0$, every firm in the intermediate non-tradable market sets the same price, since they can adjust it every single period. The measure of price dispersion $s_t = 1$ for all t so there is no inefficiency loss due to price dispersion.

Non-tradable output is given by:

$$Y_t^N = (1 - \nu) N_t^N \tag{52}$$

Every period firms in the non-tradable sector set their prices so that the final price of the non-tradable good is given by:

$$P_t^N = \frac{\mu}{1-\mu}(1-\tau)W_t^N \tag{53}$$

The rest of the equilibrium conditions are given by:

$$z_t^T(\nu N_t^T)^{\alpha_T} + \frac{d_{t+1}}{1+r_t} = C_t^T + d_t \tag{54}$$

$$W_t^T \frac{C_t^{-\sigma}}{P_t} = \kappa^T\ N_t^{T\,\phi} \tag{55}$$

$$W_t^N \frac{C_t^{-\sigma}}{P_t} = \kappa^N\ N_t^{N\,\phi} \tag{56}$$

$$C_t^{-\sigma} = \beta(1+r_t)\mathbb{E}_t\left\{C_{t+1}^{-\sigma}\frac{P_t/S_t}{P_{t+1}/S_{t+1}}\right\} \tag{57}$$

$$C_t = A(C_t^T, (1-\nu)N_t^N) \tag{58}$$

$$P_t = \frac{S_t}{A_1(C_t^T, (1-\nu)N_t^N)} \tag{59}$$

$$\frac{P_t^N}{S_t} = \frac{A_2(C_t^T, (1-\nu)N_t^N)}{A_1(C_t^T, (1-\nu)N_t^N)} \tag{60}$$

$$W_t^T = z^T\alpha_T(\nu N_t^T)^{\alpha_T-1} \tag{61}$$

The allocation that satisfies these conditions coincides with the solution to the planner's problem:

$$\max_{\{C_t^T, N_t^N, N_t^T, d_{t+1}\}} E_0\sum_{t=0}^{\infty}\beta^t\left(\frac{C_t^{\,1-\sigma}-1}{1-\sigma} - \nu\kappa^T\frac{N_t^{T\,1+\phi}}{1+\phi} - (1-\nu)\kappa^N\frac{N_t^{N\,1+\phi}}{1+\phi}\right)$$

$$\text{s.t. } z_t^T(\nu N_t^T)^{\alpha_T} + \frac{d_{t+1}}{1+r_t} = C_t^T + d_t$$

$$C_t = A(C_t^T, (1-\nu)N_t^N)$$

So the flexible-price equilibrium is Pareto optimal when there is a single household in the economy.

Claim 2: *A floating exchange rate that stabilizes non-tradable inflation replicates the flexible-price equilibrium.*

First, it is straightforward to show that for any value of θ, if $\pi_t^{NT} = 1$, the flexible-price allocation is obtained.

Now, to determine whether non-tradable inflation stabilization is attainable using the nominal exchange rate, consider the definition of π_t^{NT}:

$$\pi_t^{NT} = \frac{p_t^N}{p_{t-1}^N}\epsilon_t \tag{62}$$

where lower case variables are relative prices using tradable goods as numeraire. Then the exchange rate policy that stabilizes non-tradable inflation can be computed using the flexible-price allocation as:

$$\epsilon_t = \frac{p_{t-1}^N}{p_t^N} \tag{63}$$

Any shock that induces a fall in the relative price of non-tradable goods in the flexible-price equilibrium must be accompanied by an exchange rate depreciation in the economy with sticky prices, in order to achieve a similar change in relative prices.

D Conditional welfare cost

I follow Schmitt-Grohé & Uribe (2007) and define the conditional welfare cost of an alternative policy b as the proportional change in the stream of consumption under a reference policy a that makes households indifferent between an economy with policy b and the modified consumption stream under policy a. This welfare cost is computed conditional on an initial state of the economy (identical under both policies). See Kim et al. (2003) for a discussion on conditional versus unconditional welfare costs. Unconditional welfare costs are easier to compute since they do not consider the costs during the transition back to steady state, however, they can produce paradoxical results.

Given initial conditions x_0, the conditional welfare cost $\lambda_m(x_0, \sigma_\epsilon)$ for household m is defined as:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left(\left(1 + \frac{\lambda_m(x_0,\sigma_\epsilon)}{100}\right) C_t^m\right)^{1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{N_t^{m\,1+\phi}}{1+\phi} \right\} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\hat{C}_t^{m\,1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{\hat{N}_t^{m\,1+\phi}}{1+\phi} \right\}$$

where $\{C_t^m, N_t^m\}_{t=0}^{\infty}$ corresponds to the economy with policy a and $\left\{\hat{C}_t^m, \hat{N}_t^m\right\}_{t=0}^{\infty}$ to the economy with policy b. A positive value of $\lambda_m(x_0, \sigma_\epsilon)$ indicates that household m is better off under the alternative policy b, while a negative value indicates the household is better off under the reference rule a.

Let $v_t^{m,a} \equiv v_t^{m,a}(x_0, \sigma_\epsilon)$ denote welfare under policy a for household m, given initial conditions x_0 and volatility parameter σ_ϵ. Similarly, let $v_t^{m,b} \equiv v_t^{m,b}(x_0, \sigma_\epsilon)$ denote welfare under policy b for household m, given initial conditions $\hat{x}_0$ and volatility parameter σ_ϵ. For each policy, welfare can be written recursively as:

$$v_t^{m,a} = \frac{C_t^{m\,1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{N_t^{m\,1+\phi}}{1+\phi} + \beta \mathbb{E}_t v_{t+1}^{m,a}$$
$$v_t^{m,b} = \frac{\hat{C}_t^{m\,1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{\hat{N}_t^{m\,1+\phi}}{1+\phi} + \beta \mathbb{E}_t v_{t+1}^{m,b}$$

Similarly define the sub-welfare functions for consumption and hours under policy a as $v_t^{m,a,c} \equiv v_t^{m,a,c}(x_0, \sigma_\epsilon)$ and $v_t^{m,a,n} \equiv v_t^{m,a,n}(x_0, \sigma_\epsilon)$ respectively:

$$v_t^{m,a,c} = \frac{C_t^{m\,1-\sigma} - 1}{1-\sigma} + \beta \mathbb{E}_t v_{t+1}^{m,a,c}$$

$$v_t^{m,a,n} = \kappa^j \frac{N_t^{m\,1+\phi}}{1+\phi} + \beta \mathbb{E}_t v_{t+1}^{m,a,n}$$

Given the functional forms assumed, solving for the conditional welfare cost $\lambda_m(x_0, \sigma_\epsilon)$ results in:

$$\lambda_m(x_0, \sigma_\epsilon) = 100 \times \left[\left(\frac{\left[v^{m,b}(x_0, \sigma_\epsilon) + v^{m,a,n}(x_0, \sigma_\epsilon)\right](1-\sigma)(1-\beta)+1}{(1-\sigma)(1-\beta)v^{m,a,c}(x_0, \sigma_\epsilon)+1} \right)^{\frac{1}{1-\sigma}} - 1 \right]$$

I approximate $\lambda_m(x_0, \sigma_\epsilon)$ by taking a second-order Taylor expansion around the deterministic steady state $x_0 = x^{ss}$ and $\sigma_\epsilon = 0$:

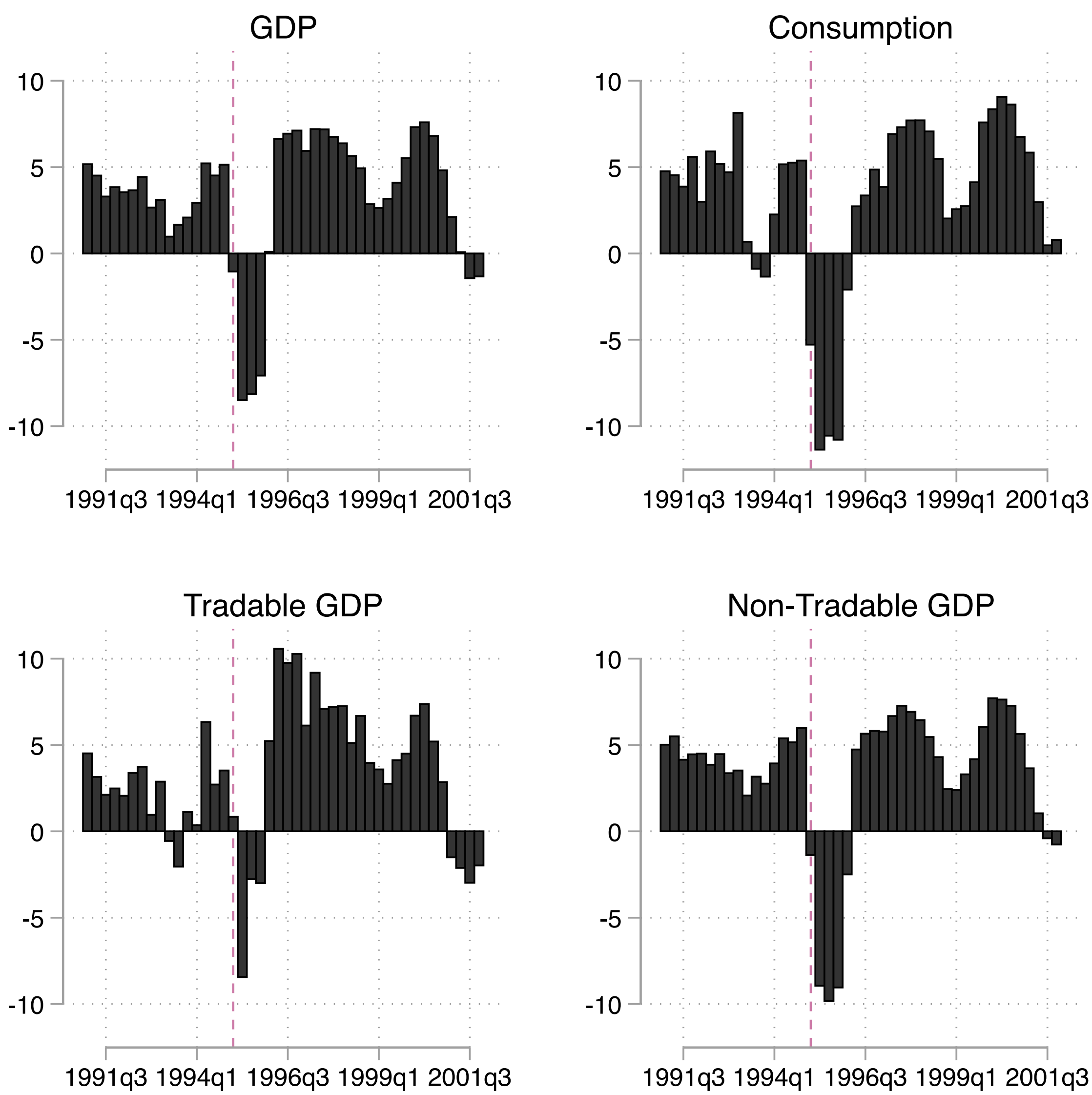
$$\lambda_m(x^{ss}, \sigma_\epsilon) = \left[\frac{v_{\sigma_\epsilon \sigma_\epsilon}^{m,b}(\hat{x}^{ss}, 0) + v_{\sigma_\epsilon \sigma_\epsilon}^{m,a,n}(x^{ss}, 0) - v_{\sigma_\epsilon \sigma_\epsilon}^{m,a,c}(x^{ss}, 0)}{v^{m,a,c}(x^{ss}, 0)(1-\sigma) + (1-\beta)^{-1}} \right] \frac{\sigma_\epsilon^2}{2} \times 100$$

The welfare cost is a now a function of derivatives of the value functions in each economy, $v_{\sigma_\epsilon \sigma_\epsilon}^{m,b}(\hat{x}^{ss}, 0)$, $v_{\sigma_\epsilon \sigma_\epsilon}^{m,a,n}(x^{ss}, 0)$ and $v_{\sigma_\epsilon \sigma_\epsilon}^{m,a,c}(x^{ss}, 0)$. To obtain an accurate measure of the welfare cost, it is necessary to approximate the equilibrium to an order higher than one. Up to first order, life-time utility is equal to the life-time utility in the deterministic steady state. Since the alternative monetary policies considered all imply the same steady state, a first order approximation would not pick up any difference across rules. I approximate the welfare functions to second-order degree by solving a second order approximation of the policy functions.

Tables and figures

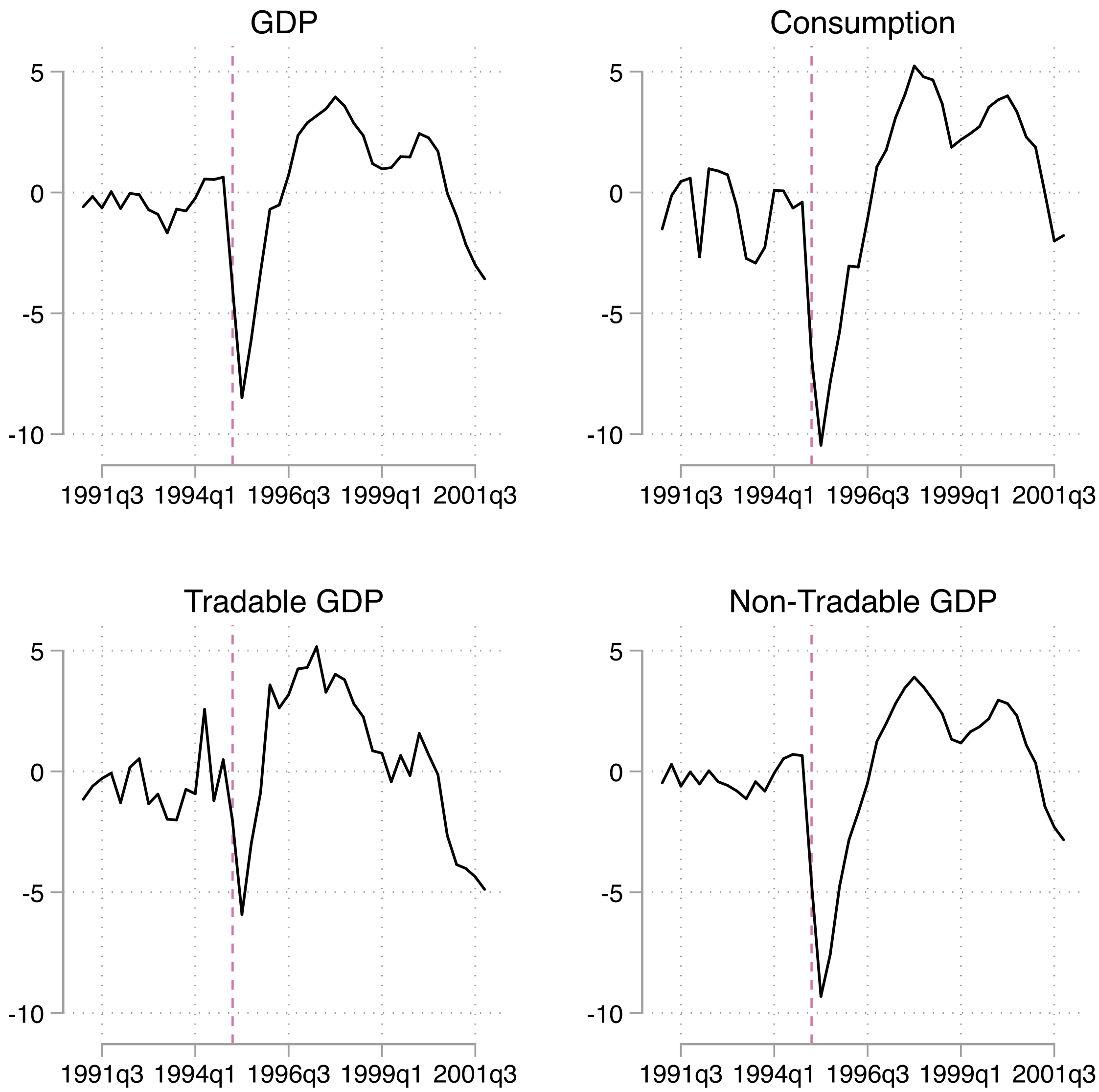
A Mexico's 1995 Tequila crisis

Figure 1: Mexico's 1995 sudden stop



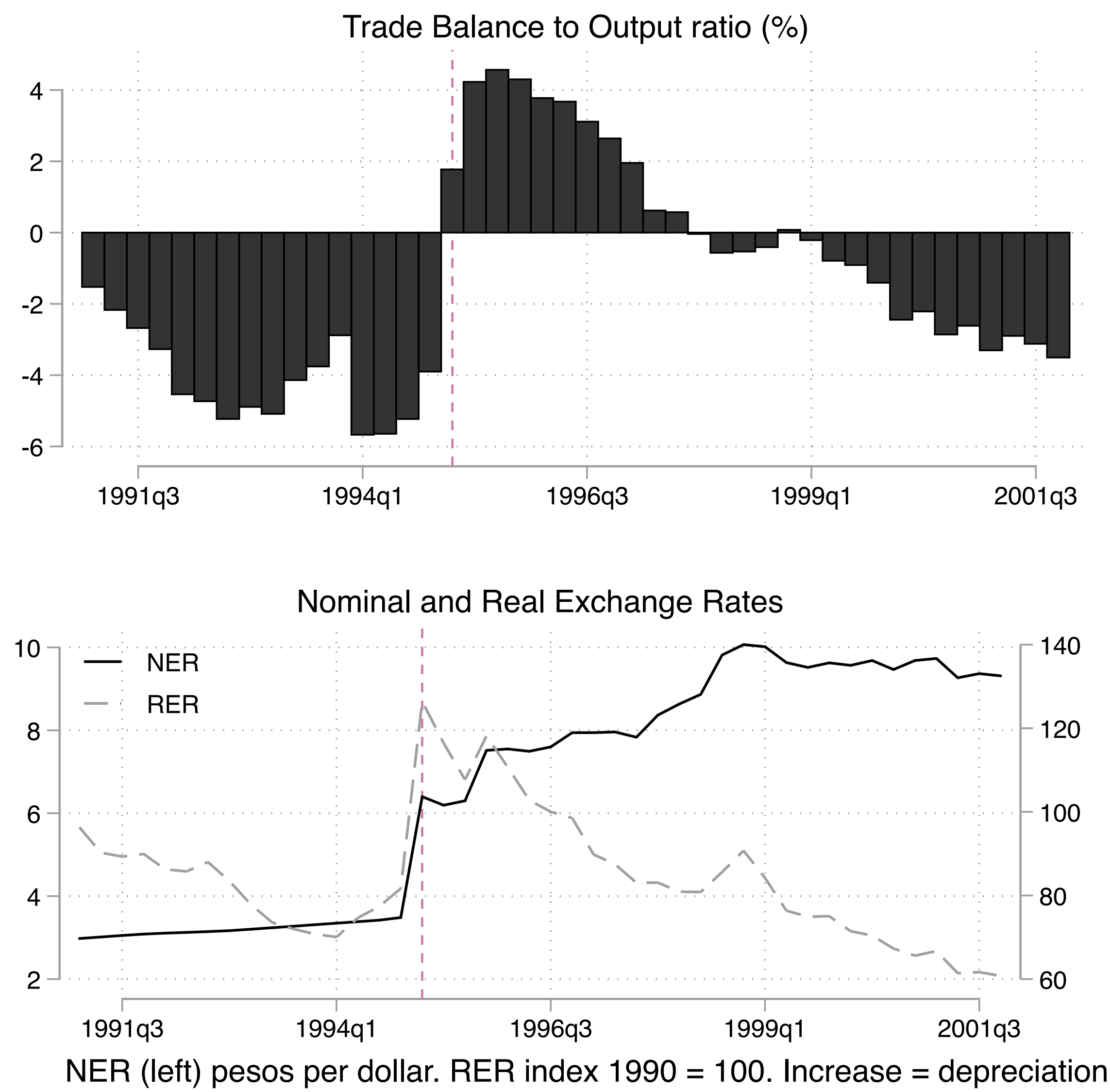
Notes: This figure presents Mexico's sudden stop in raw growth rates, as the percent change with respect to the same quarter of the previous year for GDP, Consumption (private), Tradable GDP, and Non-Tradable GDP. Data is quarterly national accounts from INEGI. Tradable GDP is real GDP from agriculture, mining, and manufacturing, while non-tradable GDP is real GDP from the rest of the sectors. All variables are in real terms. Dashed line on 1995:Q1.

Figure 2: Mexico's 1995 sudden stop in deviations from trend



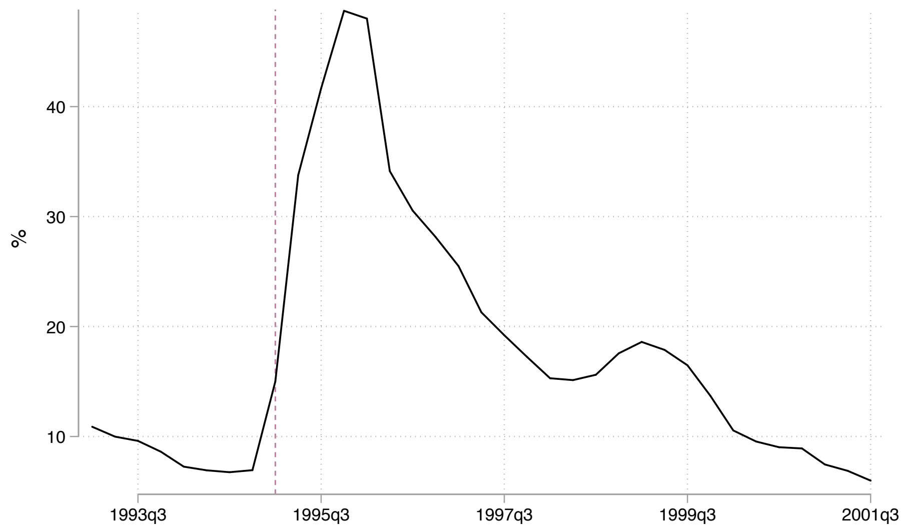
Notes: This figure presents Mexico's sudden stop in deviations from trend. The quarterly data was logged and detrended using a one-sided Hodrick-Prescott filter with smoothing parameter equal to 1600. Data is quarterly national accounts from INEGI. Tradable GDP is real GDP from agriculture, mining, and manufacturing, while non-tradable GDP is real GDP from the rest of the sectors. Dashed line on 1995:Q1.

Figure 3: Mexico's 1995 sudden stop: trade balance and exchange rate



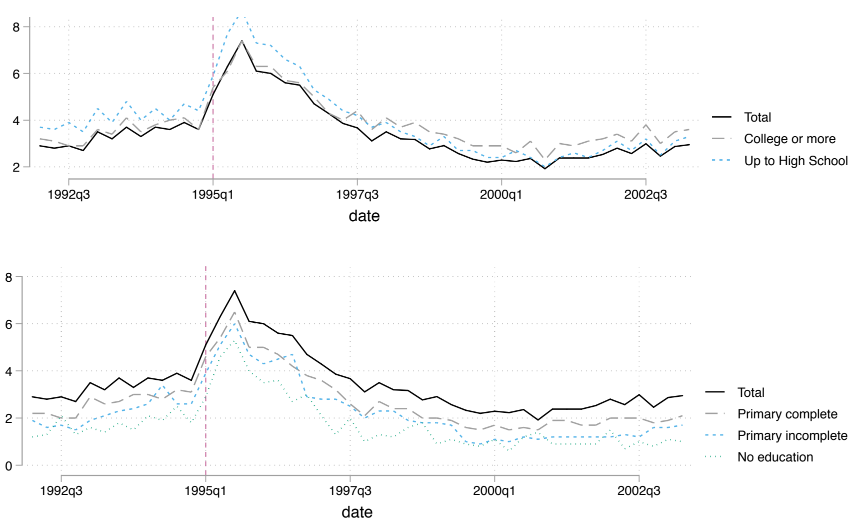
Notes: This figure presents the evolution of the trade balance to output ratio and both the nominal and real exchange rate for Mexico's 1995 crisis. The top panel presents the trade balance to output ratio computed from quarterly national accounts data from INEGI. The bottom panel presents quarterly nominal and real exchange rates from Banco de Mexico, the series are averages of monthly data during the quarter. The nominal exchange rate is in domestic currency (pesos) per U.S. dollar. The real exchange rate is an index against a basket of currencies, with base year equal to 1990. In both cases an increase represents a depreciation of the domestic currency. Dashed line on 1995:Q1.

Figure 4: Mexico's 1995 sudden stop: CPI inflation



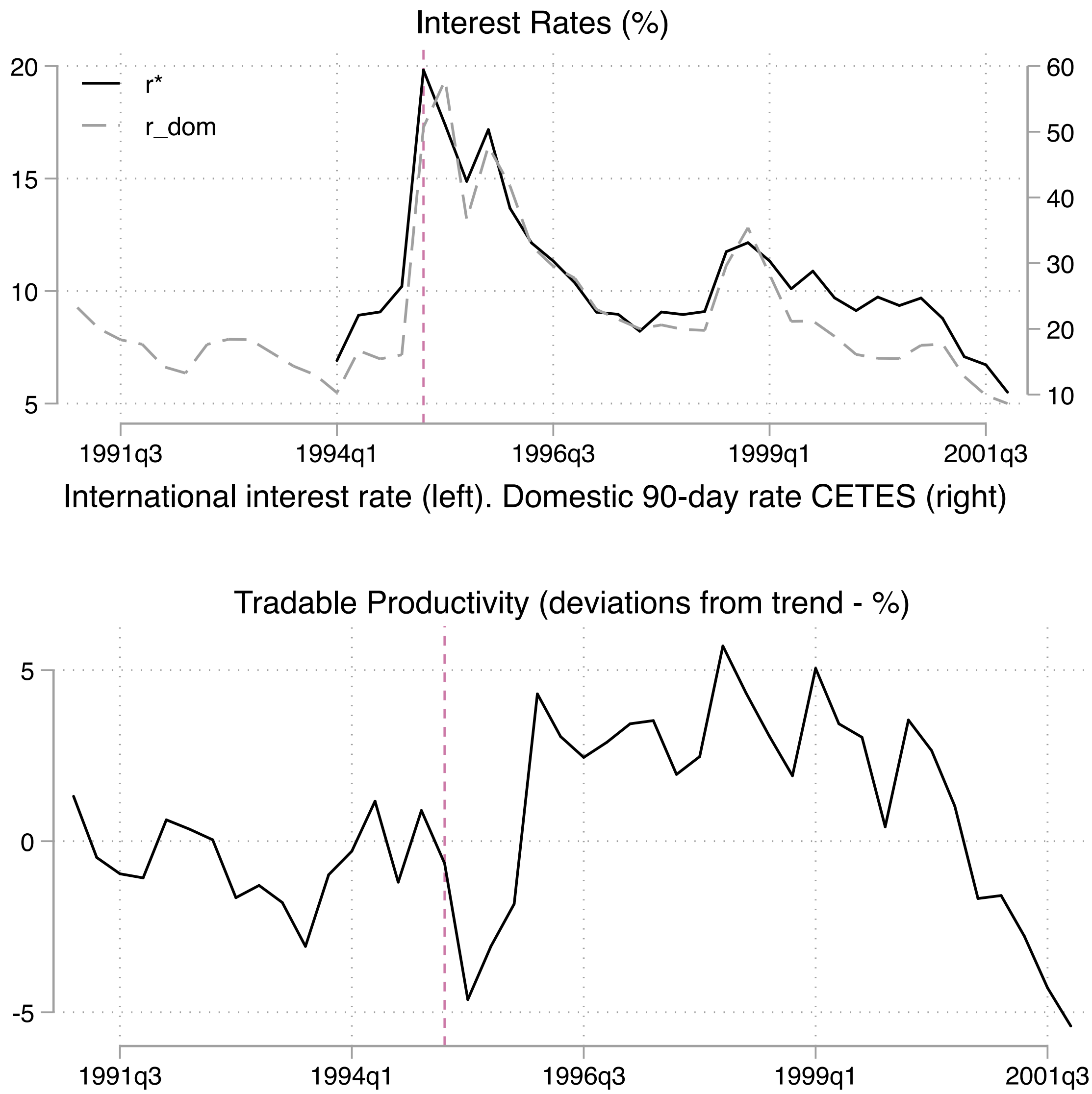
Notes: This figure presents Mexico's quarterly CPI inflation rate. Inflation rate is computed using the national consumer price index from INEGI, as the change in the CPI index with respect to the same quarter in the previous year. Dashed line on 1995:Q1.

Figure 5: Mexico's 1995 sudden stop: unemployment



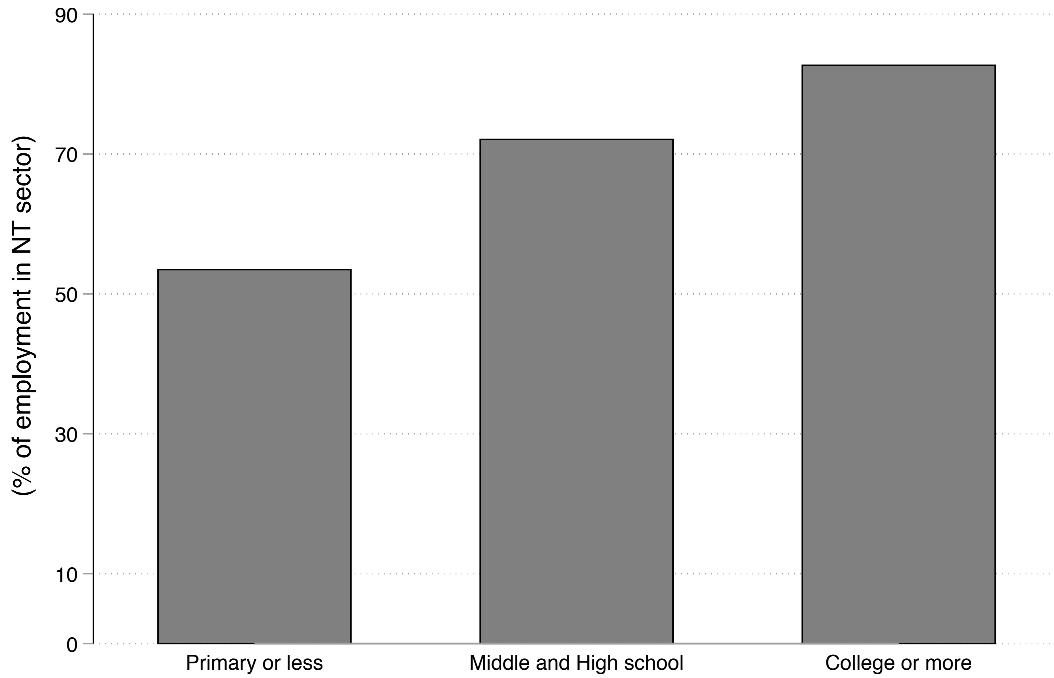
Notes: This figure presents Mexico's quarterly unemployment rate for the total population and by education level. Source: INEGI based on ENEU survey data. Dashed line on 1995:Q1.

Figure 6: Mexico's 1995 sudden stop: shocks related to the external sector



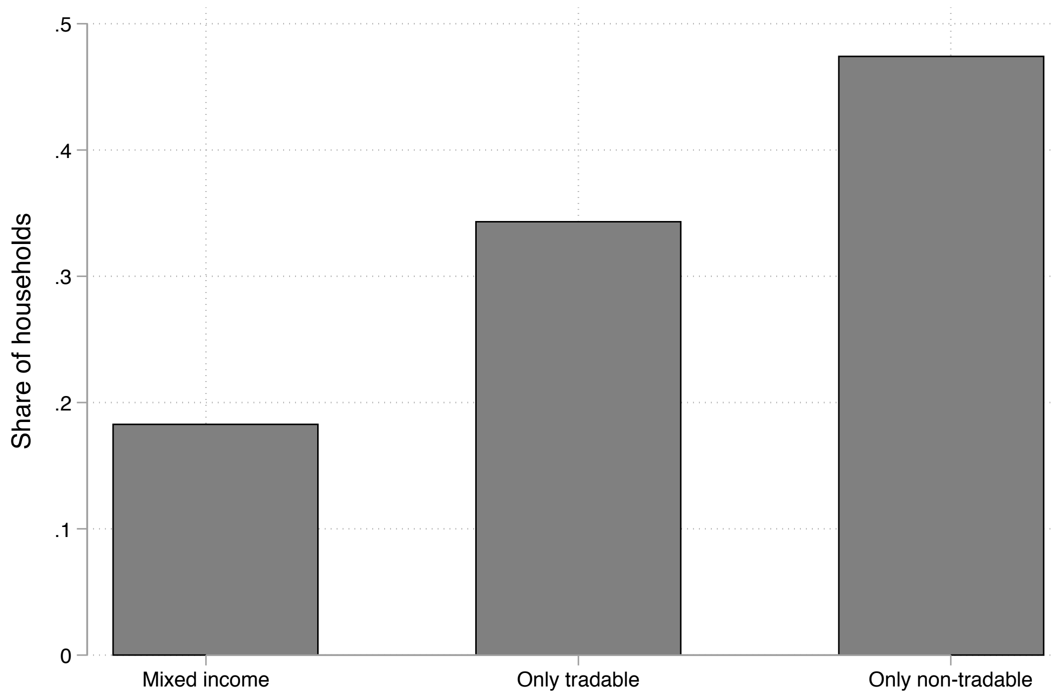
Notes: This figure presents the evolution of productivity in the tradable sector and of domestic and foreign interest rates for Mexico around the 1995 crisis. The top panel presents two interest rate series for Mexico. First, the international interest rate from Neumeyer & Perri (2005) computed as the 90-day U.S. T-bill rate plus the EMBI index for Mexico, adjusted by U.S. inflation. Second, the domestic interest rate for 90-day CETES (treasury bonds) from Banco de Mexico. The bottom panel presents the deviations from trend (in percentage) of tradable productivity. Tradable productivity is computed as value added per worker in the tradable sector (agriculture, mining and manufacturing) with quarterly data from INEGI. Then productivity is logged and detrended using a one-sided Hodrick-Prescott filter with smoothing parameter equal to 1600. Dashed line on 1995:Q1.

Figure 7: Sector of work specialization by education level, Mexico 1994



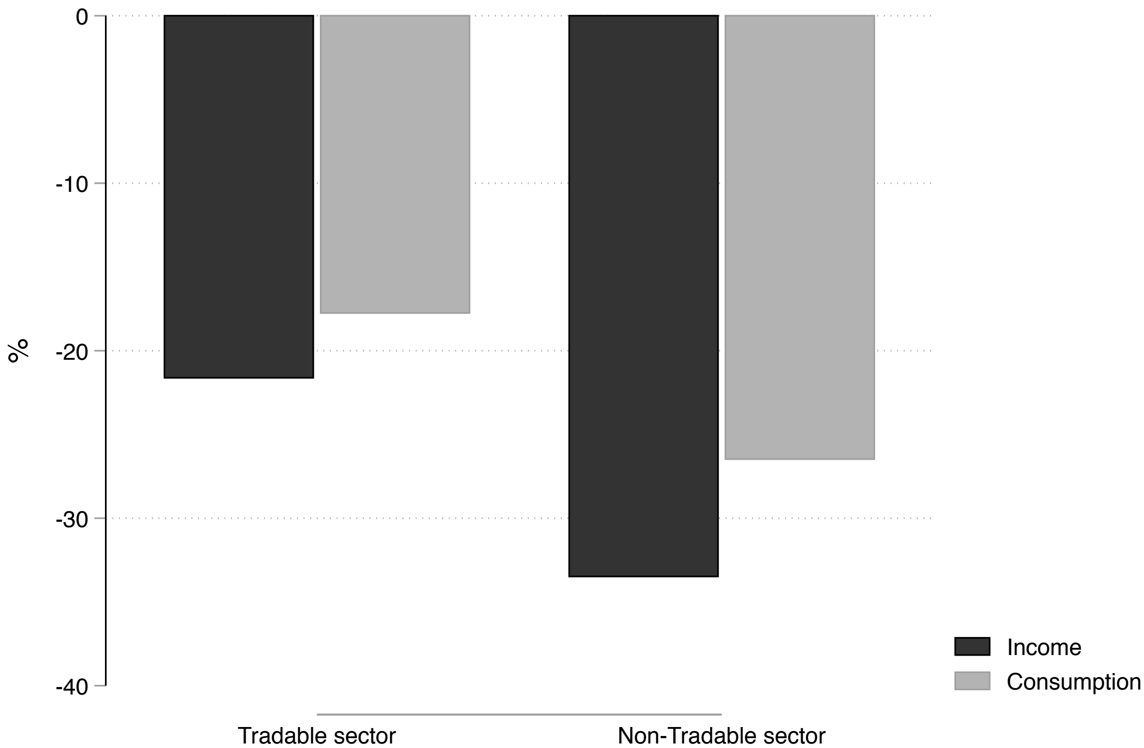
Notes: This figure presents the specialization structure by education level in Mexico, averages for 1992-1998. It shows the percentage of households in each education group with household heads working in the tradable sector (agriculture, mining and manufacturing). Own computations based on 1992-1998 ENIGH survey data from INEGI. Household heads aged 25-64.

Figure 8: Income diversification in Mexico 1994



Notes: This figure presents the income diversification structure of households in Mexico in 1994. It shows the percentage of households that receive income exclusively from the tradable sector (agriculture, mining and manufacturing), exclusively from the non-tradable sector, or a combination of both. Own computations based on 1994 ENIGH survey data from INEGI. Households with household heads aged 25-64.

Figure 9: Income and consumption losses during the Mexican 1995 crisis



Notes: This figure presents the income and consumption losses during Mexico's 1995 crisis. It shows the percentage change in average per capita household income and consumption between 1994 and 1996, for households grouped according to their household head's sector of work. The tradable sector includes agriculture, mining and manufacturing, while the remaining industries are considered non-tradable sector. Income includes labor and business income, but not income from financial sources, while consumption is total household consumption, including both durable and non-durable goods. Own computations based on 1994 and 1996 ENIGH survey data from INEGI. Households with household heads aged 25-64.

Table 1: Differential effect of the Mexican crisis

	Income 1994-96 (1)	Consumption 1994-96 (2)
NT × Post	-0.1361***	-0.0792***
	(0.0336)	(0.0284)
Primary education	0.0706	0.1123**
× Post	(0.0545)	(0.0504)
Secondary education	0.0238	0.0521
× Post	(0.0576)	(0.0541)
Government	0.0937*	0.0899*
× Post	(0.0514)	(0.0483)
Informal× Post	0.0095	0.0276
	(0.0335)	(0.0294)
Gender× Post	0.0434	-0.0011
	(0.0534)	(0.0401)
Post	-0.3325***	-0.3304***
	(0.0608)	(0.0576)
Controls	Yes	Yes
R^2	0.5430	0.5597
Observations	17813	17813

Notes: This table shows that households working in the non-tradable sector experienced a larger income and consumption loss during the Mexican 1995 crisis than those working in the tradable one. Columns (1) and (2) report regressions of the form:

$$\ln Y_{it} = \alpha + \beta \text{NT}_{it} + \gamma \text{Post}_t + \delta \text{NT}_{it} \times \text{Post}_t + \mu_1 \text{Controls}_{it} + \mu_2 \text{Controls}_{it} \times \text{Post}_t + \eta \text{Controls}_i^{FE} + \varepsilon_{it}$$

where the left-hand-side is the log-outcome for household i at period t. The outcome variable is per-capita househod income (1) and per-capita household consumption (2), deflated using the economy-wide CPI. Controls (interacted with Post_t) are given by: female-headed households, household head working in the informal sector, household head working for the government, education level (primary education or less, middle or high school, and college or more), and two age groups "young" (25-35 years old) and "old" (50-64 years old). Controls that proxy fixed effects (not interacted with Post_t) are included for households in rural areas, states in the border with the US, share of children under 12 years old in the household, and the household type (single, nuclear or extended). The "Post" coefficient represents the outcome change during the crisis for the base group given by college-educated male-headed nuclear households, with no children under 12 years old, working in the formal sector, living in an urban non-border state area, aged 35-50, working in the tradable sector. Robust standard errors in parentheses. Observations are weighted by their sample weight. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels respectively.

Table 2: Differential effect of the Mexican crisis - Disaggregated non-tradable sector

	Income 1994-96 (1)	Consumption 1994-96 (2)
NT×Post	-0.1299***	-0.0887***
	(0.0364)	(0.0311)
Construction × Post	-0.1548***	-0.0626
	(0.0499)	(0.0423)
Finance × Post	-0.1737**	-0.0579
	(0.0824)	(0.0726)
Post	-0.3302***	-0.3340***
	(0.0620)	(0.0592)
Controls	Yes	Yes
R^2	0.5445	0.5613
Observations	17813	17813

Notes: This table shows that within the non-tradable sector, households working in finance experienced a larger income loss during the Mexican 1995 crisis. Columns (1) and (2) report regressions of the form:

$$\ln Y_{it} = \alpha + \beta \text{NT}_{it} + \gamma \text{Post}_t + \delta \text{NT}_{it} \times \text{Post}_t + \mu_1 \text{Controls}_{it} + \mu_2 \text{Controls}_{it} \times \text{Post}_t + \eta \text{Controls}_i^{FE} + \varepsilon_{it}$$

where the left-hand-side is the log-outcome for household i at period t. The outcome variable is per-capita househod income (1) and per-capita household consumption (2), deflated using the economy-wide CPI. The NT sector of work is separated by subsectors: construction, government, rest of non-tradable. Controls (interacted with Post_t) are given by: female-headed households, household head working in the informal sector, household head working for the government, education level (primary education or less, middle or high school, and college or more), and two age groups "young" (25-35 years old) and "old" (50-64 years old). Controls that proxy fixed effects (not interacted with Post_t) are included for households in rural areas, states in the border with the US, share of children under 12 years old in the household, and the household type (single, nuclear or extended). The "Post" coefficient represents the outcome change during the crisis for the base group given by college-educated male-headed nuclear households, with no children under 12 years old, working in the formal sector, living in an urban non-border state area, aged 35-50, working in the tradable sector. Robust standard errors in parentheses. Observations are weighted by their sample weight. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels respectively.

Table 3: Differential effect of the Mexican crisis - Disaggregated tradable sector

	Income 1994-96 (1)	Consumption 1994-96 (2)
Agriculture	0.1611***	0.0823**
× Post	(0.0443)	(0.0370)
Manufacturing	0.0949**	0.0670*
× Post	(0.0419)	(0.0377)
Mining	0.1578	0.1165
× Post	(0.1642)	(0.1388)
Post	-0.4662***	-0.3646***
	(0.0581)	(0.0546)
Controls	Yes	Yes
R^2	0.5558	0.5495
Observations	17813	17813

Notes: This table shows that households households working in agriculture and manufacturing related tradable industries performed better during the crisis than those in the non-tradable sector. Note that the regressions Columns (1) and (2) report regressions of the form:

$$\ln Y_{it} = \alpha + \beta \mathrm{T}_{it} + \gamma \mathrm{Post}_t + \delta \mathrm{T}_{it} \times \mathrm{Post}_t + \mu_1 \mathrm{Controls}_{it} + \mu_2 \mathrm{Controls}_{it} \times \mathrm{Post}_t + \eta \mathrm{Controls}_i^{FE} + \varepsilon_{it}$$

where the left-hand-side is the log-outcome for household i at period t. The outcome variable is per-capita househod income (1) and per-capita household consumption (2), deflated using the economy-wide CPI. The T sector of work is separated by subsectors: agriculture, mining, and manufacturing. Controls (interacted with Post_t) are given by: female-headed households, household head working in the informal sector, household head working for the government, education level (primary education or less, middle or high school, and college or more), and two age groups "young" (25-35 years old) and "old" (50-64 years old). Controls that proxy fixed effects (not interacted with Post_t) are included for households in rural areas, states in the border with the US, share of children under 12 years old in the household, and the household type (single, nuclear or extended). The "Post" coefficient represents the outcome change during the crisis for the base group given by college-educated male-headed nuclear households, with no children under 12 years old, working in the formal sector, living in an urban non-border state area, aged 35-50, working in the non-tradable sector. Robust standard errors in parentheses. Observations are weighted by their sample weight. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels respectively.

Table 4: Pre- and post-crisis differential effects

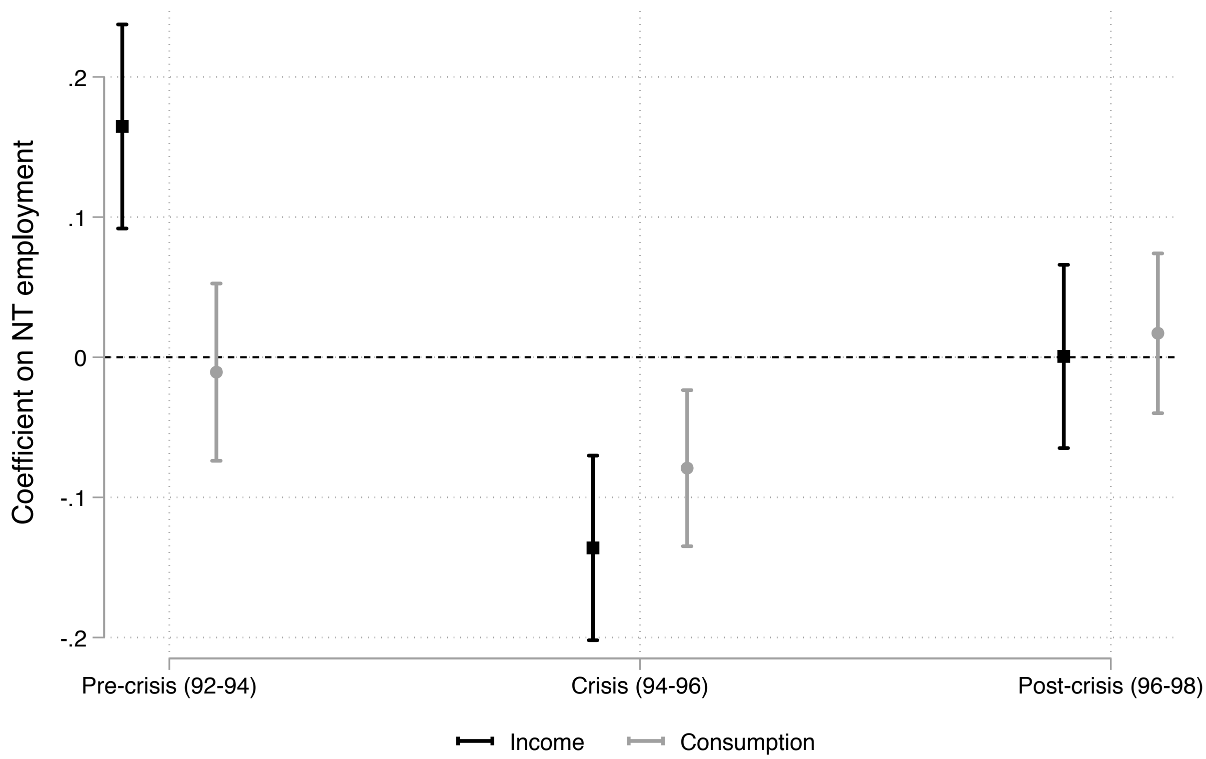
	1992-94		1996-98	
	Income	Consumption	Income	Consumption
	(1)	(2)	(3)	(4)
NT × Post	0.1647***	0.0006	-0.0107	0.0171
	(0.0371)	(0.0334)	(0.0323)	(0.0291)
Primary education	-0.0457	0.0156	-0.0184	-0.0324
× Post	(0.0597)	(0.0535)	(0.0571)	(0.0475)
Secondary education	-0.0135	-0.0151	-0.0365	-0.0386
× Post	(0.0651)	(0.0529)	(0.0614)	(0.0469)
Government	-0.0173	-0.0086	-0.0307	-0.0153
× Post	(0.0563)	(0.0449)	(0.0539)	(0.0406)
Informal× Post	-0.1289***	0.0049	-0.0074	0.0112
	(0.0381)	(0.0329)	(0.0338)	(0.0289)
Gender× Post	-0.0826	-0.0215	-0.0438	-0.0001
	(0.0599)	(0.0490)	(0.0511)	(0.0450)
Post	-0.0016	0.0882	0.0008	0.0511
	(0.0658)	(0.0568)	(0.0629)	(0.0523)
Controls	Yes	Yes	Yes	Yes
R^2	0.5279	0.5241	0.5580	0.5345
Observations	15215	16455	15215	16455

Notes: This table shows that there was no differential consumption change between households in the tradable and the non-tradable sector before or after the crisis, while in terms of income non-tradable households had an advantage before the crisis. Columns (1) to (4) report regressions of the form:

$$\ln Y_{it} = \alpha + \beta \text{NT}_{it} + \gamma \text{Post}_t + \delta \text{NT}_{it} \times \text{Post}_t + \mu_1 \text{Controls}_{it} + \mu_2 \text{Controls}_{it} \times \text{Post}_t + \eta \text{Controls}_i^{FE} + \varepsilon_{it}$$

where the left-hand-side is the log-outcome for household i at period t. The outcome variable is per-capita househod income (1) and per-capita household consumption (2), deflated using the economy-wide CPI. Controls (interacted with Post_t) are given by: female-headed households, household head working in the informal sector, household head working for the government, education level (primary education or less, middle or high school, and college or more), and two age groups "young" (25-35 years old) and "old" (50-64 years old). Controls that proxy fixed effects (not interacted with Post_t) are included for households in rural areas, states in the border with the US, share of children under 12 years old in the household, and the household type (single, nuclear or extended). The "Post" coefficient represents the outcome change during the crisis for the base group given by college-educated male-headed nuclear households, with no children under 12 years old, working in the formal sector, living in an urban non-border state area, aged 35-50, working in the tradable sector. Robust standard errors in parentheses. Observations are weighted by their sample weight. *, **, and *** indicate significance at the 0.1, 0.05, and 0.01 levels respectively.

Figure 10: Differential effect of employment in the non-tradable sector



Notes: This figure presents the coefficient on non-tradable employment for the crisis, pre- and post-crisis periods. It represents the coefficient on $NT_{it} \times Post_t$ on a regression of the type:

$$\ln Y_{it} = \alpha + \beta \text{NT}_{it} + \gamma \text{Post}_t + \delta \text{NT}_{it} \times \text{Post}_t + \mu_1 \text{Controls}_{it} + \mu_2 \text{Controls}_{it} \times \text{Post}_t + \eta \text{Controls}_i^{FE} + \varepsilon_{it}$$

for outcomes per-capita household income and per-capita household consumption. Vertical lines represent the 95% confidence interval around the estimated coefficient. Details of the estimation results are in Tables 1 and 4.

B A New Keynesian small open economy model with household heterogeneity

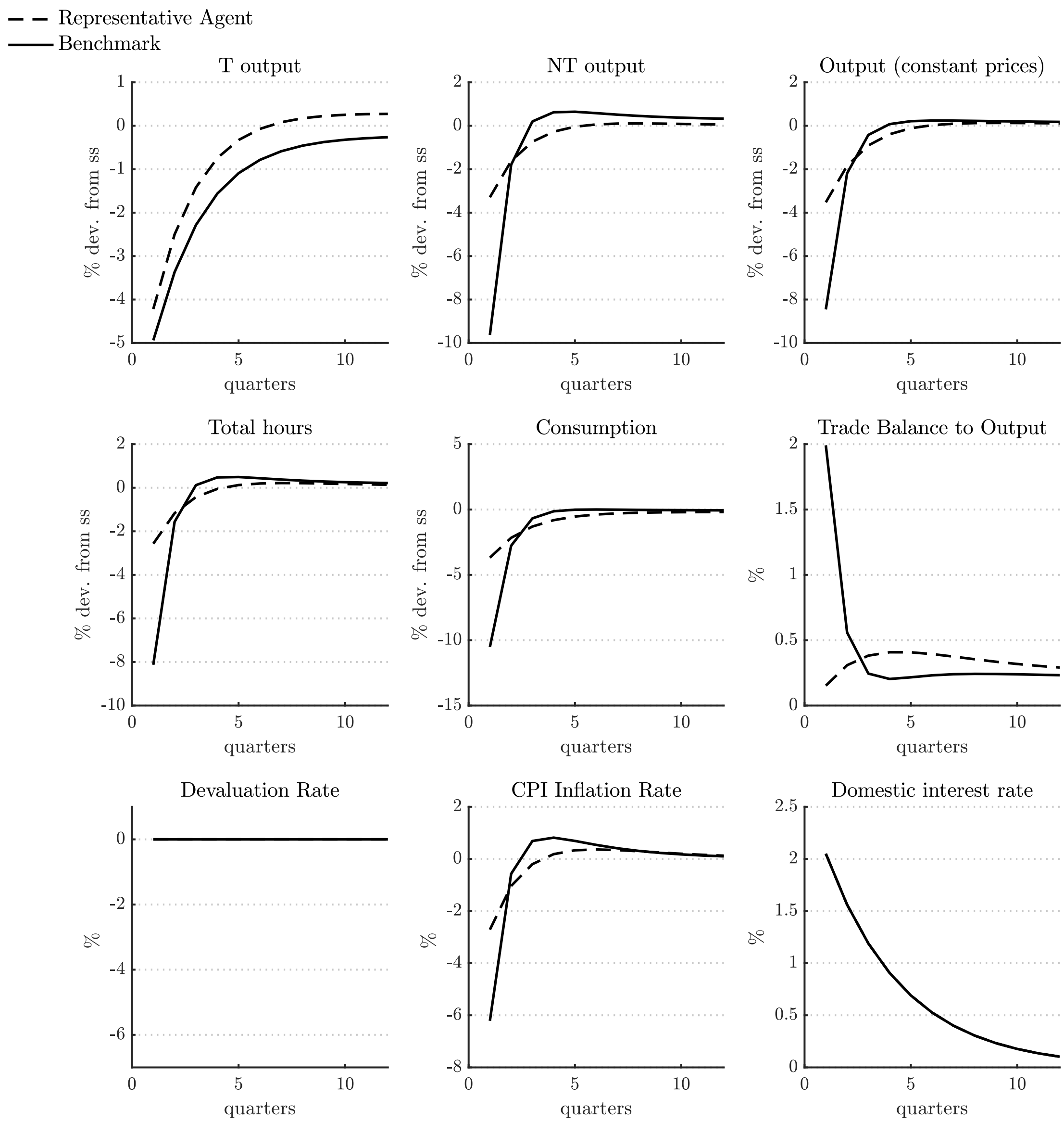
Table 5: Calibration

Parameter	Value	Meaning
σ	2	Inverse of IES - Mendoza (2002), Schmitt-Grohé & Uribe (2016)
η	$1/2$	T/NT elasticity of substitution.
ω	0.26	Weight of T goods in CES aggregator, to match $y^T/y = 0.25$
β	0.9758	Discount factor - Mexican quarterly $\bar{r} = 2.5\%$ (1994-2001).
κ^j		Scale parameter. Match time spent working in steady state and by sector. $H^T + H^N = 1/3$ and $H^T/H^N = 0.1733$
ϕ	2.9	Inverse of Frisch elasticity of labor. See section 3.10.
$\bar{d}$	1.20	Steady state level of debt. Match avg NFA/GDP of -36%.
ψ	0.0006	Interest rate elasticity to debt. Match std dev of TB/GDP ratio of 2.89%.
θ	0.7	Calvo probability of not changing prices. Gagnon (2009) for Mexico.
μ	6	Elasticity of substitution of NT varieties. 20% markup.
α_T	0.52	Labor share in T sector. Meza & Urrutia (2011) for Mexico.
s^{TR}	0.14	Unconstrained households in the tradable sector.
s^{TH}	0.23	Hand-to-mouth households in the tradable sector.
s^{NR}	0.28	Unconstrained households in the non-tradable sector.
s^{NH}	0.35	Hand-to-mouth households in the non-tradable sector.
τ^T	0.44	To match distribution of self-employment and business income in tradable sector.
τ^N	0.38	To match distribution of self-employment and business income in non-tradable sector.
ρ_{z^T}	0.65	First order auto-correlation parameter, tradable productivity shock.
$\sigma_{\epsilon_{z^T}}$	0.019	Standard deviation of productivity shock in T sector.
ρ_{r^*}	0.76	First order auto-correlation parameter, international interest rate.
$\sigma_{\epsilon_{r^*}}$	0.005	Standard deviation of the international interest rate shock.
ϕ_π	1.5	Inflation coefficient in Taylor rule.
σ_{ϵ_S}	0.008	Standard deviation of monetary policy shock, Best (2013).

Notes: This table summarizes the calibration of the model in section 3. It indicates each parameter, the calibrated value, and a brief description of the parameter, the calibrating target or source.

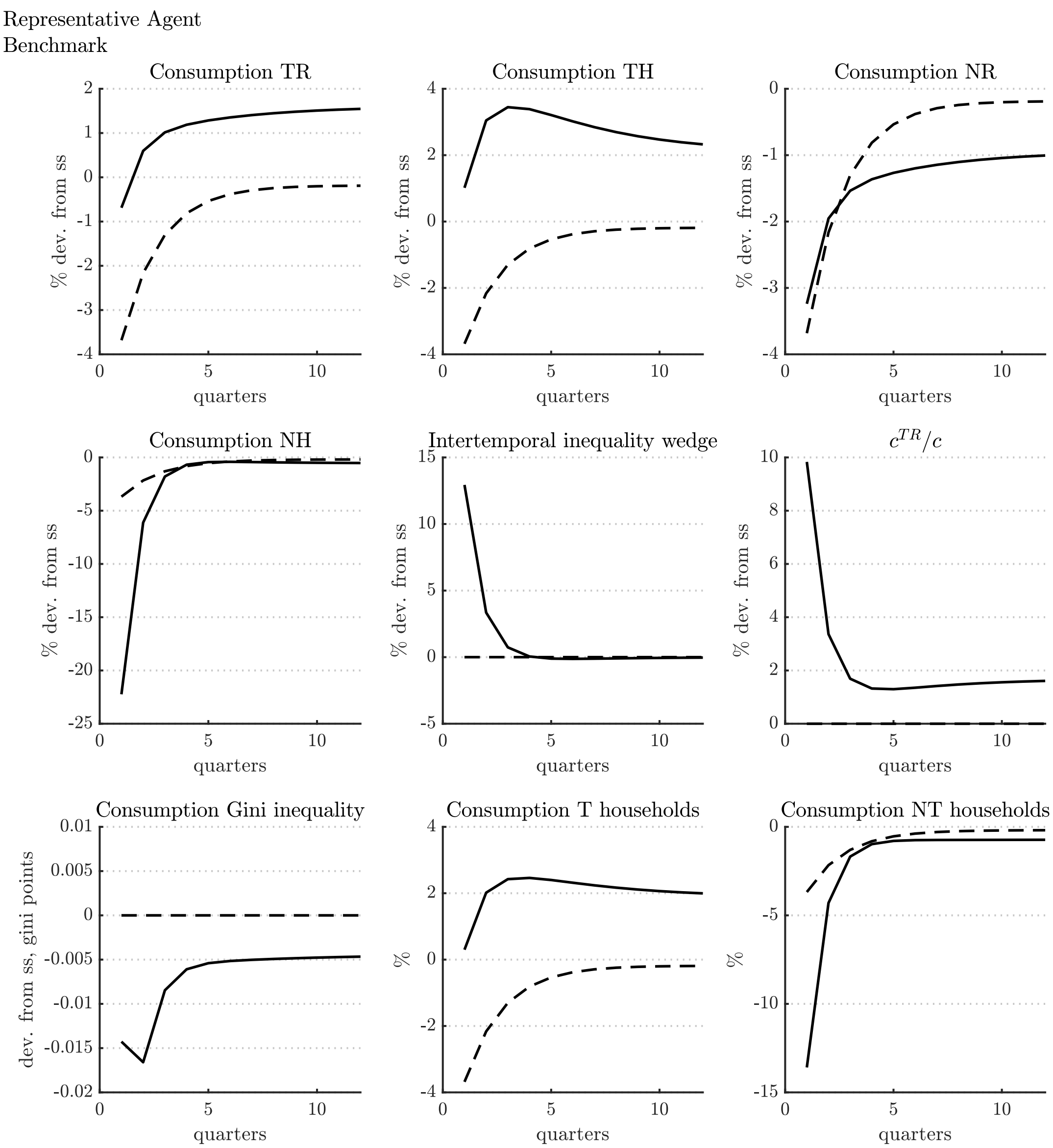
C Sudden stop crises with and without heterogeneity

Figure 11: Crisis episode: aggregate variables.



Notes: This figure presents the Impulse Response Functions for aggregate variables during a crisis episode for the benchmark model with heterogeneity and for the representative agent setup. The crisis episode consists on an unexpected increase of the international interest rate of 200 basis point and a tradable TFP shock of 500 basis points. The economy operates under a fixed exchange rate.

Figure 12: Crisis episode: cross-sectional variables.



Notes: This figure presents the Impulse Response Functions for cross-sectional variables during a crisis episode for the benchmark model with heterogeneity and for the representative agent setup. The crisis episode consists on an unexpected increase of the international interest rate of 200 basis point and a tradable TFP shock of 500 basis points. The economy operates under a fixed exchange rate. It presents the consumption IRF for each type of household: T/N refers to the sector of work of the household, while R/H refers to access to financial markets or hand-to-mouth. For example, TR refers to the household that works in the tradable sector and has unconstrained access to financial markets. The "intertemporal inequality wedge" refers to the term in equation (45), while "consumption T (NT) households" refers to the IRF of consumption of all types of households in the tradable (non-tradable) sector.

Table 6: Short-run Welfare Cost of a Sudden Stop

(a)

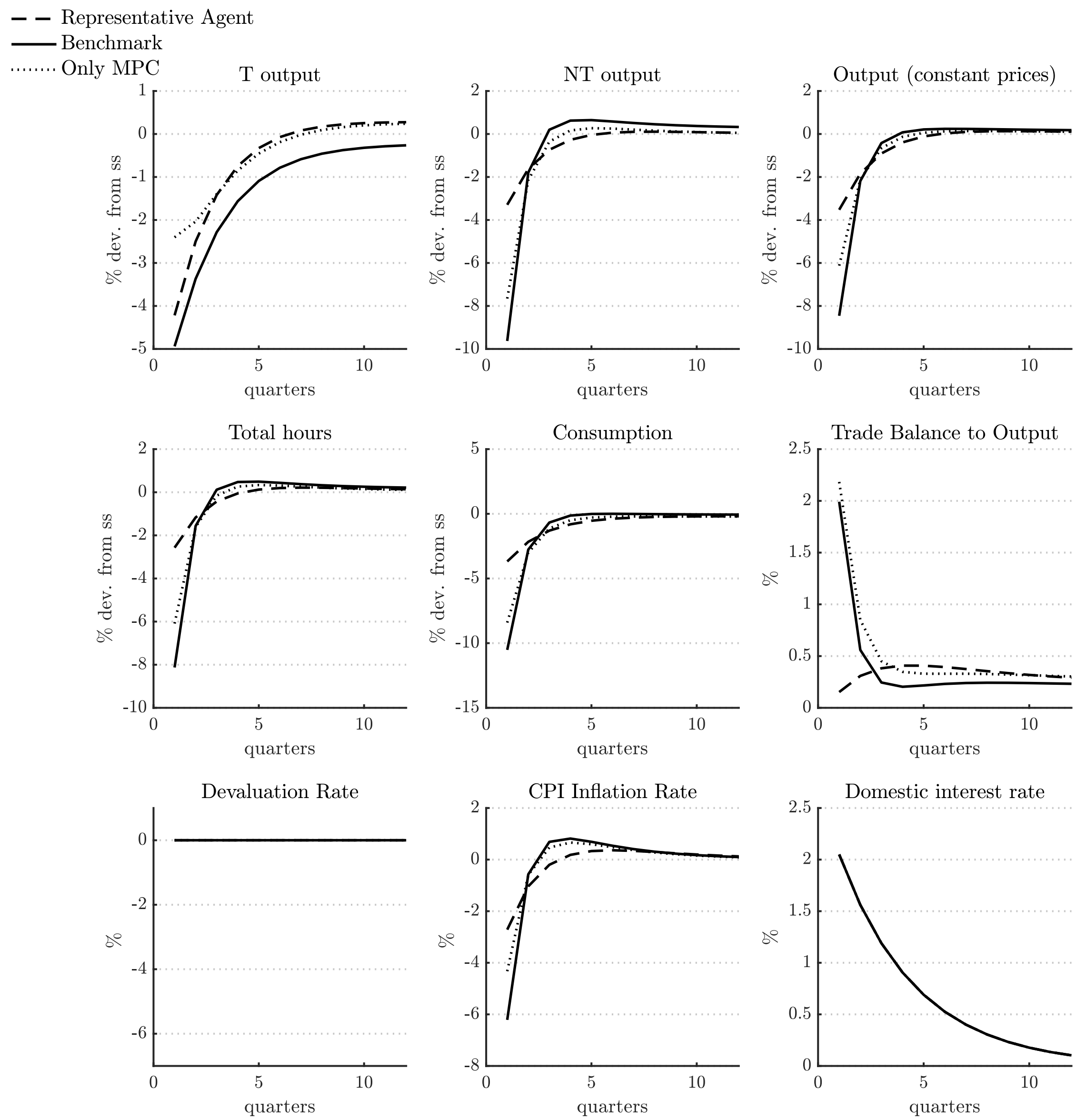
	Welfare cost ΔC		
Model	**Sudden stop**	**Switch ER**	**Floating ER**
Benchmark	-17.05%	-16.32%	-9.56%
Representative agent	-9.66%	-9.54%	-9.18%

(b)

	Welfare cost ΔC		
Household	**Sudden stop**	**Switch ER**	**Floating ER**
T, unconstrained	4.64%	5.64%	12.08%
T, hand-to-mouth	33.06%	34.44%	42.67%
NT, unconstrained	6.32%	5.64%	-16.64%
NT, hand-to-mouth	-56.58%	-52.00%	-26.7%

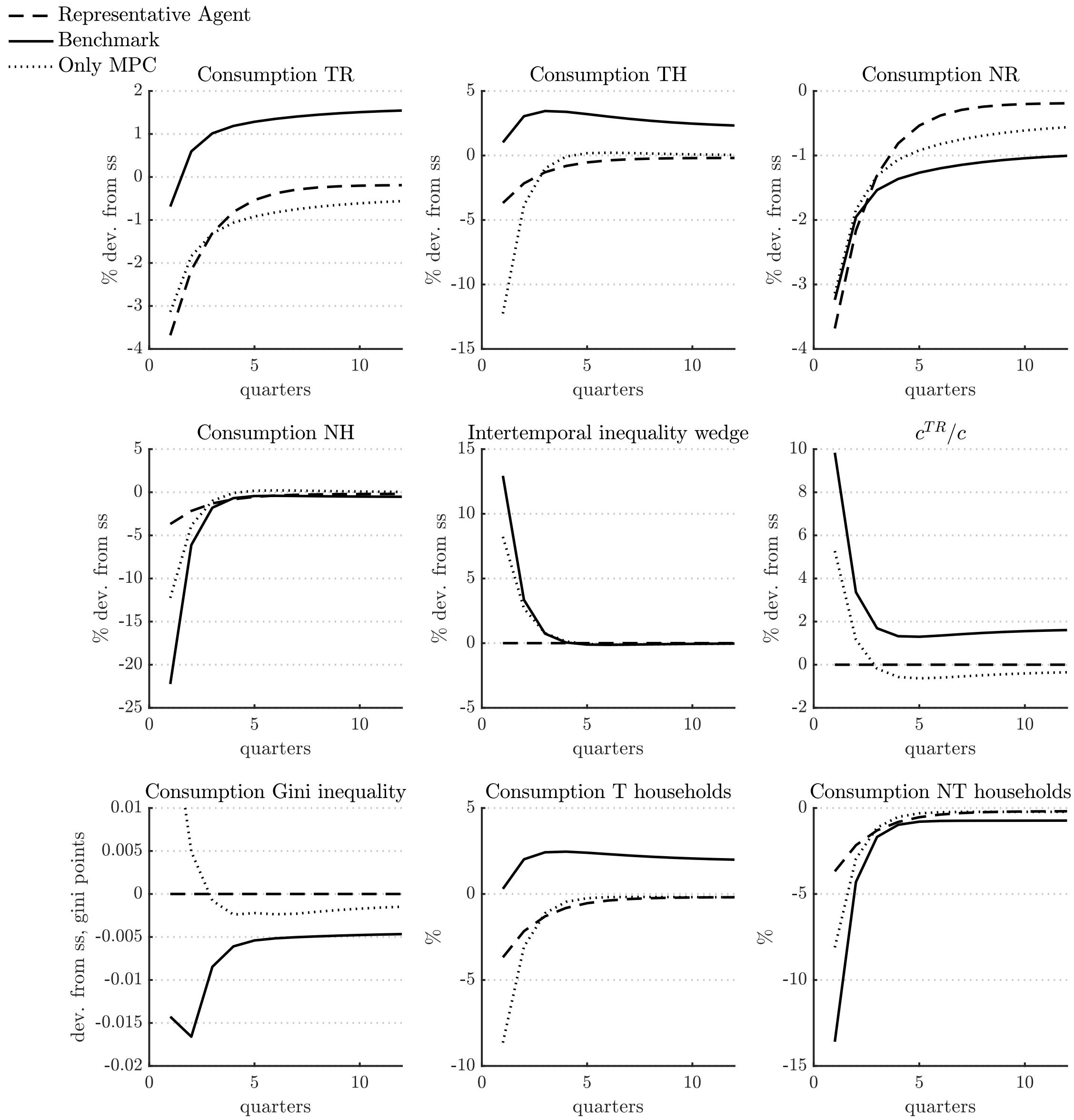
Notes: This table presents the short-run welfare cost of the sudden stop crisis episode analyzed in section 4.1. ΔC is the percentage of aggregate steady state consumption the economy is willing to give up in order to avoid the crisis. Panel (a) presents the aggregate costs, while panel (b) presents the distribution of costs across households. For each type of household, I compute the change in the discounted present value of utility with respect to steady state lifetime utility, and then use the marginal utility of consumption in steady state to translate it to consumption units: $\Delta C^m = \frac{W^m_{crisis} - W^m_{ss}}{\lambda^m_{ss} c^m_{ss}}$. To aggregate them, I weight each type of household by their consumption share in steady state: $s^{TR}C^{TR}/C = 0.1039$, $s^{TH}C^{TH}/C = 0.1415$, $s^{NR}C^{NR}/C = 0.3257$, $s^{NH}C^{NH}/C = 0.4289$ .The benchmark model has heterogeneity in both access to financial markets and uninsurable sector-specific income, while the representative agent set up considers a single household pooling all types of workers and resources. In the first column the exchange rate remains fixed throughout the episode, while in the second one it switches from a fixed exchange rate to a flexible one and in the third ones it is always flexible.

Figure 13: Crisis episode: aggregate variables. Role of access to financial markets.



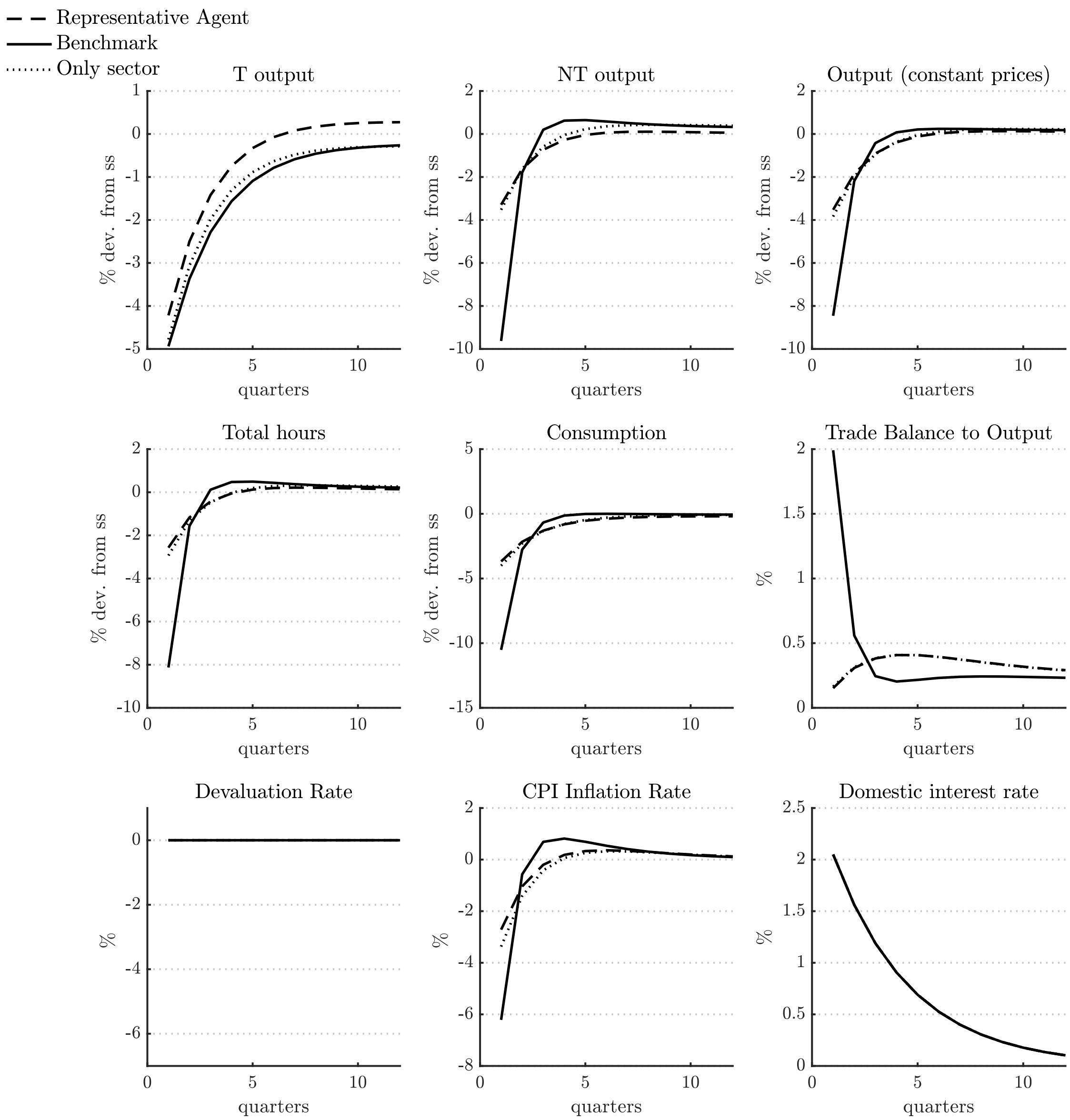
Notes: This figure reproduces the Impulse Response Functions from Figure 11 and adds the IRFs for the model with heterogeneity in access to financial markets but not in income sources (only MPC). There are two types of households, one with access to financial markets and one without, but both have workers in both sectors of the economy. The crisis episode consists on an unexpected increase of the international interest rate of 200 basis point and a tradable TFP shock of 500 basis points. The economy operates under a fixed exchange rate.

Figure 14: Crisis episode: cross-sectional variables. Role of access to financial markets.



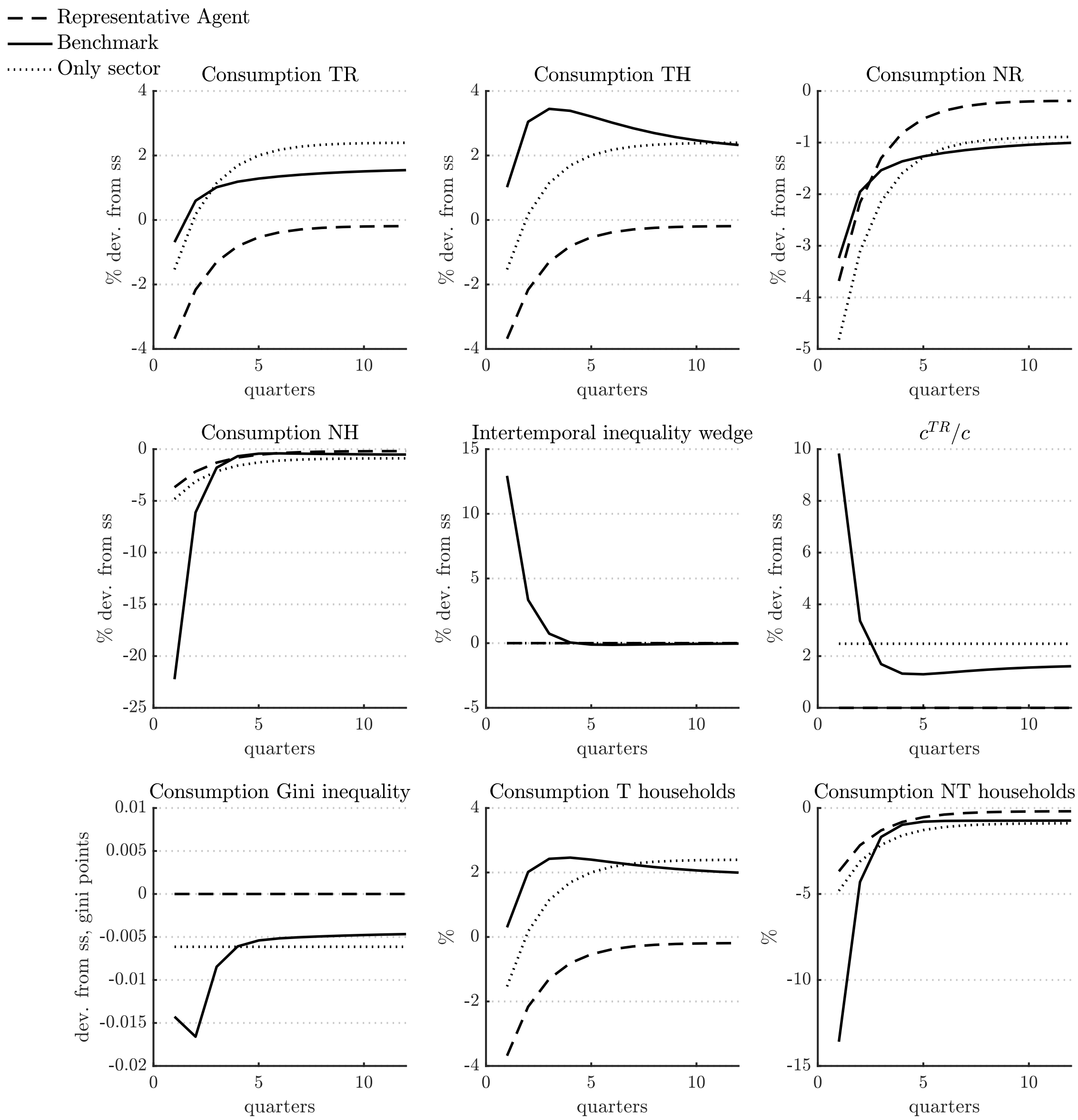
Notes: This figure reproduces the Impulse Response Functions from Figure 11 and adds the IRFs for the model with heterogeneity in access to financial markets but not in income sources (only MPC). The crisis episode consists on an unexpected increase of the international interest rate of 200 basis point and a tradable TFP shock of 500 basis points. The economy operates under a fixed exchange rate. It presents the consumption IRF for each type of household: T/NT refers to the sector of work of the household, while R/H refers to access to financial markets or hand-to-mouth. For example, TR refers to the household that works in the tradable sector and has unconstrained access to financial markets. The "intertemporal inequality wedge" refers to the term in equation (45), while $\Delta c^T - \Delta c^N$ refers to the differential in the IRF of households in the tradable sector (all types) and households in the non-tradable sector (all types).

Figure 15: Crisis episode: aggregate variables. Role of uninsurable sector-specific income.



Notes: This figure reproduces the Impulse Response Functions from Figure 11 and adds the IRFs for the model with uninsurable sector-specific income, but access to financial markets (only sector). There are two types of households, one with only tradable workers and the other with only non-tradable workers, but both have access to financial markets. The crisis episode consists on an unexpected increase of the international interest rate of 200 basis point and a tradable TFP shock of 500 basis points. The economy operates under a fixed exchange rate.

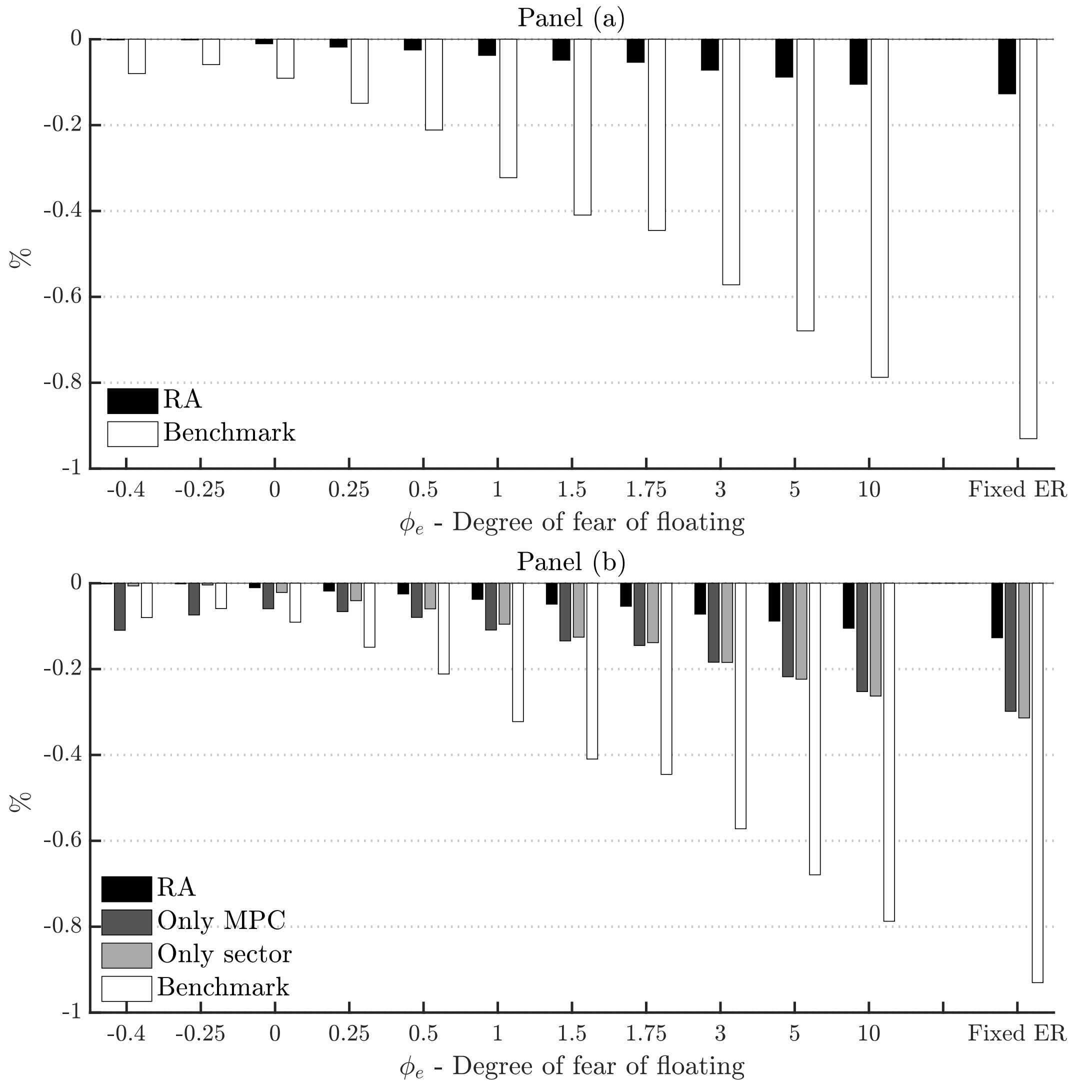
Figure 16: Crisis episode: cross-sectional variables. Uninsurable sector-specific income.



Notes: This figure reproduces the Impulse Response Functions from Figure 11 and adds the IRFs for the model with uninsurable sector-specific income, but access to financial markets (only sector). There are two types of households, one with only tradable workers and the other with only non-tradable workers, but both have access to financial markets. The crisis episode consists on an unexpected increase of the international interest rate of 200 basis point and a tradable TFP shock of 500 basis points. The economy operates under a fixed exchange rate. It presents the consumption IRF for each type of household: T/NT refers to the sector of work of the household, while R/H refers to access to financial markets or hand-to-mouth. For example, TR refers to the household that works in the tradable sector and has unconstrained access to financial markets. The "intertemporal inequality wedge" refers to the term in equation (45), while $\Delta c^T - \Delta c^N$ refers to the differential in the IRF of households in the tradable sector (all types) and households in the non-tradable sector (all types).

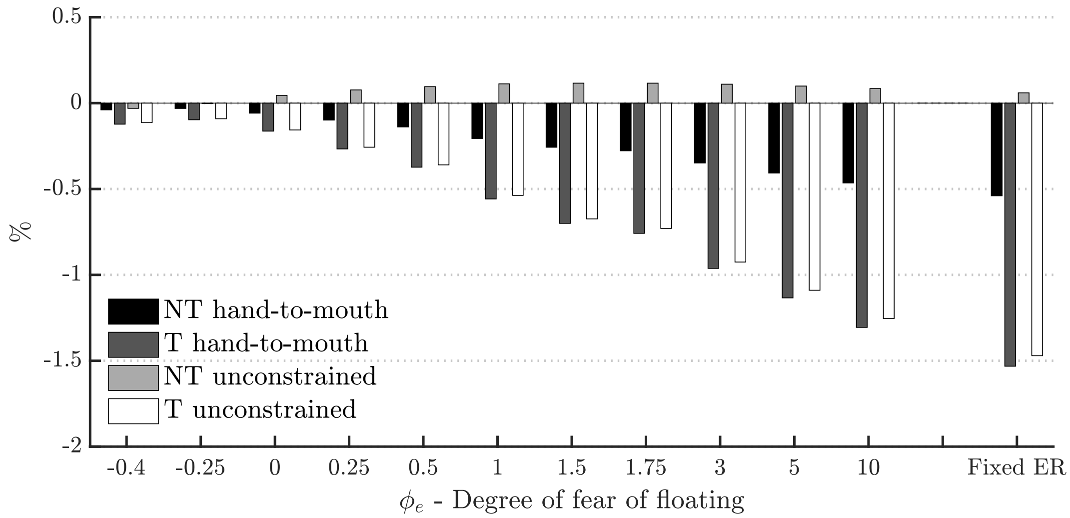
D The welfare costs of "fear of floating"

Figure 17: Welfare costs of "fear of floating"



Notes: This figure presents the conditional welfare costs from section 5, as the percentage increase/decrease of the stream of consumption under the 'optimal' floating exchange rate that would be necessary to achieve the same lifetime utility as with the corresponding "fear of floating" policy. Panel (a) presents the uniform cost for the benchmark economy and the representative agent specification. Panel (b) presents the uniform cost including the decompositions with only one type of heterogeneity active at a time. A positive value indicates that the economy is better off under the rule with "fear of floating", while a negative value indicates it is better off under the rule that replicates the flexible-price allocation.

Figure 18: Distribution of welfare costs of "fear of floating"



Notes: This figure presents the conditional welfare costs from section 5, as the percentage increase/decrease of the stream of consumption under the 'optimal' floating exchange rate that would be necessary to achieve the same lifetime utility as with the corresponding "fear of floating" policy for each type of household in the benchmark model. A positive value indicates that household m is better off under the rule with "fear of floating", while a negative value indicates the household is better off under the rule that replicates the flexible-price allocation.