

Emerging markets, household heterogeneity, and exchange rate policy

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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, with uninsurable sector-specific income playing a quantitatively larger role. 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.

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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 the abrupt decline in capital inflows and a sharp drop in output.¹ In economics, a large literature 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. I argue in this paper that accounting for household heterogeneity is particularly important for these episodes. I consider a heterogeneous agents model consistent with micro evidence and find that the output drop due to a sudden stop is almost two times as large as in a representative agent framework, while the consumption drop is one and a half times as large. 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 the 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. I use the model to perform two exercises. First, I consider a crisis episode in which there is an unexpected increase in the international interest rate and the economy abandons a fixed exchange rate policy unexpectedly after the shock takes place. I find that household heterogeneity amplifies the effects of external shocks on output 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.

¹Most 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.

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 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. My empirical analysis offers two insights: first, most households receive all of their income from just one of these two broad sectors; and second, the fact that the sector of work also affects consumption points to limited possibilities to smooth income shocks. These two observations are the building blocks of household heterogeneity in my model.

The second part of my paper focuses on understanding the effects of household heterogeneity during an emerging market crisis and the role of exchange rate policy. To do this, I construct a two-sector New Keynesian small open economy model that incorporates household heterogeneity. The model has two key ingredients: uninsurable sector-specific income and limited financial-market participation. In terms of the first ingredient, there are two types of workers according to their sector of work being tradable or non-tradable. In the baseline specification, households are made up of only one type of worker so there is no sectoral income sharing. In terms of the second ingredient, workers can accumulate uncontingent foreign debt (assets) at an exogenous interest rate. However, not all workers have access to this possibility. For each type of worker, there is a subset that has no access to financial markets, i.e. they consume all of their current income. These hand-to-mouth workers decide how much to work and consume every period, but they cannot smooth consumption over time.

To analyze the quantitative predictions of the model, I calibrate the model so that its steady state equilibrium matches long-run averages for the Mexican economy. I use household-level data to identify the share of workers in each sector, and in particular, the share of hand-to-mouth households. I identify the income/expenditure categories in the household level data that correspond to participation in formal financial markets

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

and consider as hand-to-mouth those households that did not receive/spend any income in those categories. With the calibrated model in hand, I study two situations: first, the adjustment during a crisis episode; and second, the welfare costs of monetary policy rules with different degrees of “fear of floating”.

The crisis exercise consists of analyzing the dynamic adjustment, with and without household heterogeneity, of an economy that is unexpectedly hit by an increase in the international interest rate of 200 basis points while its exchange rate is fixed. After the shock takes place, the economy unexpectedly abandons the fixed exchange rate for a floating one. The interest rate shock can be interpreted as a sudden stop of capital inflows and is of similar magnitude to the shock experienced by the Mexican economy. Similarly, the Mexican economy had a fixed exchange rate at the beginning of the crisis, but it was abandoned soon after the shock.

Consider first the case of a representative household setup in which there is a single household that pools income from all types of workers. By pooling income from both sectors, workers are insured from sectoral shocks, but not from aggregate ones. An increase in the international interest rate is an intertemporal shock that makes present consumption less attractive and reduces the present discounted value of lifetime income. The representative household would like to reduce their consumption and increase their hours worked. There is a fall in aggregate demand for both types of goods, tradable and non-tradable, while there is a surge in the supply of hours in both sectors. In the tradable sector, since the economy is a small player in the world market that takes as given the price in foreign currency, there is an increase in tradable output that absorbs the increase in labor supply even though there was a decrease in domestic aggregate demand for tradable goods. In the non-tradable sector, however, since prices are sticky and the exchange rate is fixed, relative prices cannot adjust enough to absorb the labor supply expansion. The non-tradable sector is demand-determined since the fixed exchange rate creates a rigidity in terms of the relative price of non-tradable goods. Since domestic aggregate demand was reduced, so it is non-tradable output. As soon as the fixed exchange rate is abandoned after the shock, the economy recovers since the fall in the relative price of non-tradables boosts domestic aggregate demand.

In my model, household heterogeneity amplifies the effects of the sudden stop shock. Households in each sector respond differently to the shock since their income reacts differently and they do not have the same consumption smoothing possibilities. This affects aggregate outcomes through two channels. First, households in the tradable sector do not experience a negative income shock as large as in the representative agent economy.

In fact, heterogeneity within the tradable sector dampens the increase in tradable output observed in the representative household model since not all types of households in the tradable sector will increase labor supply. 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 effect of these two channels is a larger fall in both output and consumption. When the fixed exchange rate is abandoned, this economy recovers faster than the representative agent one since the reallocation of demand towards non-tradable goods is more effective through the stronger response of hand-to-mouth households to changes in relative prices.

My 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 after experiencing sudden stop crises. “Fear of floating” can be incorporated into a standard Taylor rule by including a reaction to the nominal exchange rate depreciation. In this case, the domestic interest rate set by the central bank will react to changes in both inflation and the exchange rate depreciation. The more elastic is the domestic interest rate with respect to the depreciation rate, the higher is the “fear of floating” that the central bank experiences.

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. The welfare cost is given by the permanent percentage change in consumption under the policy that replicates the flexible-price allocation that provides the same lifetime utility as under the policy with “fear of floating”. 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 agent case. As the strength of “fear of floating” increases the policy becomes relatively more costly in the economy with heterogeneous households. Uninsurable sector-specific income plays a larger role in increasing the welfare cost of such policies than the lack of access to financial markets. 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 and sudden stops. [Mendoza \(2002\)](#) incorporates a liquidity constraint on borrowing and defines sudden stops as the moments when the constraint binds, in an otherwise standard small open economy model. [Kehoe & Ruhl \(2009\)](#) show that a multi-sector growth model can account for the trade balance reversal and the real exchange depreciation during a sudden stop, but not for the dynamics of aggregate and sectoral output, even when including labor frictions and variable capital utilization. [Gertler, Gilchrist & Natalucci \(2007\)](#) study the role of financial frictions in the propagation of a sudden stop in a New Keynesian small open economy under alternative exchange rate regimes. They find that a fixed exchange rate exacerbates sudden stops. [Schmitt-Grohé & Uribe \(2016\)](#) analyze the costs of fixed exchange rates in a two-sector economy with downwardly rigid wages and they find that the optimal policy consists of a floating exchange rate. They also study the benefits of alternative policies, such as capital controls, when monetary policy is constrained. [Burstein, Eichenbaum & Rebelo \(2007\)](#) account for the price dynamics after large devaluations in an economy with sticky prices in the non-tradable sector and distribution costs in the tradable one. [Cook & Devereux \(2006\)](#) study the role of imported intermediate inputs and financial frictions in a New Keynesian small open economy with non-tradable goods and dollar-currency pricing. Their model generates large declines in output that are very short-lived compared to the East Asian crises. The main contribution of my paper to this strand of literature is the inclusion of 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 contributes to a growing literature on household heterogeneity in New Keynesian models. [Kaplan, Moll & Violante \(2018\)](#) study the transmission mechanism of monetary policy in a closed economy with heterogeneous households that face an occasionally binding borrowing constraint. They find that heterogeneity changes the transmission mechanism of monetary policy. The indirect general equilibrium channels outweigh the direct effect of monetary policy through the intertemporal substitution channel. [Galí & Debortoli \(2018\)](#) show that a model with limited heterogeneity can replicate well the qualitative and quantitative dynamics from a complex model as the one in [Kaplan et al. \(2018\)](#). The limited heterogeneity consists of the existence of two types of agents, one that has access to financial markets or can accumulate capital, and another that is hand-to-mouth as in [Campbell & Mankiw \(1989\)](#). [Galí, López-Salido & Vallés \(2007\)](#), for example, study the effects of government spending, while [Bilbiie \(2008\)](#) studies

optimal monetary policy, aggregate dynamics, and stability. These are just some of the emerging literature in this area. A common thread in this literature is the study of a closed economy for which all markets clear domestically.³ My paper extends 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. I show that, for emerging markets, the lack of sectoral income sharing is more important in the transmission of aggregate shocks than the differences in marginal propensities to consume. This is due to sectoral incomes behaving very differently after a shock.

Finally, this paper is related to the study of the redistribution effects of monetary policy. [Doepke & Schneider \(2006\)](#) assess the effects of unexpected inflation on the value of nominal assets for different types of households. Rich old households are hurt the most by inflation since they are savers, while young middle-class households are the winners since they are borrowers with fixed-rate mortgages. [Auclert \(2017\)](#) studies the role of redistribution in the transmission of monetary policy, emphasizing the interest rate exposure channel (which considers the maturity of assets and liabilities). [Gornemann, Kuester & Nakajima \(2016\)](#) consider the distributional effects of monetary policy through its impact in labor market outcomes. Wealth-poor households benefit more from accommodative monetary policy, since they rely mostly on labor income. 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 similar to mine. They find that the short-run and long-run distributional effects of exchange rate policy can be very different. However, they do not provide evidence for the lack of income sharing and they do not systematically compare their model with the representative agent version as I do. [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 \(2018\)](#) 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

³[Drenik \(2015\)](#) is an exception that considers an open economy with heterogeneity, however, there is no reference to the channels that operate with household heterogeneity compared to a single household version.

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.

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

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 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

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

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 lower income losses both. 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. [Lopez-Acevedo & Salinas \(2000\)](#) suggest this correlation 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 47% of households with primary education or less had a household head working in the tradable sector in 1994, only 16% 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 their household head's sector of work, income and consumption losses were larger for households in the non-tradable sector.

Following [Glewwe & Hall \(1998\)](#), I investigate the role of sector of employment in explaining the differential losses in income and consumption across different types of households, with particular attention to education levels. Households' decisions are a time-variable function of fixed household characteristics, household fixed effects, and unobserved factors. Households make two types of decisions: labor market and household structure choices, such as their sector of work or which member is the household head, and consumption choices.

At the individual level, I assume that labor market and household structure choices, N_{it} , are a time-variable linear function of fixed household characteristics, household fixed effects, and unobservable factors:

$$N_{it} = \beta_{Nt}\mathbf{X}_i + F_{Ni} + u_{Nit}$$

where \mathbf{X}_i are characteristics of the household head fixed over time, F_{Ni} is a household

fixed effect and u_{Nit} represents unobserved factors.

The outcomes of interest w_{it} , per-capita household income and consumption, are a log-linear function of period t decisions as well as household fixed characteristics and fixed effects:

$$\ln(w_{it}) = \mu_t N_{it} + \beta_t \mathbf{X}_i + F_i + u_{it}$$

where F_i is a household fixed effect that captures unobservable household characteristics such as attitudes towards risk, and u_{it} represents other time-variable unobserved factors.

The outcome change during the crisis for a given household i is then given by:

$$\Delta_{t-(t-1)} \ln(w_{it}) = \Delta\mu T_{it-1} + \Delta\beta \mathbf{X}_i + \Delta\gamma \mathbf{N}_{it-1} + \Delta_{t-(t-1)} u_{it} \quad (1)$$

where T_{it-1} is the sector of work choice made at $t-1$ and other labor market and household structure choices that affect outcomes are grouped in \mathbf{N}_{it-1} and they are also measured at $t-1$ to capture the effects of initial conditions.

Since I want to study both the effects on income and consumption, I will work with the income and expenditure survey ENIGH. As I mentioned earlier, this survey is a repeated cross-section so I do not observe the same household over time. Instead, I work with groups of households by taking means over (1):

$$\Delta_{t-(t-1)} \overline{\ln(w_{it})}_c = \Delta\mu \overline{T_{it-1}}_c + \Delta\beta \overline{\mathbf{X}}_i + \Delta\gamma \overline{\mathbf{N}_{it-1}}_c + \Delta_{t-(t-1)} \overline{u_{it}}_c \quad (2)$$

where the bar above variables represents the mean over the individual households that make up group c . As long as groups are defined by characteristics that do not change from one survey to the next, (2) captures the outcome change for the same group of households, as noted by [Browning, Deaton & Irish \(1985\)](#). Under this representation, $\Delta\mu$ is the differential effect on the outcome of interest of the sector of work given by $\overline{T_{it-1}}$, $\Delta\beta$ is the change between $t-1$ and t of the effect of variables in $\overline{\mathbf{X}}_i$, while $\Delta\gamma$ is the differential effect of the initial conditions of the group given by $\overline{\mathbf{N}_{it-1}}$.

I define groups according to educational attainment, birth cohort, and location. I use three education levels: up to primary education, some secondary to complete secondary, and some college and above. I consider groups of two-year birth cohorts based on the birth year of household heads aged 25-64 in the 1994 survey.⁶ Finally, for location I consider

⁶Household heads younger than 25 might change their education attainment from one survey to the next since they are on the period of human capital accumulation, while household heads older than 64 are in their retirement period.

whether the household lives in an urban or rural area. I exclude from the sample self-employed households and business owners since they have more flexible occupations and possibly a different attitude with respect to risk than employees.

I estimate (2) for $t - 1 = 1994$ and $t = 1996$ to capture the effects of the crisis. I use educational attainment, age groups (25-35 and 50-64 years old), and location (rural versus urban) fixed effects. The labor market choice of interest is employment in the tradable sector. Additionally, I control for other household characteristics such as the number of children under 12 years old, the type of household -single parent, extended household-, whether the household head is an informal worker, and the sex of the household head. Except for variables that define the group, all other variables are averages across the group.⁷

I define employment in the tradable sector, T_{it} , as a dummy variable that indicates whether the household head of household i works in a tradable industry. In my main specification, I consider as tradable any industry in agriculture, mining or manufacturing. Results are robust to considering an alternative definition of tradable industries based on trade data or considering the sector of work of the maximum income earner in the household or a household weighted average.⁸

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 (CPI).⁹ In the main specification, I use as a measure of income the sum of labor income for all household members working, and as a measure of consumption I use total household consumption, which includes expenditures in both non-durable and semi-durable goods.

Table 1 presents the estimation results for the crisis period, 1994 to 1996, for both income and consumption. Groups with a larger share of households working in the tradable sector experienced a smaller income loss during the crisis as well as a smaller consumption loss. For every 1 percentage point (p.p.) increase in the share of households employed in the tradable sector in a group, the outcome change for the group increases by 0.62 p.p. for income and 0.64 p.p. for consumption. For example, consider the base group given by

⁷ENIGH oversamples rural areas, so I use the provided sample weights when computing group averages.

⁸See appendix A for more details on the data cleaning process and alternative definitions of the sector of employment variable.

⁹To capture some of the findings 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.

college-educated male-headed nuclear households, with no children under 12 years old, working in the formal sector, living in an urban area, aged 35-50, and no one working in the tradable sector. The constant in Table 1 indicates the income change for this group was -46%. If this exact same group had instead been working in the tradable sector, their income change would have been 17% instead.

Once the sector of work is taken into account, education levels affect income and consumption losses in a way in line with the conventional wisdom: low-educated households fare worse during the crisis.¹⁰ 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 tradable sector: agriculture, mining, and manufacturing. Households working in agriculture are not the ones driving the results in the main specification, instead households working in the manufacturing sector are.

Finally, as a placebo test, I estimate (2) for the pre-crisis and the post-crisis periods. In both cases, the share of households in the tradable sector has a small effect that is not significantly different from zero, as presented in Table 3. 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. In fact, in the pre-crisis period education levels are significant in explaining income growth and the sign of the effect is in line with the increase in the skill premium in pre-1994 Mexico as documented in Esquivel (2011). Figure 10 summarizes the results for the crisis, pre- and post-crisis periods for the coefficient of interest: sector of work affects households differentially only 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

¹⁰Halac & Schmukler (2004) and Fallon & Lucas (2002) examine the distributional effects of sudden stop financial crises and find that poor low-educated households with less access to financial markets suffered more during the crises.

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^* .¹¹ 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

¹¹This 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.

$j \in T, NT$ and access to financial markets $f \in R, H$. Household m values leisure and consumption according to:

$$U^m = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{m 1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{N_t^{m 1+\phi}}{1+\phi} \right) \quad (3)$$

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 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:

$$P_t C_t^{j,R} + S_t \frac{d_t^{j,R}}{1 - \lambda^j} = W_t^j N_t^{j,R} + (1 - \tau^j) \frac{\Pi_t^j}{s^{j,R}} + \frac{S_t}{1 + r_t^j} \frac{d_{t+1}^{j,R}}{1 - \lambda^j} \quad (4)$$

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 .¹²

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.

$$r_t^j = r_t^* + \psi \left(\exp(d_t^{j,R} - \bar{d}^{j,R}) - 1 \right) \quad (5)$$

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 .

¹²For example, the total measure of households in the tradable sector is given by $s^{TR} + s^{TH}$, then $\lambda^T = \frac{s^{TH}}{s^{TR} + s^{TH}}$.

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

$$P_t C_t^{j,H} = W_t^j N_t^{j,H} + \frac{T_t^{j,H}}{s_{j,H}} \quad (6)$$

where $T_t^{j,H}$ is a transfer received by hand-to-mouth households. In the benchmark case $T_t^{j,H} = \tau^j \Pi_t^j$, that is, it represents the share of sector j profits received by constrained households.

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:

$$P_t^T = S_t P_t^{T*} \quad (7)$$

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

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

$$Y_t^T = z_t^T (H_t^T)^{\alpha_T} \quad (8)$$

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:

$$\Pi_t^T = P_t^T Y_t^T - W_t^T H_t^T \quad (9)$$

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

$$W_t^T = \alpha_T P_t^T A_t^T (H_t^T)^{\alpha_T - 1} \quad (10)$$

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-Stiglitz aggregator production

function:

$$Y_t^N = \left[\int_0^1 (a_{it}^N)^{\frac{\mu-1}{\mu}} di \right]^{\frac{\mu}{\mu-1}} \quad (11)$$

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 (11) 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:

$$a_{it}^N = Y_t^N \left(\frac{P_{it}^N}{P_t^N} \right)^{-\mu} \quad (12)$$

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:

$$P_t^N = \left[\int_0^1 (P_{it}^N)^{1-\mu} di \right]^{\frac{1}{1-\mu}} \quad (13)$$

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:

$$y_{it}^N = H_{it}^N \quad (14)$$

Each firm faces demand for their intermediate variety given by (12), 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 .¹³ Period t profits are given by:

$$\pi_{it}^N = P_{it}^N a_{it}^N - (1 - \tau) W_t^N N_{it}^N - T_{it}^\Pi \quad (15)$$

Market clearing in each variety's market requires:

$$y_{it}^N = a_{it}^N \quad (16)$$

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

$$\pi_{it}^N = P_{it}^N Y_t^N \left(\frac{P_{it}^N}{P_t^N} \right)^{-\mu} - (1 - \tau) W_t^N Y_t^N \left(\frac{P_{it}^N}{P_t^N} \right)^{-\mu} - T_{it}^\Pi \quad (17)$$

With flexible prices intermediate good firms choose their current price P_{it}^N to maximize current profits as expressed in (17). 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 to change prices. A firm that is able to adjust its price will choose the current price \tilde{P}_{it}^N to maximize the present discounted value of expected profits generated while such price is in effect:

$$\mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s} \theta^s \left[\left(\tilde{P}_{it}^N \right)^{1-\mu} Y_{t+s}^N (P_{t+s}^N)^\mu - (1 - \tau) W_{t+s}^N Y_{t+s}^N \left(\frac{\tilde{P}_{it}^N}{P_{t+s}^N} \right)^{-\mu} - T_{it}^\Pi \right] \quad (18)$$

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}_{it}^N and rearranging:

$$\mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s} \theta^s Y_{t+s}^N \left(\frac{\tilde{P}_{it}^N}{P_{t+s}^N} \right)^{-\mu} \left[\frac{\mu - 1}{\mu} \tilde{P}_{it}^N - (1 - \tau) W_{t+s}^N \right] = 0 \quad (19)$$

¹³I 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.

Every firm that gets to reoptimize in period t will choose the same price \tilde{P}_t^N , since there are no other idiosyncratic shocks in condition (19) and the time elapsed since the last price change is irrelevant. Calvo pricing and equation (13) imply that:

$$P_t^N = \left[\theta P_{t-1}^{N 1-\mu} + (1-\theta) \tilde{P}_t^{N 1-\mu} \right] \quad (20)$$

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:

$$Q_{t,t+s} = \prod_{j=1}^s \left[(1 + r_{t+s-1}^*) \epsilon_{t+s} \right]^{-1} \text{ for } s \geq 1 \quad (21)$$

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:

$$H_t^N = \int_0^1 H_{it}^N di \quad (22)$$

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:

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

Define s_t , a measure of price dispersion, as:

$$s_t = \int_0^1 \left(\frac{P_{it}^N}{P_t^N} di \right)^{-\mu} \quad (24)$$

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

$$Y_t^N = H_t^N s_t^{-1} \quad (25)$$

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

$$s_t = \theta s_{t-1} \left(\frac{P_{t-1}^N}{P_t^N} \right)^{-\mu} + (1 - \theta) \left(\frac{\tilde{P}_t^N}{P_t^N} \right)^{-\mu} \quad (26)$$

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

$$\Pi_t^N = P_t^N Y_t^N - W_N H_t^N \quad (27)$$

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:

$$A(C_t^T, C_t^N) = \left[\omega^{1/\eta} C_t^T{}^{1-1/\eta} + (1 - \omega)^{1/\eta} C_t^N{}^{1-1/\eta} \right]^{\frac{1}{1-1/\eta}} \quad (28)$$

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:

$$P_t A(C_t^T, C_t^N) - P_t^T C_t^T - P_t^N C_t^N \quad (29)$$

Profit maximization implies the following conditions:

$$P_t A_1(C_t^T, C_t^N) = P_t^T \quad (30)$$

$$P_t A_2(C_t^T, C_t^N) = P_t^N \quad (31)$$

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 j th argument.

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

$$\frac{P_t^N}{P_t^T} = \frac{A_2(C_t^T, C_t^N)}{A_1(C_t^T, C_t^N)} \quad (32)$$

The zero-profit condition implies that the unit price of the composite consumption

good can also be written as:

$$P_t = \left(\omega P_t^T^{1-\eta} + (1-\omega) P_t^N^{1-\eta} \right)^{\frac{1}{1-\eta}} \quad (33)$$

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.

$$\int_0^1 T_{it}^{\Pi} di = \tau H_t^N \quad (34)$$

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:

$$H_t^T = \sum_{m \in T} N_t^m dm \quad (35)$$

Labor market for the non-tradable sector:

$$H_t^N = \sum_{m \in N} N_t^m dm \quad (36)$$

Non-tradable varieties, for all i :

$$y_{it}^N = a_{it}^N \quad (37)$$

Final non-tradable market:

$$Y_t^N = C_t^N \quad (38)$$

Finally, for the composite consumption good,

$$C_t = \sum_m C_{m,t} dm \quad (39)$$

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.

$$P_t^T C_t^T = P_t^T Y_t^T + S_t \left(\frac{d_{t+1}}{1 + r_t^*} - d_t \right) \quad (40)$$

in which d_t is aggregate debt from all unconstrained households.

3.7 Nominal exchange rate regime

In the quantitative analysis I will consider a crisis scenario in which the central bank is initially following a fixed exchange rate regime, but it abandons it unexpectedly after the shock takes place and adopts a floating exchange rate. 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:

$$(1 + i_t) = (1 + \bar{r}) \left(\frac{P_t}{P_{t-1}} \right)^{\phi_\pi} \epsilon_t^{\phi_e} \exp \{ \epsilon_t^S \} \quad (41)$$

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:

$$\sum_{m \in \{TR, NR\}} \frac{s^m}{s^{TR} + s^{NR}} \mathbb{E}_t \left\{ \left(\frac{C_{t+1}^m}{C_t^m} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \left((1 + r_t^j) - \frac{(1 + i_t)}{\epsilon_{t+1}} \right) \right\} = 0 \quad (42)$$

where j is the sector of work of household m .

The coefficient ϕ_e in (41) represents the central bank's degree of "fear of floating". When $\phi_e = 0$ the central bank lets the currency float freely, while when $\phi_e \rightarrow \infty$ 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 (41) 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:

$$\ln(z_t^T) = \rho_{z^T} \ln(z_{t-1}^T) + \varepsilon_t^T \quad (43)$$

$$\ln\left(\frac{1+r_t^*}{1+\bar{r}}\right) = \rho_r \ln\left(\frac{1+r_{t-1}^*}{1+\bar{r}}\right) + \varepsilon_t^r \quad (44)$$

$\rho_{z^T}, \rho_r \in (-1, 1)$ 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 $\sigma_{\varepsilon_{z^T}}$ and $\sigma_{\varepsilon_{r^*}}$ 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 (41) 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. The central component is the calibration of household heterogeneity from available micro-data. Table 4 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. Both in closed and open economy models this parameter can be calibrated between [0.2, 1.5]. I calibrate $\phi = 1$, as in Mendoza (2002), but perform robustness analysis for different values of this elasticity. 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.¹⁴

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. 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

¹⁴In appendix B, I detail the exact survey categories I consider for each case.

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).¹⁵ 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.

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 (43) and (44) 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.

¹⁵Stock market depth index comparison: <http://vif.com.mx/indice/anio/2017/>

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. I study the response of each economy under the same monetary policy regime: the economy initially operates under a fixed exchange rate that is unexpectedly abandoned one period after the shock takes place. Finally, to assess 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 $\sigma = 1/\eta$.¹⁶ 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 :

$$C_t^{jR-\sigma} = \beta (1 + r_t^j) \mathbb{E}_t \left\{ C_{t+1}^{jR-\sigma} \frac{P_t/S_t}{P_{t+1}/S_{t+1}} \right\} \quad (45)$$

Since $r_t^j \approx r_t^*$ and (30) implies $P_t = P_t^T / (C_t^{1/\eta} C_t^{T-1/\eta} \omega^{1/\eta})$, this equation can be used to write an aggregate Euler equation for tradable consumption:

$$C_t^{T-\sigma} = \beta (1 + r_t^*) \mathbb{E}_t C_{t+1}^{T-\sigma} \underbrace{\left(\frac{C_{t+1}^{jR}}{C_{t+1}} \right)^{-\sigma} \left(\frac{C_t^{jR}}{C_t} \right)^{\sigma}}_{\text{Intertemporal inequality wedge}} \quad (46)$$

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 household m

¹⁶The 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).

in sector j :

$$\kappa^j N_t^{m\phi} = W_t^j C_t^{m-\sigma} \quad (47)$$

Market clearing in the labor market for each type of labor and (30), imply a labor choice in each market given by:

$$\kappa^j H^{j\phi} = \frac{W_t^j}{S_t} C_t^{T-\sigma} \underbrace{\left[s^{jR} \left(\frac{C_t^{jR}}{C_t} \right)^{-\frac{\sigma}{\phi}} + s^{jH} \left(\frac{C_t^{jH}}{C_t} \right)^{-\frac{\sigma}{\phi}} \right]^\phi}_{\text{Intratemporal inequality wedge in sector } j} \quad (48)$$

Heterogeneity introduces an intratemporal wedge on the labor choice arising from the presence of income effects on individual labor choices. Since households of different 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 (46) 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, similar to the one experienced by the Mexican economy in the first quarter of 1995. One quarter after the shock, the economy unexpectedly abandons the fixed exchange rate regime for a floating exchange rate and a domestic Taylor rule. This is similar to the Mexican experience, except that Mexico abandoned the fixed exchange rate during the first quarter of 1995, however the central bank kept a restrictive monetary policy stance well into the second quarter of 1995.

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). When the shock hits, the domestic interest rate increases by the same amount as the 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 (3), the representative household would like to work more in both sectors.

Tradable output increases since there is an increase in the supply of labor and the sector does not face an aggregate demand constraint. Any domestic excess supply of tradable goods can be sold in international markets without affecting its price. Since domestic consumption of tradable goods falls, there is an improvement on the trade balance to output ratio. 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). Since the non-tradable sector represents a larger share of the economy, total output and hours decrease following the fall in non-tradable variables.

When the fixed exchange rate is abandoned, aggregate demand in the non-tradable sector quickly recovers. Non-tradable goods are now less expensive in real terms, even if their nominal price did not adjust much. Total output, hours and consumption also quickly recover. There is an initial deflation due to non-tradable prices falling, but then there is an peak on inflation due to the exchange rate depreciation. Once this effect vanishes the domestic interest rate is reduced again.

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, except for tradable output and the trade balance. 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.

The response of consumption and non-tradable output is amplified due to a 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, this income sharing is lost.

The response of tradable output is explained by the behavior of households within the tradable sector. As mentioned before, hand-to-mouth households in the tradable sector increase their consumption since their current real income is increasing. Due to income effects in their labor choice, they do not increase their working hours in the tradable sector. For unconstrained households, on the other hand, the negative wealth effect brought about by the increase in the international interest rate dominates in the short-run and they cut down consumption and increase hours.

Since households in the non-tradable sector are richer than households in the tradable one, 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 (46), the economy with heterogeneity displays an amplified response because the dynamics of inequality operate as an additional interest rate increase at first. After the fixed exchange rate is abandoned, the economy with heterogeneity recovers faster since inequality dynamics are akin to a reduction in the interest rate (when the inequality wedge deviation is negative).

Finally, when grouping the responses of households in each sector, there is a differential effect in favor of households in the tradable sector with respect to households in the non-tradable one. Households in the tradable sector increase their consumption, while those in the non-tradable one decrease it. This differential in favor of tradable households is in line with the empirical evidence from section 2, but the increase in tradable households' consumption is counterfactual.

Overall, these simple models match the direction of impact effects observed in the data, except in terms of the response of tradable output. In the representative household setup, the increase in tradable output is counterfactual and it has been typically fixed in the literature by assuming a utility function specification with no income effects and a concurrent productivity shock in the tradable sector. The model with heterogeneity, on the other hand, presents a dampened response in terms of tradable output. Both models

perform poorly in terms of duration of the crisis, the economy quickly recovers as soon as the fixed exchange rate is abandoned and the devaluation rate is much lower than the one observed. These two features are related to the simplicity of these models in which aggregate demand is the only driver and it features no inertia.

Quantitatively, both models are far from the observed fall in consumption and aggregate output presented in Figure 2. This is not unexpected, since both models were kept simple on purpose to highlight the role of household heterogeneity. Models in the emerging markets and sudden stops literature that can account for larger declines in consumption and output feature more frictions than the one I present here. Nonetheless, the benchmark model can account for a fall of aggregate consumption of almost 5%, while the representative agent model can only account for 3.6% of the 10% fall observed in the data. Similarly for aggregate output, the benchmark model generates a larger fall in aggregate output 3.2% versus the 1.7% generated by the representative household setup.

In terms of the welfare cost of the crisis, 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.¹⁷ For each household I compute:

$$\Delta C^m = \frac{W_{crisis}^m - W_{ss}^m}{\lambda_{ss}^m C_{ss}^m} \quad (49)$$

where ΔC^m represents the percentage of steady state consumption household of type m requires to avoid the crisis, $W_{crisis}^m = \sum_{t=1}^6 \beta^{t-1} U(C_t^m, N_t^m)$ is the present discounted value of utility during the crisis, W_{ss}^m is the corresponding value in terms of steady state consumption, C_{ss}^m is steady state consumption for household m , and λ_{ss}^m is the marginal 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:

$$\Delta C = \sum_m s^m \frac{C_{ss}^m}{C_{ss}} \Delta C^m \quad (50)$$

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 5 panel (a), I present the short-run welfare cost for each model. Despite aggregate consumption falling by a larger amount on the benchmark model, the aggregate

¹⁷This is the time it took output in Mexico to get back on trend during the Tequila crisis, as in Figure 2.

cost of the crisis is actually lower in the benchmark economy than in the representative household version. In the benchmark model, the crisis costs society about 9% of steady state consumption, while it costs 11.5% in the representative agent version. However, the distribution of welfare costs is very different across households, as shown in panel (b) of Table 5. Households in the tradable sector actually benefit from the reallocation effects triggered by the crisis. 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. During the first six quarters of adjustment, only tradable hand-to-mouth households have realized this benefit, and they would require an increase in their steady state consumption in order to avoid the crisis.

Table 5 also presents what the welfare costs would have been if exchange rate policy would have been constant during the crisis, for the case of a fixed exchange rate and a Taylor rule with a floating exchange rate. In the representative household case, the welfare cost is similar across all exchange rate regimes, about 11.5%. A flexible exchange rate reduces the impact on output and consumption, but it does not avoid the consumption loss during the sudden stop due to the increase in the interest rate. For the benchmark model, the exchange rate regime does affect welfare costs more significantly. Facing a crisis with a flexible exchange rate reduces the aggregate welfare cost to 8%, while keeping the exchange rate fixed increases it to 10%. In terms of the distribution of welfare costs, the exchange rate regime affects households differently. While a flexible exchange rate is considered better than a fixed one for both types of hand-to-mouth households, it benefits tradable unconstrained households while it harms non-tradable unconstrained ones. Non-tradable unconstrained households experience the smallest welfare cost under a fixed exchange rate, since this makes their profit income larger during the crisis and allows them to work less.

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

In this section I explore the role in driving short-run responses of each type of heterogeneity in the model and the role of household-specific income effects. To assess the importance of each type of heterogeneity, I turn on each one at a time and repeat the crisis exercise. To assess the importance of household-specific income effects, I consider a version of the benchmark model in which labor in each sector is provided by a competitive aggregate union.

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:

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

While the hand-to-mouth household faces:

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

The rest of the equilibrium operates as in the benchmark model. I calibrate the version without uninsurable sector-specific income to have the same steady state as the benchmark model and the representative household version.

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 closely track the representative agent responses, particularly for production in the tradable sector. In the non-tradable sector and in consumption there is some amplification on impact, about 0.5%, but this does not have much impact on aggregate output. In terms of cross-sectional variables, shown in Figure 14, inequality slightly goes up on impact, while there is no differential 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:

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

As before, the rest of the equilibrium operates as in the benchmark model. I calibrate the version without heterogeneity in access to financial markets to have the same steady state as the benchmark model and the representative agent version.

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 benchmark model, particularly for longer horizons. The model with only uninsurable sector-specific income displays less amplification on impact in the non-tradable sector and consumption, and it shows a stronger response of tradable output than in the benchmark model, but smaller than in the representative household case. The amplification on impact is slightly larger than in the model with only access to financial markets heterogeneity, but since the response in the tradable sector is dampened this has a larger impact on aggregate output. 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 data.

Household-specific income effects. Finally, I consider the role of household-specific income effects in driving the differences between the benchmark model and the representative agent version. In this case, I consider there is a union that supplies labor in each sector, as in Galí & Debortoli (2018), according to the following wage schedule:

$$W_t^j = \mathcal{M}^j P_t C_t^\sigma N_t^{j\phi}$$

where \mathcal{M}^j is the wage markup in sector j and every household in sector j supplies labor equal to N_t^j . To guarantee that each household actually wants to supply the amount of

work determined by the union it must be that for each household m in sector j :

$$W_t^j = \mathcal{M}^j P_t C_t^\sigma N_t^{j\phi} \geq P_t C_t^{m\sigma} N_t^{j\phi}$$

The rest of the model is as in the benchmark case. I calibrate this version of the model to have the same steady state as the benchmark model and the representative household version.

Figure 17 presents the crisis episode for the benchmark model, the representative household version, and the model with aggregate income effects (aggregate income effect, dotted line). The responses of non-tradable output and consumption are slightly larger on impact than in the benchmark model, but as time goes by they evolve as in the representative household model. This evolution is due to the response in the tradable sector, which is similar in the two models. The large amplification observed in the non-tradable sector translates to aggregate output, despite the strong counter-cyclical response in the tradable sector. In terms of cross-sectional variables, shown in Figure 18, both inequality and the tradable to non-tradable differential in consumption move in the same direction as in the benchmark model, but with an amplified response on impact and a dampened effect as time goes by.

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. Uninsurable sector-specific income plays a role quantitatively more important since it dampens the counter-cyclical response of tradable output and explains the cross-sectional differences across households. Household-specific income effects drive the response of tradable output in the benchmark model, but not the dynamics of consumption and non-tradable output.

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:

$$(1 + i_t) = (1 + \bar{r}) \left(\frac{P_t}{P_{t-1}} \right)^{\phi_\pi} \epsilon_t^{\phi_e} \exp \{ \epsilon_t^S \} \quad (41)$$

The coefficient ϕ_e in (41) represents the central bank’s degree of “fear of floating”. When $\phi_e = 0$ the central bank lets the currency float freely, while when $\phi_e \rightarrow \infty$ 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.¹⁸ 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 (41).¹⁹ 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.²⁰ The conditional welfare cost $\lambda_m(x_0, \sigma_\epsilon)$ for household m is

¹⁸See Appendix C for the proof.

¹⁹Galí, 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.

²⁰See 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 transition back to steady state, however, unconditional welfare costs can produce paradoxical results.

defined as:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left(\left(1 + \frac{\lambda_m(x_0, \sigma_\epsilon)}{100} \right) C_t^m \right)^{1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{N_t^{m \ 1+\phi}}{1+\phi} \right\} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\hat{C}_t^m \ 1-\sigma - 1}{1-\sigma} - \kappa^j \frac{\hat{N}_t^m \ 1+\phi}{1+\phi} \right\} \quad (51)$$

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 $\{\hat{C}_t^m, \hat{N}_t^m\}_{t=0}^{\infty}$ 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:

$$\begin{aligned} & \sum_m s^m \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\left(\left(1 + \frac{\lambda(x_0, \sigma_\epsilon)}{100} \right) C_t^m \right)^{1-\sigma} - 1}{1-\sigma} - \kappa^j \frac{N_t^{m \ 1+\phi}}{1+\phi} \right\} \\ & = \sum_m s^m \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{\hat{C}_t^m \ 1-\sigma - 1}{1-\sigma} - \kappa^j \frac{\hat{N}_t^m \ 1+\phi}{1+\phi} \right\} \end{aligned} \quad (52)$$

Figure 19 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

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 -0.28% 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).²¹ Panel (b) in [Figure 19](#) presents the uniform conditional welfare cost for the specifications with only heterogeneity in access to financial markets and only uninsurable sector-specific income. With respect to the representative agent specification, uninsurable sector-specific income is more important in explaining the increase of the welfare cost in the benchmark economy.

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 20](#) 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).

²¹As 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. Households in the non-tradable sector, on the other hand, prefer a fixed exchange rate since periods of low consumption are accompanied by high leisure. In the benchmark case, hand-to-mouth households receive less profits than unconstrained households, so their consumption loss from volatility is higher and they slightly prefer a floating exchange rate.

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 “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 aggregate 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 crises. 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 would 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 stimuli 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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