Monetary Policy and Redistribution in Open Economies

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This paper develops an open-economy heterogeneous-agent New Keynesian model in which households differ in their income, wealth, and real and financial integration with international markets. We use the model to reassess classic questions in international macroeconomics from a distributional perspective. Our analysis yields two main takeaways. First, heterogeneity in households' international integration plays a central role in driving the unequal consumption responses to external shocks, more so than income and wealth. Second, the conduct of monetary policy in open economies faces a stabilization-inequality tradeoff, with fixed exchange rate regimes leading to amplified but more equal consumption responses to external shocks.

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I. Introduction

The implications of globalization for the conduct of macroeconomic policies have featured prominently in policy debates in recent decades. An influential view, based on the idea of "globalization and its discontents" (Stiglitz 2002, 2017), argues that international integration has redistributive effects on households and that if traditional policies do not consider this dimension, they can amplify the resulting inequalities. Although the traditional argument for discontent with globalization was formulated with regard to emerging economies' crises in the late 1990s, similar views have become prominent in developed economies over the last decade. Related to this policy discussion, a large body of research on the intersection of international trade and labor has studied the distributional consequences of international integration and trade policies (see, e.g., Goldberg and Pavcnik 2007; Autor, Dorn, and Hanson 2013). However, less is known in international macroeconomics about the extent to which traditional macroeconomic policies affect the asymmetric effects of globalization.

In this paper, we study the distributional effects of monetary policy in open economies in the context of households' uneven international integration and exposure to external shocks. To this end, we build a framework that combines traditional elements of open-economy monetary transmission, heterogeneity in income, wealth, and households' integration with international real and financial markets. We then use this framework to reassess three classic questions in international economics that motivated the seminal work of Mundell (1963) and Fleming (1962),[1] but we focus on their distributional aspects: what are the effects of monetary policy in open economies? What are the international spillovers of policies and shocks? And how do alternative exchange rate regimes compare? We emphasize two main takeaways from our analysis. The first is that heterogeneity in households' international integration is a central dimension that drives the unequal impacts of external shocks on different households' consumption, more so than income and wealth. The second is that households' heterogeneity reveals the presence of a trade-off between aggregate stabilization and consumption inequality in the conduct of monetary policy in open economies, with fixed exchange rate regimes leading to amplified but more equal consumption responses to external shocks.

The model we develop embeds household heterogeneity in a canonical New Keynesian open-economy framework. In particular, we consider

[1] For instance, the first sentences in Mundell (1963) read, "The world is still a closed economy, but its regions and countries are becoming increasingly open. . . . The international economic climate has changed in the direction of financial integration and this has important implications for economic policy. My paper concerns the theoretical and practical implications of the increased mobility of capital" (475).

a small open economy populated by households that consume three types of goods: tradable goods produced by home firms, tradable goods produced by foreign firms, and nontradable goods (see, e.g., Obstfeld and Rogoff 2000; Gali and Monacelli 2005). To study the distributional effects of monetary policy in this open-economy framework, we introduce households' heterogeneity along two dimensions. First, households differ in their income and wealth, modeled with uninsurable labor-income shocks as in the literature on monetary policy with households' heterogeneity in closed-economy heterogeneous-agent New Keynesian (HANK) models (Kaplan, Moll, and Violante 2018). Second, households differ in their international real and financial integration, with some working in tradable sectors and others working in nontradable sectors and some having access to internationally traded securities and some restricted to domestically traded securities. With these ingredients, we aim to construct a laboratory economy that has in play the main mechanisms of the monetary transmission of open-economy models, combined with heterogeneity in marginal propensities to consume across households and uneven exposures to external shocks.

The first takeaway from our analysis is that households' uneven integration with international markets quantitatively constitutes a central dimension in the study of the distributional effects of macroeconomic policies in open economies. We find that this source of heterogeneity, which is a characteristic of open economies, explains roughly half of the inequalities in consumption responses to external macroeconomic shocks. On the real dimension, the consumption of households working in tradable sectors is more sensitive to changes in the external demand for exportable goods. This is because of the infrequent transitions of households across sectors observed in the data, which give rise to differential responses of labor income to shocks. On the financial dimension, the consumption of households that have direct or indirect holdings of foreign securities is more sensitive to the international spillovers of foreign monetary policy. This is because these shocks give rise to large deviations in the returns of foreign and domestic securities (i.e., uncovered interest rate parity [UIP] deviations as studied by Fama 1984; Itskhoki and Mukhin 2017; Kalemli-Özcan 2019), and households also exhibit infrequent transitions in their financial integration.

The second takeaway is that an economy's choice of exchange rate regime entails different distributional implications. Although fixed exchange rate regimes amplify aggregate responses to external shocks vis-à-vis floating regimes (e.g., Taylor rules), they are also associated with more even consumption responses between integrated and nonintegrated households. For instance, an external monetary expansion generates a large response of households that are integrated with international capital markets through direct channels, which leads to inequality in

consumption responses vis-à-vis nonintegrated households. Under a fixed exchange rate regime, monetary authorities respond more aggressively by cutting domestic interest rates to avoid currency appreciation, which has direct effects on the consumption of nonintegrated households and thereby reduces the unequal consumption responses to the external shock. In this sense, distributional considerations in open economies might make a case for "fear of floating" (Calvo and Reinhart 2002).

It is worth mentioning that international integration emerges as a relevant source to explain the distributional implications of aggregate shocks, insofar as economies display imperfections in labor, assets, and markets. On the labor side, frictionless sectoral reallocation would eliminate the asymmetric responses of the labor income of households working in tradable and nontradable sectors. On the financial side, the absence of limits to arbitrage would homogenize the responses of domestic and external asset prices, eliminating the dispersion in the households' returns to saving.

Finally, our paper studies the role of globalization in terms of the aggregate and distributional effects of monetary policy and external shocks. This exercise is motivated by the large increase in real and financial integration observed worldwide over the recent decades (e.g., Rogoff 2006; Obstfeld 2007). Economies with larger degrees of real and financial integration naturally experience more pronounced aggregate effects of changes in foreign demand and monetary policy, respectively. However, we show that in economies with a high degree of international integration, external shocks tend to have more even responses across households because external shocks induce larger dampening forces from prices in the rest of the economy or from the monetary authority. From this, we conclude that an important element to consider in the debate regarding the asymmetric effects of globalization is how generalized international integration is.

Related literature.—Our paper contributes to three strands of the literature. The first is the large body of literature on monetary policy in open economies. Our work builds on the literature that studies the effects on monetary policy in open economies (see, e.g., the early work of Obstfeld and Rogoff 1995, 2000; Chari, Kehoe, and McGrattan 2002; Devereux and Engel 2003; Gali and Monacelli 2005; Engel 2006; Burstein, Eichenbaum, and Rebelo 2007; Schmitt-Grohé and Uribe 2011; Burstein and Gopinath 2014).[2] We contribute to this literature by analyzing the distributional aspects of these classic questions in international macroeconomics.

Second, our paper is related to a large body of literature that studies the role of household heterogeneity in the transmission of macroeconomic

[2] The study of monetary policy in open economies is a central topic in international economics and includes work on the role of the international price system in affecting monetary policy (see, e.g., Corsetti, Dedola, and Leduc 2010; Mukhin 2018; Gopinath et al.

policies (for a recent survey, see Kaplan and Violante 2018). In open economies, early contributions include the work of Farhi and Werning (2016, 2017) on fiscal and monetary policy. More recently, a growing body of research has incorporated quantitative elements from the closed-economy literature. De Ferra, Mitman, and Romei (2020) introduce heterogeneity in households' income and wealth to study the transmission of foreign shocks. Auclert et al. (2020) study monetary transmission in an open-economy model with heterogeneous households; they provide general conditions under which households' heterogeneity matters for aggregate transmission and identify the presence of a strong real-income channel that can lead to contractionary devaluations. Other papers in this area include Cugat (2019), Zhou (2020), and Oskolkov (2021).[3] We complement this body of work by stressing how international integration constitutes a central source of heterogeneity for the conduct of monetary policy in open economies.

Finally, our paper is related to the macroeconomics literature that analyzes consumption inequality (see, e.g., Attanasio, Battistin, and Ichimura 2004; Krueger and Perri 2006; Aguiar and Bils 2015; Quadrini and Ríos-Rull 2015; Straub 2018, and references therein). Our paper complements this literature by studying the distributional aspects of monetary policy in open economies, which are characterized by inequality stemming from international integration.

The rest of the paper is organized as follows. Section II presents the model, and section III presents its parameterization. Section IV studies the three classic questions in international macroeconomics from a distributional perspective. Section V analyzes how the degree of real and financial integration affects the distributional effects of monetary policy and the responses to external shocks. Section VI concludes.

II. Model

This section describes the open-economy HANK model. The environment is that of a canonical New Keynesian open-economy model enriched

2020, and references therein); the role of international financial intermediaries, deviations of UIP, and currency risk (see, e.g., Gabaix and Maggiori 2015; Rey 2015; Hassan, Mertens, and Zhang 2016; Itskhoki and Mukhin 2017, 2021; Eichenbaum, Johannsen, and Rebelo 2021; Kekre and Lenel 2021); domestic financial frictions (see, e.g., Céspedes, Chang, and Velasco 2004; Benigno and Romei 2014; Fornaro 2015; Arellano, Bai, and Mihalache 2020; Ottonello 2021); and international coordination in the conduct of monetary and fiscal policy (see, e.g., Corsetti and Pesenti 2005; Fornaro and Romei 2019). Complementing this literature, there is a large body of empirical work on the global financial cycle and international spillovers (see, e.g., Forbes and Rigobon 2002; Giovanni et al. 2017; Gourinchas 2018; Kalemli-Özcan 2019).

[3] A related empirical literature has documented the heterogeneous impacts of currency depreciation (see, e.g., Gopinath and Neiman 2014; Cravino and Levchenko 2017; Drenik, Pereira, and Perez 2018; Blanco, Drenik, and Zaratiegui 2020).

with household heterogeneity. The economy is populated by households, firms, and a government. Households consume three goods—home, foreign, and nontradable—and can potentially save in two types of assets: domestic and external financial securities. Firms in the economy produce the home tradable goods and nontradable goods. The rest of the world exchanges tradable goods (home and foreign) and external financial securities with the small open economy. Households are heterogeneous in two dimensions. First, households face uninsurable labor-income shocks, as is standard in closed-economy HANK models. Second, households are heterogeneous in their access to international real and financial markets: some work in tradable sectors and others in nontradable sectors; some are able to save and borrow in both financial securities and others only in domestic securities. Section II.F discusses the assumptions of the baseline model, and appendix A studies alternative model environments.

A. *Households*

Households have preferences over consumption described by the lifetime utility function

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t), \tag{1}$$

where c_t and l_t denote consumption and hours worked in period t; $u : \mathbb{R}_+^2 \to \mathbb{R}$ is a continuous and differentiable function, increasing in the first argument and decreasing in the second argument; $\beta \in (0, 1)$ denotes the subjective discount factor; and $\mathbb{E}_t$ denotes the expectation conditional on the information set available at time t. The consumption good is a composite of tradable and nontradable goods, with a constant elasticity of substitution (CES) aggregation technology $c_t = \mathcal{C}_{\mathrm{TN}}(c_{\mathrm{T}t}, c_{\mathrm{N}t}) = [\omega_{\mathrm{T}}^{1/\eta}(c_{\mathrm{T}t})^{1-(1/\eta)} + (1 - \omega_{\mathrm{T}})^{1/\eta}(c_{\mathrm{N}t})^{1-(1/\eta)}]^{\eta/(\eta-1)}$, where $c_{\mathrm{T}t}$ and $c_{\mathrm{N}t}$ denote tradable and nontradable consumption and $\eta > 0$ represents the elasticity of substitution between tradable and nontradable goods. In turn, the tradable good is a composite of home and foreign tradable goods with a CES aggregation technology $c_{\mathrm{T}t} = \mathcal{C}_{\mathrm{HF}}(c_{\mathrm{H}t}, c_{\mathrm{F}t}) = [\omega_{\mathrm{H}}^{1/\eta}(c_{\mathrm{H}t})^{1-(1/\eta)} + (1 - \omega_{\mathrm{H}})^{1/\eta}(c_{\mathrm{F}t})^{1-(1/\eta)}]^{\eta/(\eta-1)}$, where $c_{\mathrm{H}t}$ and $c_{\mathrm{F}t}$ denote home tradable and foreign tradable goods and we assume that the substitution between home tradable and foreign tradable goods shares the same elasticity with the substitution between tradable and nontradable goods.[4]

We set up the households' problem recursively. The idiosyncratic state vector of a household includes its idiosyncratic income shock, z; its asset holdings, $\mathbf{b} \equiv [b_{\mathrm{D}}, b_{\mathrm{E}}]$, where b_{D} denotes holdings of domestic securities

[4] In app. sec. A9, we relax this assumption and study a parameterization with different elasticities of substitution.

and b_{E} denotes holdings of external securities; and its integration with real and financial international markets, $\mathbf{o} \equiv [o_R, o_F]$, where o_R and o_F are variables that describe the real and financial integration of the household, respectively. The variable o_R determines the household's source of income, taking a value of one if the household receives its labor income from the tradable sector and zero if it receives it from the nontradable sector. The variable o_F determines the household's access to financial securities, taking a value of one if the household can save in both types of financial securities and zero if it can save only in domestic securities. The household's recursive problem is given by

$$V_t(z, \mathbf{b}, \mathbf{o}) = \max_{c_{\mathrm{H}}, c_{\mathrm{F}}, c_{\mathrm{N}}, l, \mathbf{b}'} u(c, l) + \beta \mathbb{E}_t \left[(1 - \xi) V_{t+1}(z', \mathbf{b}', \mathbf{o}') + \xi \tilde{V}_{t+1}(z', \mathbf{b}', \mathbf{o}') \right] \quad (2)$$

$$\text{s.t. } c = \mathcal{C}_{\mathrm{TN}}(c_{\mathrm{T}}, c_{\mathrm{N}}),\ c_{\mathrm{T}} = \mathcal{C}_{\mathrm{HF}}(c_{\mathrm{H}}, c_{\mathrm{F}}), \quad (3)$$

$$\begin{aligned} & P_{\mathrm{H}t} c_{\mathrm{H}} + P_{\mathrm{F}t} c_{\mathrm{F}} + P_{\mathrm{N}t} c_{\mathrm{N}} + q_{\mathrm{D}t} b'_{\mathrm{D}} + q_{\mathrm{E}t} b'_{\mathrm{E}} + \Phi(b'_{\mathrm{D}}, b'_{\mathrm{E}}, o_F) \\ & \quad = z(1 - \tau_t) W_t(o_R) l + T_t(z) + b_{\mathrm{D}} + b_{\mathrm{E}}, \\ & \mathbf{b}' \in \mathcal{B}(o_F), \\ & \mathbf{o}' = \Gamma(\mathbf{o}), \end{aligned} \quad (4)$$

where $P_{\mathrm{H}t}$, $P_{\mathrm{F}t}$, and $P_{\mathrm{N}t}$ respectively represent the prices of home tradable goods, foreign tradable goods, and nontradable goods denominated in local currency; $q_{\mathrm{D}t}$ and $q_{\mathrm{E}t}$ represent the prices of the risk-free zero-coupon domestic and external bonds;[5] τ_t represents a labor-income tax; $T_t(z)$ represents a lump-sum transfer from the government and firms, which potentially depends on the household's idiosyncratic productivity; $\Gamma(\mathbf{o})$ denotes the law of motion of the household's financial and real integration; ξ represents the household's death rate; and $\tilde{V}_t(z, \mathbf{b}, \mathbf{o})$ denotes the value of a household that receives the realization of a shock whereby it dies and retires from the economy in the following period, given by $\tilde{V}_t(z, \mathbf{b}, \mathbf{o}) = \max_{c_{\mathrm{H}}, c_{\mathrm{F}}, c_{\mathrm{N}}, l} u(c, l)$ s.t. $P_{\mathrm{H}t} c_{\mathrm{H}} + P_{\mathrm{F}t} c_{\mathrm{F}} + P_{\mathrm{N}t} c_{\mathrm{N}} = z(1 - \tau_t) W_t(o_R) l + T_t(z) + b_{\mathrm{D}} + b_{\mathrm{E}}$. Each period, a new mass of households, ξ, is born with no assets and exogenous idiosyncratic states drawn from their ergodic distributions, so the total mass of households is always fixed at one.

International integration determines the wage $W_t(o_R)$ and the set of financial securities available for the household $\mathcal{B}(o_F)$. On the real side, the wage of integrated households is that paid to workers in the home sector $W_t(o_R = 1) = W_{\mathrm{H}t}$, while that of nonintegrated households is the wage

[5] In the baseline model of this section, we assume that bonds are denominated in local currency. Appendix section A6 studies the case of bonds denominated in foreign currency.

paid to workers in the nontradable sector $W_t(o_R = 0) = W_{Nt}$. On the financial side, the set of financial securities available for integrated households is $\mathcal{B}(o_F = 1) \equiv \{\mathbf{b}' : q_{Dt} b'_D + q_{Et} b'_E \geq \bar{b} P_t\}$, where P_t denotes the ideal price index of the consumption bundle, meaning that these households face a fixed limit for their total borrowing in real terms, and the set of financial securities available for nonintegrated households is $\mathcal{B}(o_F = 0) \equiv \{\mathbf{b}' : q_{Dt} b'_D \geq \bar{b} P_t, b'_E = 0\}$, meaning that in addition to the borrowing constraint, these households can neither save nor borrow in external securities. Finally, the function $\Phi(b'_D, b'_E, o_F)$ introduces adjustment costs in the composition of the households' financial portfolio. As further discussed below, this friction gives rise to endogenous deviations from UIP and nests the case of no UIP deviations for a particular parameterization.

B. *Firms*

The economy has access to technologies to produce two types of goods: home tradable goods (H) and nontradable goods (N). In each sector, there are two types of firms: final-good producers and intermediate-good producers. All firms are owned by domestic households.

Final-good producers.—A continuum of representative final-good producers operate in each sector and transform intermediate goods $\tilde{y}_{jst}$ into final goods with production technology

$$Y_{st} = \left(\int y_{jst}^{(\epsilon-1)/\epsilon} \mathrm{d}j \right)^{\epsilon/(\epsilon-1)},$$

where $j \in [0, 1]$ indicates the variety of each intermediate good and $s \in [\mathrm{H}, \mathrm{N}]$. Final-good producers in each sector choose intermediate inputs to maximize their static profits, which leads to a demand function faced by intermediate-good producers in each sector, $\mathcal{Y}_{jst}(p_{jst}) = (p_{jst}/P_{st})^{-\epsilon} Y_{st}$, where $P_{st} = (\int p_{jst}^{1-\epsilon} \mathrm{d}j)^{1/(1-\epsilon)}$ gives the ideal price index in sector s and period t.

Intermediate-good producers.—A continuum of intermediate-good producers uses labor n_{jst} to produce its variety j, with a constant returns technology $y_{jst} = A n_{jst}$. Each intermediate-good producer operates under monopolistic competition and sets its price in local currency to maximize the net present value of its profits, facing price adjustment costs à la Rotemberg (1982) and the demand from final-good producers,

$$\max_{p_{st}} \Pi_{st}(p_{st}) + \sum_{l=1}^{\infty} \mathbb{E}_t \left[\left(\prod_{k=1}^{l} \frac{1}{1 + r_{t+k}} \frac{1 + \pi_{st+k}}{1 + \pi_{t+k}} \right) \Pi_{st+l}(p_{s,t+l}) \right], \tag{5}$$

where $\Pi_{st}(p_t) \equiv [(p_{st}/P_{st}) - w_{st}](p_{st}/P_{st})^{-\epsilon} Y_{st} - \Theta_{st}(p_{st}/p_{st-1})$ represents profits in period t, where $w_{st} \equiv W_{st}/AP_{st}$ represents the effective real wage in sector s and $\Theta_{st}(p_{st}/p_{st-1}) = (\theta/2)[(p_{st}/p_{st-1}) - 1]^2 Y_{st} P_{st}$ represents the cost

of adjusting prices; $\pi_t \equiv (P_t/P_{t-1}) - 1$ and $\pi_{st} \equiv (P_{st}/P_{st-1}) - 1$ represent the inflation rates at the aggregate and sectoral level, respectively; and $r_{t+1} \equiv [(1 + i_t)/(1 + \pi_{t+1})] - 1$ represents the domestic real interest rate, where i_t denotes the domestic monetary policy rate.[6] Note that in problem (5) we drop the subindex j because all intermediate producers are identical. From the solution to this problem, we can derive the New Keynesian Phillips curve for each sector $s \in \{H, N\}$:

$$\pi_{st}(1 + \pi_{st}) = \frac{\epsilon}{\theta}\left(w_{st} - \frac{\epsilon - 1}{\epsilon}\right) + \mathbb{E}_t\left[\frac{1}{1 + r_{t+1}}\frac{1 + \pi_{st+1}}{1 + \pi_{t+1}}\frac{Y_{s,t+1}}{Y_{st}}(1 + \pi_{s,t+1})\pi_{s,t+1}\right].$$

C. *Government*

The government determines monetary and fiscal policies. For monetary policy, we assume that the government follows a simple Taylor rule,

$$i_t = i_{ss} + \phi\pi_t + v_t, \tag{6}$$

where v_t represents an exogenous monetary policy shock that follows the autoregressive process $v_t = \rho_m v_{t-1} + \epsilon_{m,t}$ and i_{ss} represents the steady-state nominal interest rate. This interest rate determines the price of the zero-coupon domestic bond, which is given by

$$q_{Dt} = \frac{1}{1 + i_t}. \tag{7}$$

In section IV.C, we compare the dynamics under a fixed exchange rate regime instead of a Taylor rule. On the fiscal side, the government finances the transfers to households T_t, spending G_t, and debt payment B_t by labor income tax and debt issuance. Its budget constraint is given by

$$\tau_t(N_{Ht}W_{Ht} + N_{Nt}W_{Nt}) + q_{Dt}B_{t+1} = T_t + G_t + B_t, \tag{8}$$

where $N_{st} \equiv \int n_{jst}\,dj$ represents aggregate employment in sector s. The total transfers received by households are then given by $\int T_t(z)\,dz = T_t + \Pi_t$, where Π_t represents aggregate profits in home and nontradable sectors expressed in local currency; in section III, we discuss the functional form of $T_t(z)$ used in the quantitative analysis. In the baseline model, we assume that the government follows a fiscal policy that keeps the transfer, spending, and debt issuance at a constant real value—that is, $T_t = T_{ss}P_t$,

[6] We follow Kaplan, Moll, and Violante (2018) and assume that firms discount profits at the domestic real interest rate. Also, the choice of the domestic rate for discounting renders the model closer to its representative-agent open-economy counterpart, which features domestic ownership of firms.

$G_t = G_{ss}P_t$, and $B_{t+1} = B_{ss}P_t$. In appendix section A10, we discuss the results with alternative fiscal policies.

D. *The Rest of the World*

The rest of the world trades external financial securities and tradable goods with the small open economy. From the perspective of the small open economy, the rest of the world provides an international interest rate for external securities, a foreign demand for the home tradable good, and a foreign supply of the foreign tradable good.

For external financial securities, the small open economy faces a perfectly elastic demand, with a nominal interest rate in foreign currency, i_t^*, following an exogenous autoregressive process $i_t^* = (1 - \rho_{m^*})i_{ss}^* + \rho_{m^*}i_{t-1}^* + \epsilon_{m^*,t}$, where i_{ss}^* represents the steady-state rate and $0 < \rho_{m^*} < 1$. The shock, $\epsilon_{m^*,t}$, can be interpreted as a foreign monetary-policy shock, which we study in section IV.B in analyzing international spillovers. This interest rate determines the price of the zero-coupon external bond, which is given by

$$q_{\mathrm{F}t} = \mathbb{E}_t\left[\frac{1}{1 + i_t^*}\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right], \tag{9}$$

where $\mathcal{E}_t$ denotes the nominal exchange rate of domestic currency per unit of foreign currency.

On the tradable goods side, we assume a completely elastic supply of the foreign good at a fixed price in foreign currency, which we denote as $P_{\mathrm{F}t}^*$, and a downward-sloping foreign demand of the home tradable good, which is given by

$$C_{\mathrm{H}t}^* = \left(\frac{P_{\mathrm{H}t}^*}{P_{\mathrm{F}t}^*}\right)^{-\eta} Y_{\mathrm{F}t}^*, \tag{10}$$

where $P_{\mathrm{H}t}^*$ represents the price of the home tradable good expressed in foreign currency and $Y_{\mathrm{F}t}^*$ represents a foreign demand shifter that follows an exogenous autoregressive process $\log Y_{\mathrm{F}t}^* = \rho_{y^*} \log Y_{\mathrm{F}t-1}^* + \epsilon_{y^*,t}$.

These conditions can be microfounded from the problem of a representative foreign household that is risk neutral, has CES preferences over H and F tradable goods, and is infinitely large relative to the small open economy but the share of home tradable good consumption in its consumption basket is infinitely small.[7]

[7] Under this structure, the foreign supply of the foreign good is infinitely large relative to the small open economy, which gives rise to a completely elastic supply of that good. Alternatively, the foreign demand of the home tradable good is finite from the perspective of the small open economy, by making the share of the home tradable good infinitesimally small. In fact, in this case the demand shifter is equal to $Y_{\mathrm{F}t}^* \equiv \lim_{\omega_{\mathrm{H}}^* \to 0, C_{\mathrm{F}t}^* \to \infty} [\omega_{\mathrm{H}}^*/(1 - \omega_{\mathrm{H}}^*)]^{1/\eta} C_{\mathrm{F}t}^* > 0$ and finite.

E. Equilibrium

We define the competitive equilibrium as follows.

DEFINITION 1. Given exogenous processes $\{v_t, Y^*_{Ft}, i^*_t\}$, government policies $\{i_t, \tau_t, B_{t+1}\}$, and transfers to households $\{T_t(z)\}$, an equilibrium is a stochastic sequence of households' value functions $\{V_t(z, \mathbf{b}, \mathbf{o}), \tilde{V}_t(z, \mathbf{b}, \mathbf{o})\}$ and policy functions $\{c_{H,t}(z, \mathbf{b}, \mathbf{o}), c_{F,t}(z, \mathbf{b}, \mathbf{o}), c_{N,t}(z, \mathbf{b}, \mathbf{o}), l_t(z, \mathbf{b}, \mathbf{o}), b'_{Dt}(z, \mathbf{b}, \mathbf{o})\}, b'_{Et}(z, \mathbf{b}, \mathbf{o})\}$; intermediate-good producers' choices $\{y_{st}, n_{st}, p_{st}\}_{s=\{N,T\}}$; aggregate allocations $\{Y_{s,t}, N_{s,t}\}_{s=\{N,T\}}$; prices $\{W_{H,t}, W_{N,t}, P_{Ht}, P_{Ft}, P_{Nt}, P_t, \mathcal{E}_t, q_{Dt}, q_{Et}\}$; and a distribution of households $\mu_t(z, \mathbf{b}, \mathbf{o})$, such that the following hold.

1) Households' value function $V_t(z, \mathbf{b}, \mathbf{o})$ solves problem (2) with the associated policy functions $\{c_{H,t}(z, \mathbf{b}, \mathbf{o}), c_{F,t}(z, \mathbf{b}, \mathbf{o}), c_{N,t}(z, \mathbf{b}, \mathbf{o}), l_t(z, \mathbf{b}, \mathbf{o}), b'_{Dt}(z, \mathbf{b}, \mathbf{o}), b'_{Et}(z, \mathbf{b}, \mathbf{o})\}$, taking as given the path of equilibrium prices and transfers.
2) Intermediate-good producers' choices solve problem (5) given the equilibrium prices and government policies, interest rates, policies, and transfers.
3) Bond prices satisfy (7) and (9).
4) $C^*_{H,t}$ satisfies (10), and the price of foreign tradable goods satisfies the law of one price, $P_{Ft} = P^*_F \mathcal{E}_t$.
5) The markets for nontradable-sector labor, tradable-sector labor, nontradable goods, tradable home goods, and domestic bond all clear:

$$\int z l_t(z, \mathbf{b}, \mathbf{o}) \mathbf{1}_{o_R=0} d\mu_t(z, \mathbf{b}, \mathbf{o}) = N_{N,t}, \tag{11}$$

$$\int z l_t(z, \mathbf{b}, \mathbf{o}) \mathbf{1}_{o_R=1} d\mu_t(z, \mathbf{b}, \mathbf{o}) = N_{H,t}, \tag{12}$$

$$\int c_{N,t}(z, \mathbf{b}, \mathbf{o}) d\mu_t(z, \mathbf{b}, \mathbf{o}) = Y_{N,t}, \tag{13}$$

$$\int c_{H,t}(z, \mathbf{b}, \mathbf{o}) d\mu_t(z, \mathbf{b}, \mathbf{o}) + C^*_{H,t} = Y_{H,t}, \tag{14}$$

$$\int b'_{Dt}(z, \mathbf{b}, \mathbf{o}) d\mu_t(z, \mathbf{b}, \mathbf{o}) = B_{t+1}. \tag{15}$$

6) Aggregate quantities are consistent with individual policies—that is, $Y_{st} = y_{st}$ and $N_{st} = n_{st}$ for $s = \{N, T\}$—and the law of motion of the household distribution, $\mu_t(z, \mathbf{b}, \mathbf{o})$, is consistent with individual policies.

F. Discussion of Assumptions

This section discusses the main assumptions of the baseline model. Section IV.D summarizes how our main quantitative results change under alternative model assumptions.

First, our baseline model introduces heterogeneity in households' international real and financial integration. On the real side, households' heterogeneity builds on the sectoral distinction of tradable and nontradable goods production, which is widely used in international macro models. Our model assumes that households work in either of the two sectors and receive uninsurable labor income from that sector. This gives rise to the heterogeneous effects of aggregate shocks for households working in different sectors, which have been studied in the macrolabor and international trade literature (e.g., Goldberg and Pavcnik 2007; Autor, Dorn, and Hanson 2013; Hausman, Rhode, and Wieland 2019). On the financial side, households' heterogeneity builds on market segmentation, which is another widely studied friction in macro models (e.g., Alvarez, Atkeson, and Kehoe 2002; Chien, Cole, and Lustig 2012). Our model assumes that agents differ in their access to international financial markets, consistent with evidence in the international macro literature (e.g., Maggiori, Neiman, and Schreger 2017; Maggiori 2022). In addition, we incorporate rich heterogeneity along the income and wealth dimension. Doing so allows us to contrast the relevance of heterogeneity in international integration with that in wealth and income, which has been the main focus in the closed-economy literature.

Second, regarding households' mobility along international integration, our baseline model abstracts from endogenous transitions. Although in appendix section A1 we endogenize these transitions using techniques from dynamic discrete-choice models, we choose a more parsimonious exogenous specification for transitions because of the low frequencies of transitions observed in the data.[8] On the real side, the labor literature shows that sectoral transitions occur infrequently and most workers' transitions occur without changing sector (e.g., Lilien 1982; Loungani and Rogerson 1989; Pilossoph 2014; Chodorow-Reich and Wieland 2020). On the financial side, infrequent transitions between international integration are consistent with the fact that households infrequently adjust their financial portfolios and maintain sticky relationships with their financial intermediaries (e.g., Agnew, Balduzzi, and Sundn 2003; Chodorow-Reich 2013; Giglio et al. 2019).

[8] As we show in app. sec. A1, the low frequencies of transitions imply that endogenizing such transitions does not lead to quantitatively different results. In that appendix, we also study how the results in the baseline model and in the model with endogenous transitions are affected by the degree of persistence in international integration.

Third, our model features the possibility of endogenous deviations from UIP, which have been documented as sizable in the data (e.g., Fama 1984; Kalemli-Özcan 2019). Our model builds on the literature that links such deviations to frictions in international financial markets (e.g., Gabaix and Maggiori 2015; Itskhoki and Mukhin 2017; Maggiori 2022) and does so through international market segmentation and costly adjustments of portfolios. An advantage of such a specification is that we can nest the particular case of no deviations from UIP (for details, see app. sec. A3). It is worth noting that our formulation abstracts from UIP deviations that stem from currency risk premium (see, e.g., Lustig and Verdelhan 2007; Hassan and Zhang 2021).[9]

Finally, our baseline model assumes that the prices of both goods and financial securities are denominated in local currency. Appendix section A5 studies an environment in which the prices of tradable goods are set in foreign currency, which has been documented to be commonly used as a unit of account and shown to be relevant for the transmission of monetary policy (e.g., Devereux and Engel 2003; Corsetti, Dedola, and Leduc 2010; Gopinath, Itskhoki, and Rigobon 2010; Mukhin 2018; Gopinath et al. 2020). In addition, appendix section A6 analyzes the case in which financial securities are denominated in foreign currency, following the literature of "original sin" (Eichengreen, Hausmann, and Panizza 2002; Ottonello and Perez 2019; Du, Pflueger, and Schreger 2020; Engel and Park 2021).

III. Parameterization

We calibrate our model to Canada, which is a prototypical small open economy that has been extensively analyzed in the literature. Our calibration strategy targets key macro moments of the economy and micro moments related to household heterogeneity. One period is a quarter. We calibrate the model in three steps.

In the first step, we fix a subset of parameters to standard values in the literature. These are reported in table 1. The exit rate for households is set at $1/(82.5 \times 4)$ to match the average life expectancy for Canada in 2020 of 82.5 years. For households' preferences, we assume a separable period utility,

$$u(c, l) = \frac{c^{1-\nu_c}}{1-\nu_c} - \psi \frac{l^{1+\nu_L}}{1+\nu_L},$$

and set the intertemporal elasticity of substitution $1/\nu_c$ and the Frisch elasticity of labor supply ν_L to one. We set the disutility of labor supply

[9] While introducing risk considerations in the households' portfolio problem is worth analyzing, doing so would require a solution method different from that used in our paper and the current generation of HANK models.

TABLE 1
FIXED PARAMETERS

Parameter	Description	Value
Households:		
ξ	Exit rate	$1/(82.5 \times 4)$
$1/\nu_c$	Intertemporal elasticity of substitution	1
$1/\nu_l$	Frisch elasticity of labor supply	1
ψ	Disutility of labor	7.93
β	Discount factor	.96
Firms:		
ϵ	Elasticity of substitution for final goods aggregator	10
θ	Adjustment cost of goods price	100
Government and rest of the world:		
τ	Income tax rate	.20
T_{ss}	Total transfer	.12
B_{ss}	Government debt	.85
i_{ss}	Steady-state domestic interest rate	.01
i^*_{ss}	Steady-state international interest rate	.01

NOTE.—Intermediaries' productivity was set to $A = 3.37$ to normalize the average labor income in steady state to one.

ψ to target a steady-state level of hours of 1/3 and the discount factor to target a steady-state domestic annual interest rate of 4%. For firms, we set the elasticity of substitution in the technology of final-good producers to $\epsilon = 10$, which implies a markup of 11%. We set the parameter that governs the adjustment costs of prices to $\theta = 100$, which implies a slope of the Phillips curve of 0.1, as in Kaplan, Moll, and Violante (2018). For the government, we set transfers to $T_{ss} = 0.12$ and government spending to $G_{ss} = 0.08$ to match the fraction of transfers and tax payments in total household income for Canada, computed from the 2016 Survey of Financial Security (SFS). Regarding government debt, we set $B_{ss} = 0.85$ to target a median liquid wealth-to-income ratio of 0.35 for Canada, also computed from the 2016 SFS. Finally, we set the steady-state domestic and international interest rates to $i_{ss} = i^*_{ss} = 1\%$. Given that there is zero inflation and exchange rate depreciation in the steady state, this implies that UIP holds in the steady state.

The second step of our calibration targets steady-state moments with the subset of parameters reported in table 2. For the parameters that govern households' idiosyncratic income processes, we follow recent literature on households' heterogeneity applied to the case of Canada. In particular, the idiosyncratic income shock process is constructed as a mixture of two independent Markov processes: $z = z_1 + z_2$, where z_1 and z_2 respectively represent the persistent and temporary components of households' idiosyncratic income process. We follow Rouwenhorst (1995, 294–330) to construct the discretized process of z_1 and z_2. Under this

TABLE 2
CALIBRATED PARAMETERS

Parameter	Description	Value
	A. Parameters Governing the Steady State	
Idiosyncratic risk:		
ρ_1	Persistent idiosyncratic income, autocorrelation	.75
σ_1	Persistent idiosyncratic income, unconditional standard deviation	.78
skew_1	Persistent idiosyncratic income, unconditional skewness	−4.07
ρ_2	Transitory idiosyncratic income, autocorrelation	.25
σ_2	Transitory idiosyncratic income, unconditional standard deviation	.31
skew_2	Transitory idiosyncratic income, unconditional skewness	−2.05
$\underline{b}$	Borrowing constraint	−.29
International integration:		
λ_F^1	Financial integration, probability of remaining integrated	92%
λ_F^0	Financial integration, probability of remaining nonintegrated	96.06%
λ_R^1	Real integration, probability of remaining integrated	96%
λ_R^0	Real integration, probability of remaining nonintegrated	97.65%
$\bar{\alpha}(o_F = 1)$	Asset home bias of financially integrated households	.79
Preferences:		
ω_T	Fraction of tradable goods in consumption basket	.33
ω_H	Fraction of home goods in tradable goods consumption basket	.60
	B. Parameters Governing the Aggregate Responses	
Households and government:		
ϕ_b	Portfolio adjustment cost	.80
η	Intratemporal elasticity of substitution	6.19
ϕ_π	Taylor rule, coefficient of inflation	1.10
ϕ_i	Taylor rule, coefficient of lagged nominal interest rate	.87
Aggregate shocks:		
ρ_m	Domestic monetary shock, persistence	.68
σ_m	Domestic monetary shock, standard deviation	.25%
ρ_{m^*}	Foreign monetary shock, persistence	.81
σ_{m^*}	Foreign monetary shock, standard deviation	.25%
ρ_{y^*}	Foreign demand shock, persistence	.50
σ_{y^*}	Foreign demand shock, standard	15%

NOTE.—The value of $\underline{b}$ is expressed as a share of households' quarterly average labor income in steady state.

construction, each of these two processes is uniquely determined by three moments: first-order autocorrelation ρ_i, standard deviation σ_i, and skewness skew_i, for $i = 1, 2$. The mixture of these processes allows us to match a key set of data moments of log earnings dynamics, reported in table D.1: the variance, skewness, and kurtosis of the 1- and 5-year changes in log annual earnings. For further details on the identification of these moments using the Rouwenhorst method, see Lkhagvasuren (2012) and

Gospodinov and Lkhagvasuren (2014). Finally, for the distribution of transfers, we follow Kaplan, Moll, and Violante (2018) and assume that the aggregate profits are distributed to households proportional to the level of their idiosyncratic productivity—that is, $T_t(z) = T_t + (z/\bar{z})\Pi_t$, where $\bar{z}$ denotes the average idiosyncratic labor productivity across households. Figure D.6 compares the liquid wealth distribution in our model with that observed in the Canadian data. Although the model captures the overall shape of the distribution, it underestimates the right tail—as is the case in one-asset models, as shown by Kaplan and Violante (2022).

Given these income processes, the borrowing constraint $\underline{b}$ is set to one-third of the average quarterly labor income to match the median marginal propensity to consume (MPC) of households. In the steady state of our model, the median MPC is 15%, which is within the range of the estimates for the MPC of nondurable goods reported by Parker et al. (2013). Additionally, we calibrate the share of home goods in the tradable consumption basket $\omega_{\mathrm{H}} = 0.6$ to match the ratio of exports to output and the share of tradable goods in the consumption basket $\omega_{\mathrm{T}} = 0.33$ to target equal wages per efficiency for households working in different sectors, which makes analysis of the distributional implications of macroeconomic shocks more transparent. In appendix section A8, we analyze how the quantitative results are affected when we target different wages by sector in the steady state.

The most novel part of our calibration is the group of steady-state moments and parameters that are related to households' international integration. In our baseline calibration, we assume an exogenous evolution of households' real and financial integration and study the case of endogenous transitions in appendix section A1. We model real and financial integration as independent Markov processes with transition-probability matrices $\begin{bmatrix} \lambda_j^1 & 1-\lambda_j^1 \\ 1-\lambda_j^0 & \lambda_j^0 \end{bmatrix}$ for $j = R, F$, where λ_R^1, λ_R^0 denote the probabilities of remaining in the state of real integration and nonintegration, respectively, and λ_F^1, λ_F^0 denote the probabilities of remaining in the state of financial integration and nonintegration, respectively. Under this process, the unconditional share of integrated households is given by $(1 - \lambda_j^0)/(2 - \lambda_j^1 - \lambda_j^0)$.

In each dimension of international integration, we calibrate λ_j^1, λ_j^0 to match the unconditional share of integrated households and the persistence of the integrated status. Regarding real integration, we estimate a 37% share of households working in the tradable sector in Canada. In addition, we target a persistent process for real integration based on the infrequent changes in sectoral occupations estimated in the labor literature (Loungani and Rogerson 1989). The calibrated parameters are $\lambda_R^1 = 96\%$ and $\lambda_R^0 = 97.65\%$, which also imply a persistent process for

real integration. We present the details of these measurements in appendix B. Additionally, appendix section A1 studies how the quantitative results vary with alternative targets and endogenous transitions.

Regarding financial integration, we measure households' direct and indirect holdings of external securities. For direct holdings, we use data from the Canadian Financial Monitor. For indirect holdings, we measure the holdings of external securities of the main intermediary that the household is associated with, using intermediaries' balance sheet data from the Return of the Geographical Distribution of Assets and Liabilities Booked in Canada. Using these data, we identify integrated households as those with substantive levels of direct and indirect holdings of external securities. We describe the data, provide descriptive statistics, and present the details of this measurement in appendix B. We estimate a 33% share of financially integrated households and a 73.5% annual probability of remaining integrated. The calibrated parameters are $\lambda_F^1 = 92\%$ and $\lambda_F^0 = 96.06\%$, which imply a fairly persistent financial integration.

We parameterize the portfolio adjustment friction as

$$\Phi(b'_{\mathrm{D}}, b'_{\mathrm{E}}, o_F) = \frac{\phi_b}{2}\left(\frac{b'_{\mathrm{D}}}{b'_{\mathrm{D}} + b'_{\mathrm{E}}} - \bar{\alpha}(o_F)\right)^2 |b'_{\mathrm{D}} + b'_{\mathrm{E}}|,$$

where $\bar{\alpha}(o_F)$ represents the steady-state portfolio share of domestic securities, which depends on households' financial integration. For nonintegrated households, $\bar{\alpha}(o_F = 0) = 1$, so that they do not face any adjustment cost in equilibrium. For integrated households, we calibrate $\bar{\alpha}(o_F = 1) = 0.79$ to match the average portfolio composition of financially integrated households in Canada. We also consider alternative specifications in the robustness analysis.

The last step of our calibration targets aggregate responses to macroeconomic shocks. We do so to highlight the distributional implications of shocks whose aggregate responses are aligned with the data. The first of these targeted aggregate responses are to a domestic monetary policy shock. We focus on the peak responses of aggregate consumption, the nominal policy rate, the price index, and the UIP deviation to a 25 basis point (bp) monetary policy shock, documented by Champagne and Sekkel (2018). The parameters that are most relevant to determine the responses of consumption, the nominal policy rate, and the price index are the inflation coefficient in Taylor rule ϕ_π, the persistence of Taylor rule ϕ_i, and the persistence of the monetary policy shock ρ_M. The strength of the portfolio adjustment costs, ϕ_b, mostly determines the strength of the UIP deviation: as shown in appendix section A3, the case of $\phi_b = 0$ corresponds to no deviations from UIP. The larger the ϕ_b, the stronger the deviations from UIP. The second set of targeted aggregate responses are to the foreign demand shock, as documented by Charnavoki and Dolado (2014). We set the persistence and standard deviation of the foreign

demand shock, ρ_Y^H and σ_Y^H, and the intratemporal elasticity of substitution in the consumption aggregator, η, to match the peak responses of the exchange rate, exports, and aggregate consumption to foreign demand shocks. Finally, we set the persistence of foreign monetary policy shocks to match the autocorrelation of US policy rates between 1980:Q1 and 2007:Q1 and set its standard deviation to 25 bp to obtain a clear comparison of the effects from the domestic monetary shock and those from the foreign monetary shock. All parameter values are reported in table 2, and the targeted moments are reported in table D.2.

We solve the model using the method proposed by Reiter (2009), which consists of two steps. First, we solve the steady state with no aggregate shocks. The steady state characterizes the distribution of households and the heterogeneity of their consumption and saving when the aggregate quantities and prices are fixed at their steady-state levels. Then we solve the first-order perturbation around the steady state. The solved dynamics characterize the responses of different households' consumption and saving policies, the distribution of households, and the aggregate quantities and prices following the different types of aggregate shocks.

IV. Classic Questions in International Macroeconomics from a Distributional Perspective

This section uses our open-economy model to reassess three classic questions in international macroeconomics from a distributional perspective: section IV.A analyzes the effects of monetary policy, section IV.B analyzes the international spillovers of external shocks and policies, and section IV.C studies the implications of different exchange rate regimes. Finally, section IV.D analyzes how the answers to these questions vary under alternative model environments.

A. *Effects of Monetary Policy*

Aggregate effects.—We begin by studying the aggregate and distributional effects of changes in domestic monetary policy. Figure 1 shows the aggregate response to an expansionary monetary policy shock: a negative innovation to the Taylor rule $\epsilon_t^m = -0.0025$ (more detailed responses are depicted in fig. D.1). The peak responses of aggregate consumption, inflation, and the exchange rate are targeted by our calibration and (by design) aligned with the data. Due to price rigidities, the nominal decline in rates translates to a decline in real rates, which increases consumption, with a peak effect close to 0.5%. Currency depreciates in nominal and real terms, which generates an increase in external demand and higher exports. Firms respond to increased external and domestic demand by increasing both their output and their prices. The increase in

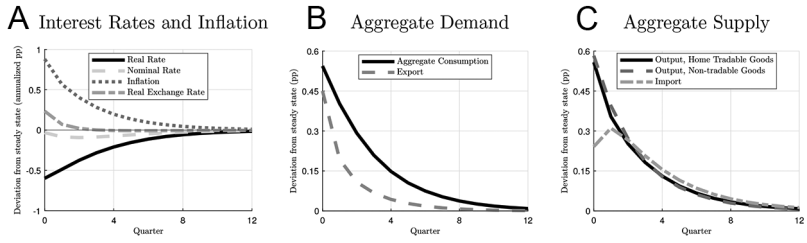

FIG. 1.—Aggregate effects of monetary policy shocks. This figure shows the responses of various aggregate variables in deviations from their steady-state value to a 25-bp expansionary monetary policy shock (i.e., $\epsilon_{m,t} = -0.0025$). *A*, Responses of nominal and real interest rates, the inflation rate of the ideal price index, and the (log) real exchange rate. *B*, Log deviations of aggregate consumption and exports. *C*, Log deviations of the home tradable goods output, nontradable goods output, and imports.

firms' output leads to higher wages, leading to additional increases in domestic consumption.

To further analyze the transmission of monetary policy shocks, panel A of table 3 decomposes the consumption responses into different channels: a real interest rate channel, which measures the effect on consumption of changes in nominal rates in local currency and inflation; a labor income channel, which measures the effect on consumption of households' labor income changes in response to shocks; and "others," which measures the effect of consumption on the rest of the general equilibrium responses to shocks, including profits, government taxes and transfers, and changes in the wealth distribution.[10] Indirect effects account for the majority of the real effects of a monetary stimulus. In particular, changes in labor income induced by changes in monetary policy and its effect on aggregate demand account for 51% of aggregate responses. In addition, appendix C compares the transmission of monetary policy with two benchmark models: a representative-agent open-economy model and a heterogeneous-agent closed-economy model. We show that, consistent with findings in the closed-economy literature, introducing heterogeneity in households' income and wealth leads to strong labor income channels in the transmission of monetary policy shocks. As we show in the next section, the main difference introduced by the open-economy aspect of

[10] We focus on decomposing the peak consumption responses. To do this, we first solve the equilibrium paths of the aggregate prices and quantities. For a specific variable, we fit its equilibrium path into the decision problem of households and keep all other relevant variables constant at their steady-state levels. The fraction between the solved consumption response and their full-equilibrium response is our measure of the contribution from the variation in this specific variable.

TABLE 3
DECOMPOSITION OF CONSUMPTION RESPONSES BY TRANSMISSION CHANNELS (%)

		By Real Integration		By Financial Integration		By Net Wealth	
	Aggregate	Nonintegrated	Integrated	Nonintegrated	Integrated	Low	High
				A. Domestic Monetary Shock			
Response with respect to the aggregate	1.00	1.02	.97	1.02	.96	1.24	.87
Decomposition by different channels:							
Real interest	.38	.38	.38	.40	.34	.23	.48
Nominal rate in domestic currency	.05	.05	.05	.07	.01	.02	.07
Inflation	.33	.33	.33	.33	.33	.22	.41
Labor income	.51	.53	.48	.51	.51	.81	.33
Others	.11	.11	.12	.11	.12	.20	.06
				B. Foreign Demand Shock			
Response with respect to the aggregate	1.00	.26	2.26	1.10	.80	1.22	.86
Decomposition by different channels:							
Real interest	.42	.42	.43	.52	.23	.18	.57
Nominal rate in domestic currency	.30	.30	.30	.40	.10	.16	.38
Inflation	.13	.13	.13	.13	.13	.01	.19
Labor income	.47	−.27	1.74	.47	.47	.93	.20
Others	.10	.10	.10	.10	.10	.12	.09
				C. Foreign Monetary Shock			
Response with respect to the aggregate	1.00	1.95	−.62	−.26	3.56	−.56	1.94
Decomposition by different channels:							
Real interest	1.73	1.73	1.73	.47	4.29	.91	2.21
Nominal rate in domestic currency	1.24	1.24	1.24	−.03	3.80	.69	1.57
Inflation	.49	.49	.49	.49	.49	.22	.65
Labor income	−.61	.34	−2.23	−.61	−.61	−1.31	−.18
Others	−.12	−.12	−.12	−.12	−.12	−.16	−.10

NOTE.—This table decomposes the consumption responses of different groups of households. Consumption responses correspond to the period in which the aggregate consumption response reaches its peak and are normalized by the size of peak aggregate consumption responses. Within each panel, the first row reports the total consumption response. The remaining rows report the response of consumption that is explained by the dynamics of different variables.

the heterogeneous-agent model is linked to external shocks and heterogeneity in international integration.

Distributional effects.—Our main focus is on the distributional consequences of monetary policy in the open-economy model. Panel A of table 4 shows that changes in monetary policy have uneven effects on households, as measured by the standard deviation of consumption responses, the difference between the 75th and 25th percentiles of consumption responses, and the difference between the 90th and 10th percentiles, all scaled by the peak effect of aggregate consumption (table D.3 presents the unscaled versions of these statistics). All of these measures increase in response to the shock; for instance, the differential consumption effect of households in the 90th and 10th percentiles is 50% of the consumption peak effect.

Panel B of table 4 decomposes the sources of heterogeneity in consumption response into the shares explained by differences in wealth, income, and international real and financial integration. This exercise shows that differences in wealth are the main source of heterogeneous responses to a monetary policy shock. Consistent with findings in closed-economy models, households with lower levels of wealth exhibit larger

TABLE 4
DISTRIBUTIONAL EFFECTS OF AGGREGATE SHOCKS

	Domestic Monetary Shock	Foreign Demand Shock	Foreign Monetary Shock
	A. Cross-Section Dispersion of Individual Consumption Responses		
Standard deviation	.25	1.47	3.21
Interquantile range	.30	1.20	1.64
90th–10th percentile range	.50	4.54	10.37
	B. Variance Decomposition of the Cross-Section Dispersion (%)		
Real integration	1.1	54.4	19.5
Financial integration	1.2	.8	26.2
Net wealth	36.3	2.8	19.7
Idiosyncratic labor income	34.2	.4	.8

NOTE.—Panel A reports various statistics to measure the cross-section dispersion of individual consumption responses when the aggregate consumption response reaches its peak. All statistics are normalized by the size of the peak aggregate consumption response. Panel B reports the contribution of each dimension of heterogeneity to the cross-section variance of individual consumption responses when the aggregate consumption response reaches its peak. The contribution is measured based on the decomposition identity $V[Y] = \mathbb{E}[V[Y|X]] + V[\mathbb{E}[Y|X]]$, where $V[Y]$ denotes the cross-sectional variance of consumption responses Y; $\mathbb{E}[V[Y|X]]$ denotes the average of within-group consumption response variance across the groups categorized by household characteristic X (i.e., real integration, financial integration, net wealth, idiosyncratic labor income); and $V[\mathbb{E}[Y|X]]$ denotes the variance of the corresponding within-group averages. The reported contributions of different dimensions of heterogeneity are measured by $V[\mathbb{E}[Y|X]]/V[Y]$.

marginal propensities to consume and are more responsive to changes in monetary policy. In fact, as shown in appendix C, the heterogeneous responses by wealth are quantitatively similar in our model to those in the closed-economy HANK. For this type of shock, heterogeneity in international integration does not play a predominant role. On the one hand, as shown in figure 1, changes in monetary policy induce similar responses in tradable and nontradable production, which lead to similar wage reactions of households with different international real integration. On the other hand, given the high degree of home bias in the assets of integrated households, all households have substantive exposure to changes in the domestic interest rate. In the next subsection, we show that for external shocks, international integration does play a predominant role in accounting for heterogeneity in consumption responses.

B. International Spillovers

Our second set of exercises studies the aggregate and distributional effects of external shocks. We consider two sources of shocks that are important for open economies: shocks to external demand and shocks to foreign monetary policy.

1. External Demand

Panels *A*–*C* of figure 2 show the aggregate responses of a positive shock to the external demand of home tradable goods (i.e., a positive innovation of $\epsilon_{y^*,t} = 0.15$), with more details provided in figure D.2. Firms in the home tradable goods sector respond to higher external demand by increasing their output and prices. On the one hand, the increase in output leads to higher wages and consumption for workers employed in the tradable sector. On the other hand, the relative price of home and foreign tradable goods adjusts through a currency appreciation and leads to an expenditure switching of domestic households toward foreign tradable goods.[11] Currency appreciation pushes down inflation, leading the monetary authority to cut its policy rate, which further amplifies the increase in domestic demand. The net effect of the external demand shock in the nontradable sector is modest, because the expansion in demand is offset by the expenditure switching induced by real exchange rate appreciation.

[11] The aggregate effects of the foreign demand shock on the exchange rate can be understood in terms of the classic textbook argument: an increase in exports generates a current account surplus, which induces capital outflows through an exchange rate appreciation. These responses are qualitatively consistent with the effects of the terms of trade shocks documented in the literature (see, e.g., Mendoza 1995; Schmitt-Grohé and Uribe 2018).

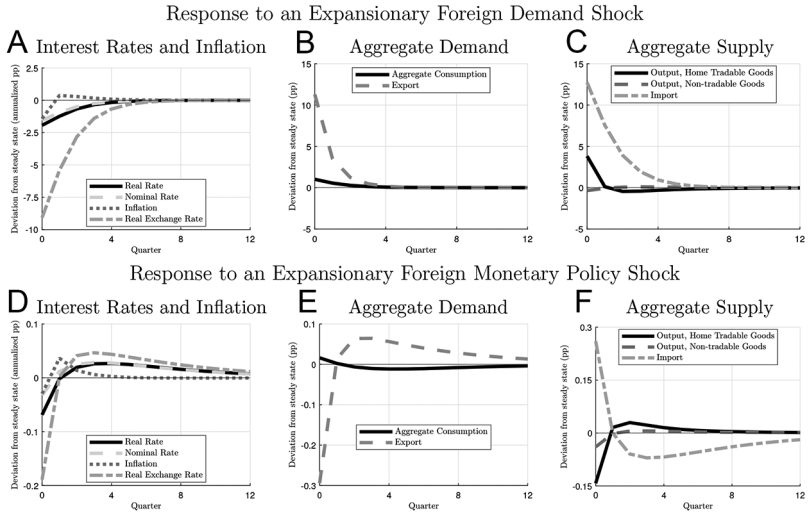

FIG. 2.—Aggregate effects of external shocks. *A–C*, Responses of various aggregate variables in deviations from their steady-state value to a 1 standard deviation expansionary external demand shock (i.e., $\epsilon_{y^*,t} = 0.15$). *D–F*, Responses of the same variables to a 25-bp expansionary foreign monetary policy shock (i.e., $\epsilon_{m^*,t} = -0.0025$). Panels *A* and *D* show the responses of nominal and real interest rates, the inflation rate of the ideal price index, and the (log) real exchange rate. Panels *B* and *E* show the log deviations of aggregate consumption and exports. Panels *C* and *F* show the log deviations of the home tradable goods output, nontradable goods output, and imports.

Panel A of table 4 shows that the external demand shock leads to uneven responses in consumption across households, as measured by the standard deviation of consumption responses, the difference between the 75th and 25th percentiles, and the difference between the 90th and 10th percentiles. Panel B of table 4 shows that the uneven real integration of households constitutes the most relevant dimension that drives heterogeneity in consumption responses to external demand shocks and accounts for 54% of the cross-sectional variance of consumption responses.

To visualize the heterogeneous effects on consumption responses along the novel dimensions of heterogeneity in our model, figure 3 depicts the peak consumption response for households with different international integration, normalized by the peak aggregate consumption response.[12] We vary the real integration of households along the horizontal axis, with the western (eastern) point showing the response of households

[12] Peak consumption responses at the individual level in this paper refer to individual consumption responses in the period when the aggregate consumption response reaches its peak. Under the current calibration, the consumption responses of almost all of the households reach their peaks in the same period in which the aggregate consumption response reaches its peak.

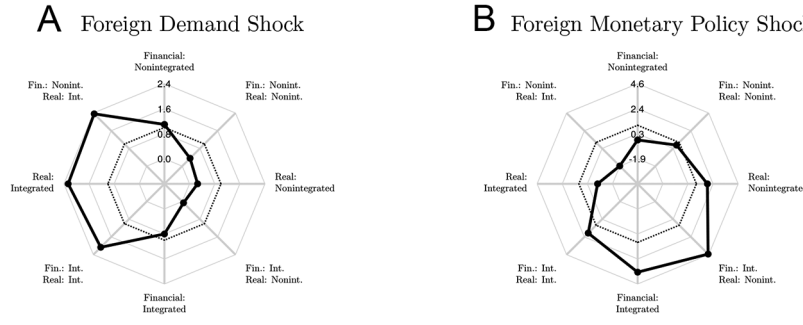

FIG. 3.—Heterogeneous consumption responses to expansionary external shocks. *A*, Distributional effects of a 1 standard deviation expansionary external demand shock (i.e., $\epsilon_{y^*,t} = 0.15$) on consumption. *B*, Distributional effects of a 25-bp expansionary foreign monetary policy shock (i.e., $\epsilon_{m^*,t} = -0.0025$) on consumption. Each panel shows the responses of the average consumption of different subgroups of households in the period when the aggregate consumption response reaches its peak. Households are categorized by their type of real and financial integration. All responses are normalized by the peak responses of aggregate consumption. As a benchmark, the dotted line corresponds to the case of homogeneous consumption responses. Fin. = financial integration; Int. = integrated; Non-int. = nonintegrated; Real = real integration.

working in the tradable (nontradable) sector. Similarly, we vary the financial integration of households along the vertical axis, with the northern (southern) point showing the response of households not integrated (integrated) with international capital markets. The diagonals show different cases, conditioning on both dimensions of international integration. The results show that the consumption of households working in the tradable sector is one order of magnitude more responsive to external demand shocks than that of households working in the nontradable sector. As shown in table 3, this is mostly due to the effect of external demand shocks on labor income, which are concentrated mostly in households working in the tradable sector.

2. Foreign Monetary Policy

Panels *D–F* of figure 2 show the aggregate responses to a foreign monetary policy expansion, with more details provided in figure D.3. The decline in foreign interest rates renders the returns of domestic securities relatively more attractive, which induces financially integrated households to tilt their portfolios toward domestic securities. This creates a sharp appreciation of the local currency on impact, leading to an expenditure switching of domestic households toward foreign tradable goods and a contraction in the output of tradable and nontradable goods. This contraction occurs despite the fact that the shock leads to a mild increase in domestic consumption triggered by direct channels from the decline in foreign rates. Appendix section A9 shows how the aggregate effects of

foreign monetary policy shocks are governed by the elasticity of substitution between home and foreign goods and the degree of home bias in the financial portfolios of integrated households. For our baseline parameterization, this shock has a modest effect on consumption, which is one order of magnitude lower than the effect of domestic monetary policy.

Panel A of table 4 shows that the foreign monetary policy shock has uneven effects across different households, with increases in the standard deviation of consumption responses, the difference between the 75th and 25th percentiles, and the difference between the 90th and 10th percentiles. As shown in table 3, this is to a large extent because the foreign monetary policy shock induces direct channels that affect only financially integrated households. Figure 3*B* shows that because of these direct channels, the consumption of financially integrated households responds around four times more than aggregate consumption. Table 4 shows that heterogeneity in financial integration accounts for 26% of the cross-sectional variance of consumption responses. In addition, this table shows that real integration plays an important role in the heterogeneous responses to a foreign monetary policy shock. This is because the real exchange rate appreciation has a negative impact on households' wages, which is more pronounced for those working in the tradable sector (see fig. 3; table 4).

3. The Relevance of Heterogeneity in Households' International Integration

We conclude by emphasizing a key takeaway from this section. It is well documented that an important part of fluctuations in open economies stems from foreign macroeconomic shocks. Our analysis shows that the uneven international integration of households gives rise to inequality in the individual responses to these shocks, more so than heterogeneity in income and wealth, which has been the main focus of the closed-economy literature on household heterogeneity.

C. Exchange Rate Regimes

The third classic question we address is how different exchange rate regimes compare. To answer this question, we compare the aggregate and distributional responses to external shocks under the flexible exchange rate regime from the Taylor rule in our baseline model (described in sec. IV.B) with those in an economy in which the monetary authority chooses domestic interest rates to set $\mathcal{E}_t = 1$ for all periods.

Panels *A* and *C* of figure 4 show that, as is standard in representative-agent open-economy New Keynesian models (e.g., Gali and Monacelli 2005), aggregate consumption has a larger response to shocks under a fixed exchange rate regime than under a flexible regime. As further

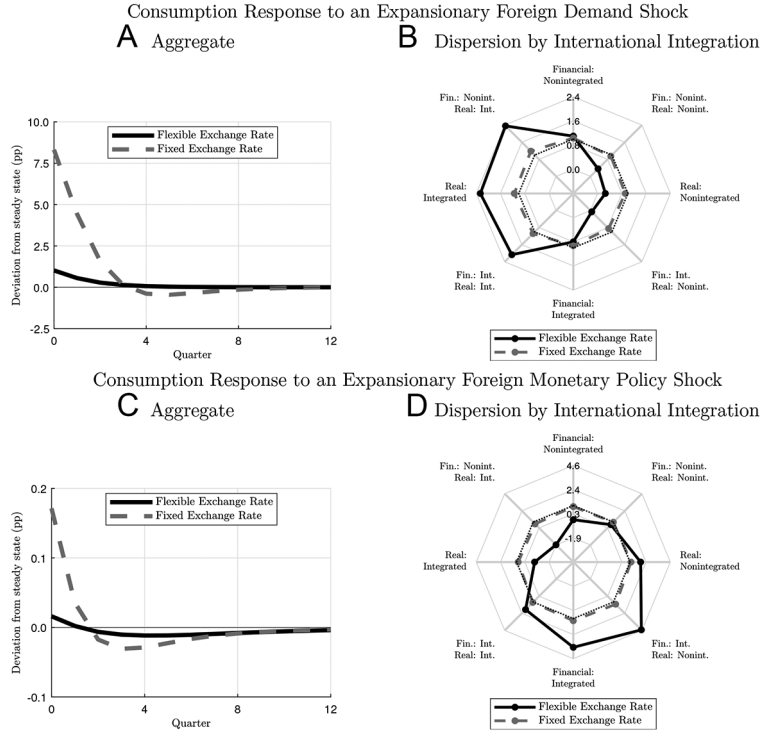

FIG. 4.—Aggregate and distributional effects of external shocks under alternative exchange rate regimes. *A, B,* Impact of a 1 standard deviation of external demand shock (i.e., $\epsilon_{y^*,t} = 0.15$) on consumption under different exchange rate regimes. *C, D,* Impact of a 25-bp expansionary foreign monetary policy shock (i.e., $\epsilon_{m^*,t} = -0.0025$) on consumption under different exchange rate regimes. Panels *A* and *C* show the responses of aggregate consumption. Panels *B* and *D* show the responses of the total consumption of different subgroups of households in the period in which the aggregate consumption response reaches its peak. Households are categorized by their type of real and financial integration. All responses are normalized by the peak responses of aggregate consumption. As a benchmark, the solid line corresponds to the case of homogeneous consumption responses. "Flexible Exchange Rate" corresponds to the baseline model (described in sec. II). "Fixed Exchange Rate" corresponds to the equilibrium under which the monetary policy sets the nominal rate to target $\mathcal{E}_t = 1$ in all periods. Fin. = financial integration; Int. = integrated; Non-int. = nonintegrated; Real = real integration.

detailed in figures D.4 and D.5, this is because when there is an expansion induced by either an external demand shock or a foreign monetary policy shock, under a fixed exchange rate regime the monetary authority decreases its interest rate more sharply to avoid currency appreciation, which creates additional expansions in domestic demand. As a result, for both increases in external demand and declines in foreign interest

rates, the aggregate consumption response is larger under a fixed exchange rate regime than under a Taylor rule.[13]

Figure 4 also compares the distributional implications of the different exchange rate regimes, by depicting the relative consumption responses of households with different degrees of international integration. Figure 4*B* shows the case of external demand shocks, which indicates that a flexible exchange rate regime leads to more unequal responses between households working in different sectors relative to a fixed exchange rate regime. As shown in table D.4, this is due to the differential effect of the external demand shock on their labor income, which is more uneven under a flexible exchange rate. Under a fixed exchange rate, as the monetary authority declines rates to prevent currency appreciation it stimulates aggregate demand. This increases the labor income of households working in nontradable sectors and attenuates the differential consumption responses of households along the real integration dimension.

Figure 4*D* shows that a fixed exchange rate regime is also associated with more even consumption responses between integrated and nonintegrated households in the case of foreign monetary policy shocks. In this case, the main source of inequality in consumption responses under the flexible exchange rate regime is the uneven impact of direct changes in interest rates for households that are integrated with international financial markets vis-à-vis those not integrated with international markets (see table D.4). Under the fixed exchange rate regime, the reduction in the domestic policy rate to prevent currency appreciation triggers direct expansionary channels for households not integrated with international financial markets, which causes the interest rate channel to be more even for both integrated and nonintegrated households. An implication of this analysis is that the dispersion of relative consumption responses can be smaller under a fixed exchange rate regime than under a flexible one (see fig. D.7).

Stabilization-inequality trade-off of exchange rate regimes.—A second takeaway is that the choice of monetary policy in open economies—and in particular the choice of exchange rate regimes—entails distributional consequences for households with different degrees of international integration. To the extent that the objective of monetary authorities includes inequality considerations, our results indicate the presence of a trade-off between aggregate stabilization and consumption inequality in the conduct of monetary policy.

[13] See Broda (2004) for empirical evidence on the larger output response to a terms-of-trade shock in countries with fixed exchange rate regimes vs. those with flexible exchange rate regimes.

D. Extensions

Appendix A analyzes the results of the aggregate and redistributional effects of monetary policy under different model extensions. First, we study the role of mobility in international integration. For this, appendix section A1 endogenizes households' international integration. If we target the same persistence of international integration as in our baseline model, endogenizing transitions does not alter our quantitative conclusions. However, table A2 shows that for economies with more frequent transitions between integration and nonintegration, the distributional effects of aggregate shocks are dampened with endogenous transitions.

Second, we study the role of international integration with financial markets that drive the aggregate and distributional responses to shocks. Appendix section A2 analyzes an economy in which financially integrated households do not have home bias in their asset portfolios. In that economy, the direct effects of changes in the foreign monetary policy rate are larger, and so are their aggregate effects on consumption. Additionally, financial integration is a more relevant source of heterogeneity in consumption responses to domestic monetary policy shocks, which do not affect financially integrated households through direct channels. Appendix section A3 analyzes an economy without deviations from UIP; in this economy, financial integration ceases to be a relevant source of heterogeneity. Appendix section A4 shows that the main distributional conclusions still hold in an economy in which integrated households face the costs of adjusting only their external bond positions.

Third, we study the role of currencies as units of account. Appendix section A5 studies an economy in which the price of tradable goods is denominated in foreign currency. Appendix section A6 considers an economy in which financial securities are denominated in foreign currency. Both of these economies feature larger distributional effects of domestic monetary policy shocks. In the case of foreign currency denomination of prices, currency depreciation stimulates more income and consumption by workers in nontradable sectors, which generates more uneven responses along real integration. In the case of foreign-currency-denominated securities, currency depreciation triggers heterogeneous wealth effects that depend on the households' net asset positions, which generates more uneven consumption responses.

Finally, appendix sections A7 and A8 consider two additional model extensions. First, we extend the model to an economy with investment. The main difference is that this economy features milder consumption responses because expansionary shocks lead to large investment responses, which lead to more aggressive monetary policy reactions. Second, we study economies in which households' wealth is correlated with their international integration. The main takeaway from this analysis is that the

interaction between wealth and international integration becomes a relevant source of heterogeneity in accounting for the dispersion of consumption responses to shocks.

V. Globalization and Monetary Policy

So far, we have focused on how monetary policy affects the asymmetric effects of external shocks for a given degree of international integration. In this section, we examine how our conclusions are affected by two dimensions of globalization: the degree of international integration and capital flow mobility that characterize the economy. From a positive perspective, this exercise helps us understand how changes in the international integration and capital flow mobility that countries often experience are expected to alter the effects of shocks and the ability of monetary policy to influence these effects. From a normative perspective, this is an important input to the debate on the consequences of globalization that motivates this paper.

A. The Role of International Integration

To study the role of international integration, we compare the responses to macro shocks of the baseline economy with an identical economy with levels of real and financial integration that are half those of the baseline economy.[14] In this exercise, to decrease the level of real integration, we jointly decrease the share of households working in the tradable home goods sector relative to those working in the nontradable sector and the share of tradable home goods in the consumption basket relative to that of nontradable goods; to decrease the level of financial integration, we decrease the share of households that have access to financial securities that are internationally traded. This exercise aims to capture the changes that occur due to, for instance, trade and financial liberalizations, in which some goods the economy produces switch from being traded only by domestic households to also face demand from the rest of the world and in which households that have access to only domestically traded securities start having access to financial securities traded with the rest of the world.

Panel A of table 5 shows the aggregate responses to macro shocks, with two main results. First, the aggregate effects of domestic monetary policy are relatively unaffected by integration. This is because all households, including those that are financially integrated, hold most of their savings

[14] Subramanian and Kessler (2013) document that real integration, as measured by global trade flows of goods and services, roughly doubled in the last four decades. Obstfeld (2007) shows that financial integration, as measured by global capital flows, increased by a similar magnitude. Our exercise is motivated by these global trends.

TABLE 5
EFFECTS OF EXTERNAL SHOCKS UNDER DIFFERENT LEVELS OF INTERNATIONAL INTEGRATION

	Baseline Level	Low Level
	A. Aggregate Consumption Responses (%)	
Domestic monetary shock	.54	.56
Foreign demand shock	1.02	.41
Foreign monetary shock	.02	.01
	B. Cross-Section Standard Deviation of Individual Consumption Responses	
Domestic monetary shock	.25	.24
Foreign demand shock	1.47	2.33
Foreign monetary shock	3.21	7.71

NOTE.—This table reports the effects of a 25-bp expansionary monetary policy shock ($\epsilon_{m,t=-0.0025}$), a 1 standard deviation expansionary external demand shock ($\epsilon_{y^*,t} = 0.15$), and a 25-bp expansionary foreign monetary policy shock ($\epsilon_{m^*,t} = -0.0025$) in two economies with different degrees of international integration. "Baseline Level" corresponds to the baseline calibration of the model, where the fractions of financially integrated households and real integrated households are 33% and 37%. "Low Level" corresponds to a parameterization in which we recalibrate the degrees of international integration to be half the baseline levels—i.e., the fraction of financially integrated households and real integrated households are 16.5% and 18.5%. In the "Low Level" case, we also recalibrate the model to have the same wealth distribution as the baseline model. Panel A reports the peak consumption responses. Panel B reports the cross-section standard deviation of individual consumption responses when aggregate consumption reaches its peak after being normalized by the size of peak aggregate responses.

in the domestic asset due to the large degree of home bias in financial portfolios exhibited in the data. Second, higher international integration amplifies the aggregate effect of external shocks. This is because changes in external demand have larger effects when the share of the tradable sector is high, and changes in foreign monetary policy are larger when the share of households integrated with international capital markets is large.

Panel B compares the distributional effects of macroeconomic shocks with different levels of international integration. The main takeaway is that a higher degree of international integration dampens the distributional impacts of external shocks. This is because in economies with a low degree of international integration, external shocks have little impact on aggregates and the small share of households that are integrated experience large swings relative to the aggregate response to international shocks.[15] In this sense, economies with a low degree of international integration can suffer more unequal responses to globalization.

[15] To further explain this result, fig. D.8 shows how the distributional effects of macro shocks vary when we vary the degree of real and financial integration separately. We show these results by tracing the standard deviation of consumption responses, with and without normalizing by the aggregate response to the shocks. Figure D.8*a* and D.8*b* shows that without normalizing for the aggregate response, there is a nonmonotonic relationship between the dispersion of consumption responses and the degree of international integration. The

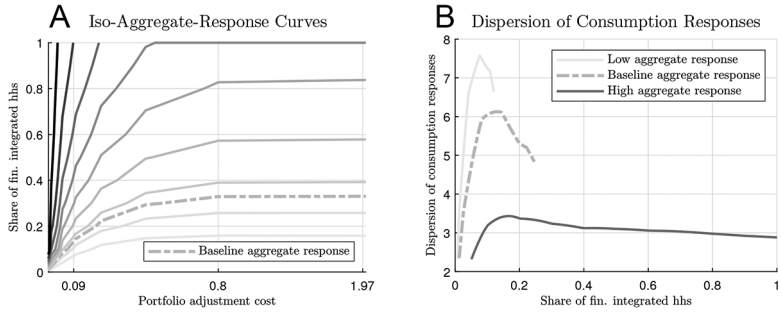

FIG. 5.—Consumption responses to foreign monetary shocks: the role of portfolio adjustment cost and degrees of financial integration. In *A*, each line depicts a combination of portfolio adjustment cost and the share of financially integrated households (fin. integrated hhs) that generate a fixed level of aggregate consumption response to a 25-bp expansionary foreign monetary shock ($\epsilon_{m^*,t} = -0.25\,\%$). In *B*, each line depicts the cross-sectional dispersion of consumption responses for different shares of financially integrated households and their corresponding portfolio adjustment cost that keeps a same aggregate consumption response. Lines in lighter shading indicate a lower level of aggregate consumption response. The dashed line corresponds to the level of aggregate consumption response under the baseline calibration. The dispersion of consumption responses is measured by the standard deviation of individual consumption responses normalized by the size of aggregate consumption response in the period when the aggregate consumption response reaches its peak.

B. Financial Integration and Capital Flow Mobility

We now focus on the financial dimension of globalization. Economies can open their capital account by making foreign securities available to a larger share of the population or by reducing the capital controls or portfolio frictions faced by financially integrated households. In this section, we assess the aggregate and distributional effects of foreign monetary shocks in economies with different shares of financial integration and capital controls. Figure 5*A* shows that increasing pairs of the share of financially integrated households and portfolio adjustment costs can be associated with a same response of aggregate consumption to a foreign monetary expansion (i.e., "iso-aggregate response curves"). A higher share of integrated households can amplify aggregate effects, but larger adjustment costs increase UIP deviations and limit the pass-through of the foreign interest rate shock into both the local interest rate and the exchange rate. We argue that these calibrations that have associated same aggregate effects can have different distributional implications. Figure 5*B* shows the cross-sectional standard deviation of consumption responses to a foreign monetary shock associated with different parameterizations of

dispersion is maximal in economies that have considerable shares of both integrated and nonintegrated households. Figure D.8*c* and D.8*d* shows that once we normalize by the aggregate response, the dispersion becomes monotonically decreasing (increasing) in the degree of international integration in response to external (domestic) shocks.

the share of financial integration and portfolio adjustment costs that have associated the same aggregate consumption response. Consistent with the results from the previous analysis, the cross-sectional dispersion is maximized with low shares of financially integrated households.

VI. Conclusion

Motivated by the asymmetric effects of globalization documented over the last three decades, we study how monetary policy shapes the effects of external shocks in open economies. We focus on new sources of household heterogeneity that are linked to their international integration—namely, the sector in which they work and their access to international capital markets. We argue that these dimensions are more relevant in accounting for the distributive effects of external shocks than income and wealth, which are the main focus of closed-economy heterogeneous-agent models. In confronting these shocks, monetary authorities may face a trade-off between maintaining aggregate stability and reducing income and consumption inequalities. Fixed exchange rate regimes, which typically amplify the aggregate effects of an external shock, can reduce the consumption inequalities that stem from external shocks. Our paper also shows that although lower international integration dampens the aggregate exposure to external shocks, it also increases the distributional impacts of these shocks. From this, we conclude that the discontents of globalization might arise, perhaps paradoxically, from international integration's not being sufficiently generalized. Overall, our results indicate that redistribution constitutes a relevant consideration for monetary policy in open economies. This suggests that an important area for future research is the interaction between monetary and fiscal policies with households' heterogeneity in open economies.

Appendix A

Model Extensions

This appendix presents various model extensions and analyzes their quantitative results by comparing them with those of the baseline model. We study seven model extensions: endogenous transitions between international integration, no home bias for integrated households, no UIP deviations, tradable prices in foreign currency, financial securities in foreign currency, investment, and correlated wealth and integration.

A1. Endogenous Transition of International Integration Status

Model.—This extension studies a model with endogenous choices of international integration by households. We model this choice using techniques from dynamic discrete choice models, by assuming that households face a fixed cost of switching

their international integration status and have a preference shock associated with each international integration status, which follows an extreme value distribution. In particular, households enter the period with their integration status from the previous period, receive the vector of preference shocks, and decide their new integration status. Then they choose their consumption and savings for the following period.

The recursive problem of the household under this setup is given by

$$U_t(z, \mathbf{b}, \mathbf{o}^-, \varepsilon) = \max_{o_R, o_F} \{(1 - \xi) V_t(z, \mathbf{b}, \mathbf{o}) + \xi \tilde{V}_t(z, \mathbf{b}, \mathbf{o}) + \varepsilon_{\mathbf{o}} - c_{\mathbf{o}^-,\mathbf{o}}\},$$

where $U_t(z, \mathbf{b}, \mathbf{o}', \varepsilon)$ denotes the value after choosing their integration status, with $\mathbf{o}'$ denoting the integration status from the previous period; $V_t(z, \mathbf{b}, \mathbf{o})$ and $\tilde{V}_t(z, \mathbf{b}, \mathbf{o})$ denote the household's value after they choose their integration status, conditional on their survival status; $c_{\mathbf{o}^-,\mathbf{o}}$ denotes the cost of switching integration status from $\mathbf{o}^-$ to $\mathbf{o}$; and $\varepsilon_{\mathbf{o}}$ denotes an independent and identically distributed (i.i.d.) preference shock associated with households' integration status. We assume that the preference shock follows a Gumbel distribution with cumulative distribution function (CDF) as $e^{-e^{-\varepsilon_{\mathbf{o}}}}$ and the adjustment costs $\mathbf{c}_{\mathbf{o}^-,\mathbf{o}} = \mathbf{c}^R_{o_R^-,o_R} + \mathbf{c}^F_{o_F^-,o_F}$, where $\mathbf{c}^R_{o_R^-,o_R}$ and $\mathbf{c}^F_{o_F^-,o_F}$ denote the cost of switching real and financial integration. Finally, we assume that there are no costs of maintaining the previous integration status—that is, $\mathbf{c}^R_{o_R^-,o_R} = 0$ if $o_R^- = o_R$ and $\mathbf{c}^F_{o_F^-,o_F} = 0$ if $o_F^- = o_F$.

The value of consuming and saving is given by

$$\begin{aligned}
V_t(z, \mathbf{b}, \mathbf{o}) &= \max_{c_H, c_F, c_N, l, \mathbf{b}'} u(c, l) + \beta \mathbb{E}_t[U_{t+1}(z', \mathbf{b}', \mathbf{o}, \varepsilon')] \\
&\text{s.t. } c = \mathcal{C}_{TN}(c_T, c_N), \; c_T = \mathcal{C}_{HF}(c_H, c_F), \\
&\quad P_{H,t} c_H + P_{F,t} c_F + P_{N,t} c_N + q_{Dt} b'_D + q_{Et} b'_E + \Phi(b'_D, b'_E, o_F) \\
&\quad = z(1 - \tau_t) W_t(o_R) l + T_t(z) + b_D + b_E, \\
&\quad \mathbf{b}' \in \mathcal{B}(o_F), \\
&\quad z' \in \Gamma_z(z),
\end{aligned}$$

where all variables are defined as in the baseline model and $\Gamma_z(z)$ denotes the same exogenous transition rules for the idiosyncratic labor income.

The above Bellman equation system shares most of the elements of the baseline setup and provides an endogenous evolution of the integration status. The endogenous transition probability from $\mathbf{o}^-$ to $\mathbf{o}$ is

$$\frac{\exp(\bar{V}_t(z, b, \mathbf{o}) - \mathbf{c}_{\mathbf{o}^-,\mathbf{o}})}{\sum_{\tilde{\mathbf{o}}} \exp(\bar{V}_t(z, b, \tilde{\mathbf{o}}) - \mathbf{c}_{\mathbf{o}^-,\tilde{\mathbf{o}}})},$$

where $\bar{V}_t(z, b, \mathbf{o}) \equiv (1 - \xi) V_t(z, \mathbf{b}, \mathbf{o}) + \xi \tilde{V}_t(z, \mathbf{b}, \mathbf{o})$ denotes the expected value of choosing integration status $\mathbf{o}$. The transition probability depends on households' idiosyncratic state z and $\mathbf{b}$.

Calibration.—We calibrate the adjustment costs to target the same steady-state moments as in the baseline model. This way, the average transition probability of international integration status under this extension matches that of the baseline model in the steady state. We also recalibrate the level of government debt and borrowing constraint so that the current model has the same median

wealth-to-income ratio and median MPC as in the baseline model. The calibration of these parameters is summarized in table A1. For the parameters with directly targeting moments—ψ, β, ω_T—we use the same targets as in the baseline model to calibrate them.[16] All other parameters are set to the same values as in the baseline model. The main results from this model are summarized in column 2 of table A6.

To better understand the impacts from the endogenous transition, we also conduct a comparison of the baseline model and this extension, calibrated to match a lower persistence in households' international integration status. We recalibrate the average persistence of households' financial and real integration status to be 90% in both the baseline model and this extension (for details on the calibration, see table A1). We collect the effects of various aggregate shocks within these two models in table A2. When calibrated to a lower persistence, the model with endogenous transitions features dampened cross-sectional dispersion in the responses to external macroeconomic shocks.

A2. Financially Integrated Households without Home Bias in Assets

Model.—This extension studies how results vary when financially integrated households save or borrow exclusively in external securities. This corresponds to a particular parameterization of the portfolio adjustment costs of financially integrated households, such that the steady state of domestic securities of $\bar{\alpha}(o_F = 1) = 0$, and sufficiently large ϕ_b, which parameterizes the costs of deviating from the steady-state portfolio.

Calibration.—We recalibrate the level of government debt B_{ss} and the borrowing constraint to match the median wealth-to-income ratio and median MPC in the baseline model. We also recalibrate ψ, β, ω_T to target the same moments as in the baseline model. We set the remaining parameters to the same values as in the baseline model. The recalibrated parameters are collected in table A3, and the results from this extension are summarized in column 3 of table A6.

A3. No UIP Deviations

Model.—This extension studies a variant of the baseline model in which UIP holds in equilibrium. This corresponds to a particular case without portfolio adjustment costs for financially integrated households—that is, $\phi_b = 0$.

Under this parameterization, the intertemporal first-order conditions of financially integrated households imply equal returns on domestic and external securities, $q_{D,t} = q_{E,t}$, which is approximately equivalent to

$$i_t = i_t^* + \mathbb{E}_t[\Delta\mathcal{E}_{t+1}],$$

where $\Delta\mathcal{E}_t \equiv \log(\mathcal{E}_t/\mathcal{E}_{t-1})$ denotes the depreciation of domestic currency.

Calibration.—For all other parameters, we use the same parameterization as in the baseline model. The results from this extension are summarized in column 4 of table A6.

[16] More specifically, we calibrate ω_T to equalize the wages across sectors in steady state, ψ to target the steady-state hours at 1/3, and β to target the steady-state domestic annual interest rate of 4%.

A4. Alternative Portfolio Adjustment Cost

Model.—This extension studies a variant of the baseline model in which the portfolio adjustment cost depends only on the quantity of external bond—that is,

$$\Phi(b'_{\mathrm{D}}, b'_{\mathrm{E}}, o_F) = \frac{\phi_b}{2}(b'_{\mathrm{E}} - \bar{b}_{\mathrm{E}})^2 \mathbf{1}_{o_F=1}.$$

Calibration.—For all the parameters other than $\bar{b}_{\mathrm{E}}$ and ϕ_b, we use the same parameterization as in the baseline model. To make it comparable with the baseline model, we calibrate $\bar{b}_{\mathrm{E}} = 0.1930$ and $\phi_b = 0.5$ such that the model implies the same aggregate level of external bond holding in steady state and response of UIP deviation conditional on domestic monetary shock as in the baseline model. The results from this extension are summarized in column 5 of table A6. Overall, the aggregate and distributional responses to shocks are similar to those in the baseline model. The only qualitative difference is that, unlike our baseline specification, the alternative formulation of portfolio adjustment costs implies that aggregate consumption exhibits a mild decline in response to an expansionary foreign monetary shock. In this case, a decrease in the foreign interest rate leads to a small contraction in aggregate consumption. The reason is that the substitution effect in response to the decrease in the foreign rate is attenuated relative to the wealth effect; this is because financially integrated households need to pay adjustment costs to increase their consumption, whereas in the baseline model they could in principle increase consumption without paying adjustment costs by maintaining the composition of their asset holdings. In spite of this difference, the distributional implications of this shock are similar to those in the baseline model; financial integration constitutes the most relevant dimension that drives heterogeneity in consumption responses. Due to the direct exposure to the negative wealth effects caused by the lower foreign interest rate, integrated households experience a larger decrease in consumption than nonintegrated ones.

A5. Tradable Prices Denominated in Foreign Currency

Model.—In this extension, we analyze a variant of the model in which the prices of the home tradable good are sticky in foreign currency. In particular, we assume that firms face the following cost to adjust the prices of home tradable goods in terms of the foreign currency—that is,

$$\Theta_{\mathrm{H},t}\left(\frac{p_{\mathrm{H},t}}{p_{\mathrm{H},t-1}}\right) = \frac{\theta}{2}\left(\frac{p_{\mathrm{H},t}/\mathcal{E}_t}{p_{\mathrm{H},t-1}/\mathcal{E}_{t-1}} - 1\right)^2 Y_{\mathrm{H},t} P_{\mathrm{H},t}. \tag{A1}$$

Under this setup, the inflation dynamics of the home goods price can be characterized by the modified Philips curve

$$\tilde{\pi}_{\mathrm{H},t} - \tilde{\Delta}\mathcal{E}_t = \frac{\epsilon}{\theta}(\tilde{mc}_{\mathrm{H},t} - \tilde{p}_{\mathrm{H},t}) + \frac{1}{1+i_{ss}}\mathbb{E}_t\left[\tilde{\pi}_{\mathrm{H},t+1} - \widetilde{\Delta\mathcal{E}}_{t+1}\right], \tag{A2}$$

where $\tilde{x}$ denotes the deviation of x from its steady-state level.

Calibration.—We parameterize this model with the same values for all parameters as in the baseline model. The results of this extension are summarized in column 6 of table A6.

A6. Financial Securities Denominated in Foreign Currency

Model.—This extension studies a model in which domestic and external bonds are denominated in foreign currency. Under this assumption, the budget constraint for households is given by

$$\begin{aligned} P_{\mathrm{H}t}c_{\mathrm{H}} + P_{\mathrm{F}t}c_{\mathrm{F}} + P_{\mathrm{N}t}c_{\mathrm{N}} + q_{\mathrm{D}t}b'_{\mathrm{D}}\mathcal{E}_t + q_{\mathrm{E}t}b'_{\mathrm{E}}\mathcal{E}_t + \Phi(b'_{\mathrm{D}}, b'_{\mathrm{E}}, o_F) \\ = z(1-\tau_t)W_t(o_R)l + T_t(z) + (b_{\mathrm{D}} + b_{\mathrm{E}})\mathcal{E}_t, \end{aligned} \tag{A3}$$

and the prices of zero-coupon bonds are

$$q_{\mathrm{D},t} = \frac{1}{1+i_t}\mathbb{E}_t\left[\frac{\mathcal{E}_t}{\mathcal{E}_{t+1}}\right], \tag{A4}$$

$$q_{\mathrm{E},t} = \frac{1}{1+i_t^*}. \tag{A5}$$

Calibration.—We use the same parameterization as in the baseline model, and the results of this extension are summarized in column 7 of table A6.

A7. Physical Capital and Investment

Model.—In this extension, we introduce physical capital and investment. For this, we assume that intermediate-good producers' technology uses capital and labor as inputs:

$$Y_{s,t} = AK_{s,t}^{\alpha}N_{s,t}^{1-\alpha},$$

for $s \in \{N, H\}$. To render the structure more comparable to that of our baseline model, we introduce a separate firm in the economy that accumulates capital and rents it to intermediate-good producers in a competitive market. These capital-good producers have access to the technology to produce capital goods using foreign goods as inputs:

$$K_{t+1} = (1-\delta)K_t + \Phi(I_t, K_t)K_t,$$

where I_t denotes investment in terms of foreign goods and $\Phi(I, K) = I - (\phi_k/2)[(I/K) - \delta]^2K$ is a function that introduces capital adjustment costs, which are important in open-economy models to match the investment volatility observed in the data. The capital-good producers' problem is

$$\begin{aligned} \max_{I_t, K_{t+1}} \ & \frac{R_t}{\mathcal{E}_t}K_t - I_tP_{F,t}^* + \sum_{s=1}^{\infty}\mathbb{E}_t\left[\left(\prod_{\iota=1}^{s}\frac{1}{1+i_{t+\iota-1}}\right)\left(\frac{R_{t+s}}{\mathcal{E}_{t+s}}K_{t+s} - I_{t+s}P_{F,t+s}^*\right)\right] \\ \text{s.t.} \quad & K_{t+s+1} = (1-\delta)K_{t+s} + \phi(I_{t+s}, K_{t+s})K_{t+s}, \end{aligned}$$

where R_t represents the rental rate of capital expressed in domestic currency. Capital-good producers' profits are assumed to be transferred to households in the same way as profits from the intermediate-good producers.

Calibration.—We follow a strategy similar to our baseline calibration. For the new parameters, we set the capital share to $\alpha = 0.3$ and the depreciation rate to $\delta = 0.025$, which are standard values in the literature; we calibrate ϕ_k to match

an investment response to the domestic monetary shock of 2.5%, which is in the middle range of the estimated response for Canada documented by Champagne and Sekkel (2018). We recalibrate ψ, β, ω_T to target the same moments as in the baseline model and set the rest of the parameter values as in our baseline calibration. The recalibrated parameters are collected in table A4, and the main results from this extension are summarized in column 8 of table A6.

A8. Correlation between Integration Status and Net Wealth

Model.—In this extension, we allow for integrated and nonintegrated households to have different income and wealth levels in the steady state. We do so by allowing the integration status to scale the idiosyncratic productivity of households. In particular, the households' budget constraint is given by

$$\begin{aligned} P_{\mathrm{H}t}c_{\mathrm{H}} + P_{\mathrm{F}t}c_{\mathrm{F}} + P_{\mathrm{N}t}c_{\mathrm{N}} + q_{\mathrm{D}t}b'_{\mathrm{D}} + q_{\mathrm{E}t}b'_{\mathrm{E}} + \Phi(b'_{\mathrm{D}}, b'_{\mathrm{E}}, o_F) \\ = z(1 + \delta^R_{o_R} + \delta^F_{o_F})(1 - \tau_t)W_t(o_R)l + T_t(z) + b_{\mathrm{D}} + b_{\mathrm{E}}\mathcal{E}_t, \end{aligned} \tag{A6}$$

where households' individual income depends on their international integration status.

Calibration.—We calibrate all other parameters to share the same values as in the baseline model except for $\delta^R_{o^R}$ and $\delta^F_{o^F}$. For $\delta^R_{o^R}$ and $\delta^F_{o^F}$, we parameterize them as follows:

$$\delta^R_1 = \frac{\delta^R}{\bar{P}^R_1}, \ \delta^R_0 = -\frac{\delta^R}{\bar{P}^R_0}, \tag{A7}$$

$$\delta^F_1 = \frac{\delta^F}{\bar{P}^F_1}, \ \delta^F_0 = -\frac{\delta^F}{\bar{P}^F_0}, \tag{A8}$$

where $\bar{P}^s_{o_s}$ denotes the fraction of households with status o^s in the integration dimension s in the steady state and δ^R and δ^F control the correlation between net wealth level and international integration status. When we set $\delta^R = \delta^F = 0$, the model collapses to the baseline model. To study to what extent the correlation between wealth level and international integration status affects our baseline results, we perform a comparative static analysis in which we vary the values for δ^F and δ^R. Results are presented in figure A1. The main takeaway is that as real integrated households become wealthier relative to nonintegrated households, the dispersion of consumption responses by real integration to an expansionary foreign demand shock is dampened, since wealthy households have lower MPCs. Similarly, as financial integrated households become wealthier relative to nonintegrated, the dispersion of consumption responses by financial integration to an expansionary foreign monetary policy shock is dampened.

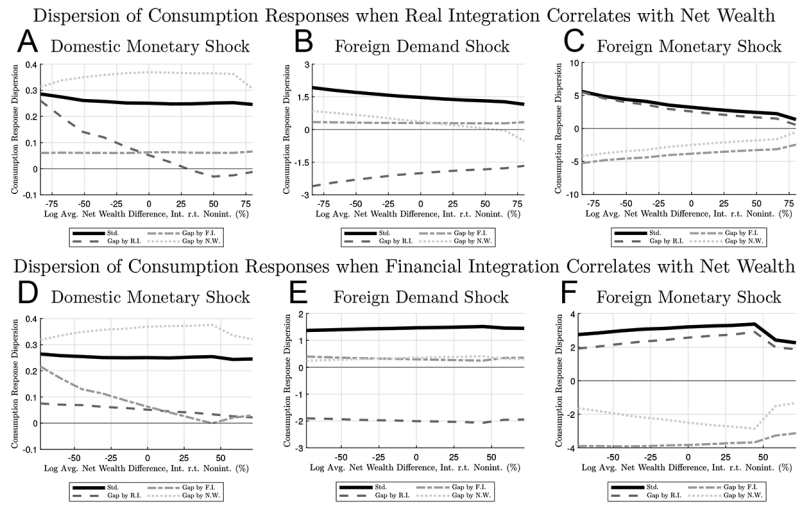

FIG. A1.—Distributional effects when international integration correlates with net wealth. *A*, *D*, Effects of a 25-bp expansionary monetary policy shock (i.e., $\epsilon_{m,t} = -0.0025$). *B*, *E*, Effects of a 15% expansionary external demand shock ($\epsilon_{y^*,t} = 0.15$). *C*, *F*, Effects of a 25-bp expansionary foreign monetary policy shock ($\epsilon_{m^*,t} = -0.0025$). Panels *A*–*C* summarize the variation in the correlation between the net wealth and real integration status (i.e., $\delta^R \neq 0$ and $\delta^F = 0$), and the *x*-axis shows the log difference in the average net wealth between financially integrated and nonintegrated households. Panels *D*–*F* summarize the variation in the correlation between the net wealth and financial integration status (i.e., $\delta^R = 0$ and $\delta^F \neq 0$), and the *x*-axis shows the log difference in the average net wealth between real integrated and nonintegrated households. In each panel, "gap by R.I." (real integration) refers to the consumption-response difference between real nonintegrated households and real integrated households, "gap by F.I." (financial integration) refers to the consumption-response difference between financially nonintegrated households and financially integrated households, and "gap by N.W." (net wealth) refers to the consumption-response difference between households with net wealth below the median and those with net wealth above the median. All statistics for the cross-sectional dispersion are normalized by the size of peak consumption responses.

A9. Sensitivity Analysis to Elasticity of Substitution

In the baseline model, we assume that the elasticity of substitution between tradable and nontradable goods (η_{TN}) and between home and foreign tradable goods (η_{HF}) are the same and calibrate them at 6.19. Table A7 shows how our results vary for alternative values of the elasticities of substitution. Column 2 shows the results when we first lower the elasticity of substitution between tradables and nontradables to $\eta_{\text{TN}} = 1$. Column 3 shows the results when we first lower the elasticity of substitution between foreign and home to $\eta_{\text{HF}} = 3$, and column 4 reports results when we lower both elasticities jointly. The main takeaway from this analysis is that as we lower the elasticity of substitution between home and foreign goods, the expenditure-switching channel becomes weaker and the aggregate effects on the consumption of expansionary external shocks are larger. In addition, this

analysis shows that our distributional conclusions regarding the importance of heterogeneity in international integration are preserved for alternative elasticities of substitution.

A10. Alternative Fiscal Policies

In this section, we analyze the sensitivity of our results to alternative fiscal policy rules. First, we consider a fiscal rule in which the government maintains a constant tax rate, real value of spending, and real value of bond issuance and varies the real value of transfers in response to shocks. Second, we consider another fiscal rule in which the government maintains a constant tax rate, real value of transfers, and real value of bond issuance and varies the real value of spending in response to shocks. Table A8 reports the results under these fiscal rules and compares them with the benchmark rule that leaves constant the real value of transfers, government spending, and bond issuance and varies the tax rate in response to shocks. Consistent with the findings of the closed-economy literature (e.g., Kaplan, Moll, and Violante 2018), different fiscal policy rules lead to differences in the aggregate responses to shocks. However, our distributional conclusions are robust to alternative fiscal policies; in all cases, the heterogeneity in households' international integration is more relevant in accounting for the distributional effects of external shocks than the heterogeneity in their income and wealth.

A11. Tables

TABLE A1
CALIBRATION OF THE MODEL WITH ENDOGENOUS TRANSITION IN INTEGRATION STATUS

	Baseline Persistence		Lower Persistence	
	Exogenous	Endogenous	Exogenous	Endogenous
	A. Parameters			
Cost to adjust integration status:				
$\mathbf{c}^{R}_{0,1}$; real integration, to be integrated		4.13		3.87
$\mathbf{c}^{R}_{1,0}$; real integration, to be nonintegrated		2.78		1.10
$\mathbf{c}^{F}_{0,1}$; financial integration, to be integrated		4.20		4.31
$\mathbf{c}^{F}_{1,0}$; financial integration, to be nonintegrated		1.43		.85
Wealth level and financial frictions:				
B_{ss}; government debt	.85	.87	.85	.76
$\underline{b}$; borrowing constraint	−.29	−.20	−.29	−.37
Households' preference:				
β; discounting factor	.96	.96	.96	.96
ψ; disutility of labor	7.93	7.91	7.93	7.93
ω_T; fraction of tradable goods consumption	.33	.33	.33	.33

TABLE A1 (*Continued*)

	Baseline Persistence		Lower Persistence	
	Exogenous	Endogenous	Exogenous	Endogenous
	B. Key Moments in Steady State			
Average transition probability of international integration status (%):				
Real integration, remaining integrated	96	96	90	90
Real integration, remaining nonintegrated	97.65	97.66	94.13	94.13
Financial integration, remaining integrated	92	92	90	90
Financial integration, remaining nonintegrated	96.06	96.06	95.07	95.09
Wealth-to-income ratio and MPC:				
Median wealth-to-income ratio	.35	.35	.35	.35
Median MPC	.15	.15	.15	.15

Note.—This table reports the calibration and key steady-state moments of different models with different persistence of international integration status. "Baseline Persistence" refers to models with the baseline calibration of the average transition probability across households' integration status (for details, see table 2); "Lower Persistence" refers to models with the persistence of both the real and the financially integrated status at 90%. "Exogenous" refers to the model in which the transition of international integration status is exogenous, as specified in sec. II; "Endogenous" refers to the model in which the transition is endogenous and subject to adjustment costs, as specified in app. sec. A1. The value of adjustment costs, B_{ss}, and $\underline{b}$ are expressed in the unit of households' quarterly average labor income in the corresponding steady state.

TABLE A2

Implications of Exogenous and Endogenous Transition with Less Persistent Integration Status

	Domestic Monetary Shock		Foreign Demand Shock		Foreign Monetary Shock	
	Exogenous	Endogenous	Exogenous	Endogenous	Exogenous	Endogenous
	A. Aggregate Responses (%)					
Consumption	.54	.54	1.01	.97	.02	.02
Nominal interest rate	−.03	−.03	−1.56	−1.51	−.03	−.03
Inflation	.88	.89	−1.42	−1.37	−.03	−.03
Exchange rate	.28	.28	−2.63	−2.68	−.05	−.06
	B. Cross-Sectional Dispersion of Consumption Responses					
Standard deviation	.25	.24	1.47	1.18	3.19	2.71
Gap by real integration	.05	.03	−2.00	−1.60	2.65	1.96
Gap by financial integration	.06	.05	.29	.26	−3.67	−2.85
Gap by net wealth	.36	.37	.36	.37	−2.50	−2.30

Note.—This table reports the effects of a 25-bp expansionary monetary shock ($\epsilon_{m,t} = -0.25\%$), a 15% expansionary foreign demand shock ($\epsilon_{y^*,t} = 15\%$), and a 25-bp expansionary foreign monetary shock ($\epsilon_{m^*,t} = -0.25\%$) in two models with different setups for the transition of integration status. "Exogenous" and "Endogenous" label the models with exogenous and endogenous transition in households' international integration status. Panel A reports the responses of various aggregate variables in the period in which the aggregate consumption responses reach their peak. In panel B, "Gap by real integration" refers to the consumption-response difference between real nonintegrated households and real integrated households, "Gap by financial integration" refers to the consumption-response difference between financially nonintegrated households and financially integrated households, and "Gap by net wealth" refers to the consumption-response difference between households with net wealth below the median and those with net wealth above the median. All statistics for the cross-sectional dispersion are normalized by the size of peak consumption responses.

TABLE A3
CALIBRATION OF THE MODEL WITHOUT ASSET HOME BIAS

	Baseline	Extension
	A. Parameters	
Wealth level and financial frictions:		
B_{ss}; government debt	.85	.61
$\underline{b}$; borrowing constraint	−.29	−.29
Households' preferences:		
β; discounting factor	.96	.96
ψ; disutility of labor	7.93	7.93
ω_T; fraction of tradable goods in consumption basket	.33	.33
	B. Key Moments in Steady State	
Wealth-to-income ratio and MPC:		
Median wealth-to-income ratio	.35	.35
Median MPC	.15	.15

NOTE.—Values of B_{ss} and $\underline{b}$ are expressed in units of households' quarterly average labor income in steady state.

TABLE A4
CALIBRATION OF THE MODEL WITH CAPITAL AND INVESTMENT

	Baseline	Extension
	A. Parameters	
Capital related:		
α; capital share		.30
δ; depreciation rate		.025
ϕ_k; capital adjustment cost		.10
Wealth level and financial frictions:		
B_{ss}; government debt	.85	.80
$\underline{b}$; borrowing constraint	−.29	−.37
Households' preference:		
β; discounting factor	.96	.96
ψ; disutility of labor	7.93	7.11
ω_T; fraction of tradable goods in consumption basket	.33	.13
	B. Key Moments in Steady State	
Wealth-to-income ratio and MPC:		
Median wealth-to-income ratio	.35	.35
Median MPC	.15	.15

NOTE.—Values of B_{ss} and $\underline{b}$ are expressed in the unit of households' quarterly average labor income in steady state.

TABLE A5

EFFECTS OF AGGREGATE SHOCKS WITHIN THE MODEL WITH CAPITAL AND INVESTMENT

	Domestic Monetary Shock	Foreign Demand Shock	Foreign Monetary Shock
Aggregate quantities (%):			
Consumption	.27	−.44	.02
Investment	2.61	17.08	−.22
Export	1.92	12.04	−.09
Import	−1.63	1.56	.16
Aggregate prices (%):			
Nominal interest rate	.20	.61	.01
Inflation	1.09	.55	.01
Exchange rate	.64	−.25	−.02

NOTE.—This table reports the effects of a 25-bp expansionary monetary shock ($\epsilon_{m,t=-0.25\%}$), a 15% expansionary foreign demand shock ($\epsilon_{y^*,t} = 15\%$), and a 25-bp expansionary foreign monetary shock ($\epsilon_{m^*,t} = -0.25\%$). All responses correspond to the period when aggregate consumption response reaches its peak.

TABLE A6
SUMMARY OF MODEL EXTENSIONS

	Baseline (1)	Endogenous Transition (2)	No Home Bias (3)	No UIP Deviations (4)	Alternative Adjustment Cost (5)	Foreign Currency Prices (6)	Foreign Currency Securities (7)	Capital and Investment (8)
	A. Domestic Monetary Shocks							
Aggregate responses (%):								
Consumption	.54	.54	.46	.49	.58	.39	.55	.27
Inflation	.88	.88	.90	1.08	.89	1.04	.84	1.09
Exchange rate	.28	.28	.32	.50	.27	.33	.23	.64
Cross-sectional dispersion of consumption responses:								
Standard deviation	.25	.26	.33	.48	.22	.62	.23	1.07
Gap by real integration	.05	.04	−.04	−.27	.08	.89	.11	−1.55
Gap by financial integration	.06	.05	.31	.00	−.01	.05	.07	−.02
Gap by net wealth	.37	.36	.46	.78	.30	.47	.22	.51
	B. Foreign Demand Shocks							
Aggregate responses (%):								
Consumption	1.02	1.00	.51	.85	1.13	3.10	.93	−.44
Inflation	−1.42	−1.40	−1.55	.30	−1.26	−4.77	−.68	.55
Exchange rate	−2.62	−2.65	−2.59	−.71	−2.55	−3.77	−1.71	−.25
Cross-sectional dispersion of consumption responses:								
Standard deviation	1.47	1.35	3.42	3.11	1.25	1.65	2.17	4.92
Gap by real integration	−2.01	−1.85	−4.30	−3.93	−1.70	−2.29	−2.87	−7.23
Gap by financial integration	.30	.25	2.87	.00	−.07	.18	.18	.00
Gap by net wealth	.36	.37	.81	2.13	.36	.25	1.52	−.29

	C. Foreign Monetary Shocks							
Aggregate responses (%):								
Consumption	.02	.02	.11	.15	−.01	.06	.02	.02
Inflation	−.03	−.03	−.01	−.41	.00	−.12	−.01	.01
Exchange rate	−.05	−.06	−.09	−.48	.01	−.08	−.03	−.02
Cross-sectional dispersion of consumption responses:								
Standard deviation	3.21	3.18	1.56	2.21	1.43	1.15	2.50	1.44
Gap by real integration	2.57	2.51	.84	2.38	−.06	−1.33	1.51	1.60
Gap by financial integration	−3.83	−3.27	−2.76	.00	1.26	−.93	−3.97	−1.73
Gap by net wealth	−2.50	−2.75	−.76	−2.62	.74	−.46	−.97	.41

NOTE.—This table reports the effects of a 25-bp expansionary monetary shock ($\epsilon_{m,t=-0.25\%}$), a 15% expansionary foreign demand shock ($\epsilon_{y^*,t} = 15\%$), and a 25-bp expansionary foreign monetary shock ($\epsilon_{m^*,t} = -0.25\%$) in the period when aggregate consumption response reaches its peak in various models. "Gap by real integration" refers to the consumption-response difference between real nonintegrated households and real integrated households, "Gap by financial integration" refers to the consumption-response difference between financially nonintegrated households and financially integrated households, and "Gap by net wealth" refers to the consumption-response difference between the households with net wealth below the median and those with net wealth above the median. All statistics of the cross-sectional dispersion are normalized by the size of peak consumption responses.

TABLE A7
EFFECTS OF AGGREGATE SHOCKS WITH LOWER ELASTICITY OF SUBSTITUTION

	Baseline: $\eta_{TN} = 6.19$; $\eta_{HF} = 6.19$ (1)	Lower Elasticity of Substitution		
		$\eta_{TN} = 1$; $\eta_{HF} = 6.19$ (2)	$\eta_{TN} = 6.19$; $\eta_{HF} = 3$ (3)	$\eta_{TN} = 1$; $\eta_{HF} = 3$ (4)
	A. Domestic Monetary Shocks			
Aggregate responses (%):				
Consumption	.54	.49	.49	.45
Inflation	.88	.94	.95	.99
Exchange rate	.28	.35	.37	.44
Cross-sectional dispersion of individual consumption responses:				
Standard deviation	.25	.40	.25	.39
Gap by real integration	.05	−.48	−.03	−.47
Gap by financial integration	.06	.06	.05	.04
Gap by net wealth	.37	.40	.38	.41
	B. Foreign Demand Shocks			
Aggregate responses (%):				
Consumption	1.02	1.48	2.38	2.95
Inflation	−1.42	−2.07	−3.29	−3.93
Exchange rate	−2.62	−2.95	−4.72	−5.70
Cross-sectional dispersion of individual consumption responses:				
Standard deviation	1.47	.54	1.28	.49
Gap by real integration	−2.01	−.57	−1.80	−.52
Gap by financial integration	.30	.23	.23	.22
Gap by net wealth	.36	.30	.28	.26
	C. Foreign Monetary Shocks			
Aggregate responses (%):				
Consumption	.02	.03	.04	.05
Inflation	−.03	−.06	−.07	−.09
Exchange rate	−.05	−.07	−.08	−.10
Cross-sectional dispersion of individual consumption responses:				
Standard deviation	3.21	2.49	.95	1.30
Gap by real integration	2.57	2.75	.16	1.45
Gap by financial integration	−3.83	−1.99	−1.54	−1.15
Gap by net wealth	−2.50	−1.20	−.86	−.59

NOTE.—This table reports the effects of a 25-bp expansionary monetary shock ($\epsilon_{m,t=-0.25\%}$), a 15% expansionary foreign demand shock ($\epsilon_{y^*,t} = 15\%$), and a 25-bp expansionary foreign monetary shock ($\epsilon_{m^*,t} = -0.25\%$) in the period when aggregate consumption response reaches its peak under different calibrations of the substitution elasticity between tradable and nontradable goods (η_{TN}) and the substitution elasticity between home and foreign goods (η_{HF}). "Gap by real integration" refers to the consumption-response difference between real nonintegrated households and real integrated households, "Gap by financial integration" refers to the consumption-response difference between financially nonintegrated households and financially integrated households, and "Gap by net wealth" refers to the consumption-response difference between the households with net wealth below the median and those with net wealth above the median. All statistics of the cross-sectional dispersion are normalized by the size of peak consumption responses.

TABLE A8
ALTERNATIVE FISCAL POLICIES

		ALTERNATIVE POLICIES	
	BASELINE: VARYING τ_t	Varying T_t/P_t	Varying G_t/P_t
	A. Domestic Monetary Shocks		
Aggregate responses (%):			
Consumption	.54	.39	.17
Inflation	.88	1.02	1.23
Exchange rate	.28	.32	.54
Cross-sectional dispersion of consumption responses:			
Standard deviation	.25	1.98	.94
Gap by real integration	.05	−.13	−1.22
Gap by financial integration	.06	.06	−.04
Gap by net wealth	.37	.61	.86
	B. Foreign Demand Shocks		
Aggregate responses (%):			
Consumption	1.02	1.10	.77
Inflation	−1.42	−1.61	−1.24
Exchange rate	−2.62	−2.52	−2.14
Cross-sectional dispersion of consumption responses:			
Standard deviation	1.47	1.94	2.40
Gap by real integration	−2.01	−2.10	−3.33
Gap by financial integration	.30	.27	.31
Gap by net wealth	.36	.42	.38
	C. Foreign Monetary Shocks		
Aggregate responses (%):			
Consumption	.02	.03	.03
Nominal interest rate	−.03	−.06	−.07
Inflation	−.03	−.05	−.06
Exchange rate	−.05	−.05	−.06
Cross-sectional dispersion of consumption responses:			
Standard deviation	3.21	2.48	1.51
Gap by real integration	2.57	1.33	1.25
Gap by financial integration	−3.83	−2.40	−1.86
Gap by net wealth	−2.50	−1.64	−1.08

NOTE.—This table reports the effects of a 25-bp expansionary monetary shock ($\epsilon_{m,t=-0.25\%}$), a 15% expansionary foreign demand shock ($\epsilon_{y^*,t} = 15\%$), and a 25-bp expansionary foreign monetary shock ($\epsilon_{m^*,t} = -0.25\%$) in the period when aggregate consumption response reaches its peak under different fiscal policies. "Gap by real integration" refers to the consumption-response difference between real nonintegrated households and real integrated households, "Gap by financial integration" refers to the consumption-response difference between financially nonintegrated households and financially integrated households, and "Gap by net wealth" refers to the consumption-response difference between the households with net wealth below the median and those with net wealth above the median. All statistics of the cross-sectional dispersion are normalized by the size of peak consumption responses.

References

Agnew, J., P. Balduzzi, and A. Sundn. 2003. "Portfolio Choice and Trading in a Large 401(k) Plan." *A.E.R.* 93 (1): 193–215.

Aguiar, M., and M. Bils. 2015. "Has Consumption Inequality Mirrored Income Inequality?" *A.E.R.* 105 (9): 2725–56.

Alvarez, F., A. Atkeson, and P. Kehoe. 2002. "Money, Interest Rates, and Exchange Rates with Endogenously Segmented Markets." *J.P.E.* 110 (1): 73–112.

Arellano, C., Y. Bai, and G. P. Mihalache. 2020. "Monetary Policy and Sovereign Risk in Emerging Economies (NK-Default)." Working Paper no. 26671, NBER, Cambridge, MA.

Attanasio, O., E. Battistin, and H. Ichimura. 2004. "What Really Happened to Consumption Inequality in the US?" Working Paper no. 10338, NBER, Cambridge, MA.

Auclert, A., M. Rognlie, M. Souchier, and L. Straub. 2020. "Monetary Policy and Exchange Rates with Heterogeneous Agents: Resurrecting the Real Income Channel." Manuscript.

Autor, D. H., D. Dorn, and G. H. Hanson. 2013. "The China Syndrome: Local Labor Market Effects of Import Competition in the United States." *A.E.R.* 103 (6): 2121–68.

Benigno, P., and F. Romei. 2014. "Debt Deleveraging and the Exchange Rate." *J. Internat. Econ.* 93 (1): 1–16.

Blanco, A., A. Drenik, and E. Zaratiegui. 2020. "Devaluations, Inflation, and Labor Income Dynamics." Manuscript.

Broda, C. 2004. "Terms of Trade and Exchange Rate Regimes in Developing Countries." *J. Internat. Econ.* 63 (1): 31–58.

Burstein, A., M. Eichenbaum, and S. Rebelo. 2007. "Modeling Exchange Rate Passthrough after Large Devaluations." *J. Monetary Econ.* 54 (2): 346–68.

Burstein, A., and G. Gopinath. 2014. "International Prices and Exchange Rates." In *Handbook of International Economics*, vol. 4, edited by G. Gopinath, E. Helpman, and K. Rogoff, 391–451. Amsterdam: North-Holland.

Calvo, G. A., and C. M. Reinhart. 2002. "Fear of Floating." *Q.J.E.* 117 (2): 379–408.

Céspedes, L. F., R. Chang, and A. Velasco. 2004. "Balance Sheets and Exchange Rate Policy." *A.E.R.* 94 (4): 1183–93.

Champagne, J., and R. Sekkel. 2018. "Changes in Monetary Regimes and the Identification of Monetary Policy Shocks: Narrative Evidence from Canada." *J. Monetary Econ.* 99:72–87.

Chari, V. V., P. J. Kehoe, and E. R. McGrattan. 2002. "Can Sticky Price Models Generate Volatile and Persistent Real Exchange Rates?" *Rev. Econ. Studies* 69 (3): 533–63.

Charnavoki, V., and J. J. Dolado. 2014. "The Effects of Global Shocks on Small Commodity-Exporting Economies: Lessons from Canada." *American Econ. J. Macroeconomics* 6 (2): 207–37.

Chien, Y., H. Cole, and H. Lustig. 2012. "Is the Volatility of the Market Price of Risk Due to Intermittent Portfolio Rebalancing?" *A.E.R.* 102 (6): 2859–96.

Chodorow-Reich, G. 2013. "The Employment Effects of Credit Market Disruptions: Firm-Level Evidence from the 2008–9 Financial Crisis." *Q.J.E.* 129 (1): 1–59.

Chodorow-Reich, G., and J. Wieland. 2020. "Secular Labor Reallocation and Business Cycles." *J.P.E.* 128 (6): 2245–87.

Corsetti, G., L. Dedola, and S. Leduc. 2010. "Optimal Monetary Policy in Open Economies." In *Handbook of Monetary Economics*, vol. 3, edited by B. M. Friedman and M. Woodford, 861–933. Amsterdam: North-Holland.

Corsetti, G., and P. Pesenti. 2005. "International Dimensions of Optimal Monetary Policy." *J. Monetary Econ.* 52 (2): 281–305.
Cravino, J., and A. A. Levchenko. 2017. "The Distributional Consequences of Large Devaluations." *A.E.R.* 107 (11): 3477–509.
Cugat, G. 2019. "Emerging Markets, Household Heterogeneity, and Exchange Rate Policy." Manuscript.
de Ferra, S., K. Mitman, and F. Romei. 2020. "Household Heterogeneity and the Transmission of Foreign Shocks." *J. Internat. Econ.* 124:103303.
Devereux, M. B., and C. Engel. 2003. "Monetary Policy in the Open Economy Revisited: Price Setting and Exchange-Rate Flexibility." *Rev. Econ. Studies* 70 (4): 765–83.
Drenik, A., G. Pereira, and D. J. Perez. 2018. "Wealth Redistribution after Exchange Rate Devaluations." *AEA Papers and Proc.* 108:552–56.
Du, W., C. E. Pflueger, and J. Schreger. 2020. "Sovereign Debt Portfolios, Bond Risks, and the Credibility of Monetary Policy." *J. Finance* 75 (6): 3097–138.
Eichenbaum, M. S., B. K. Johannsen, and S. T. Rebelo. 2021. "Monetary Policy and the Predictability of Nominal Exchange Rates." *Rev. Econ. Studies* 88 (1): 192–228.
Eichengreen, B. J., R. Hausmann, and U. Panizza. 2002. "Original Sin: The Pain, the Mystery, and the Road to Redemption." Paper presented at the "Currency and Maturity Matchmaking: Redeeming Debt from Original Sin" conference, Inter-American Development Bank, Washington, DC, November 21–22.
Engel, C. 2006. "Equivalence Results for Optimal Pass-through, Optimal Indexing to Exchange Rates, and Optimal Choice of Currency for Export Pricing." *J. European Econ. Assoc.* 4 (6): 1249–60.
Engel, C., and J. Park. 2021. "Debauchery and Original Sin: The Currency Composition of Sovereign Debt." Manuscript, Univ. Wisconsin, Madison.
Fama, E. F. 1984. "Forward and Spot Exchange Rates." *J. Monetary Econ.* 14 (3): 319–38.
Farhi, E., and I. Werning. 2016. "Fiscal Multipliers: Liquidity Traps and Currency Unions." In *Handbook of Macroeconomics*, vol. 2, edited by J. B. Taylor and H. Uhlig, 2417–92. Amsterdam: North-Holland.
———. 2017. "Fiscal Unions." *A.E.R.* 107 (12): 3788–834.
Fleming, J. M. 1962. "Domestic Financial Policies under Fixed and under Floating Exchange Rates." *IMF Staff Papers* 9 (3): 369–80.
Forbes, K. J., and R. Rigobon. 2002. "No Contagion, Only Interdependence: Measuring Stock Market Comovements." *J. Finance* 57 (5): 2223–61.
Fornaro, L. 2015. "Financial Crises and Exchange Rate Policy." *J. Internat. Econ.* 95 (2): 202–15.
Fornaro, L., and F. Romei. 2019. "The Paradox of Global Thrift." *A.E.R.* 109 (11): 3745–79.
Gabaix, X., and M. Maggiori. 2015. "International Liquidity and Exchange Rate Dynamics." *Q.J.E.* 130 (3): 1369–420.
Gali, J., and T. Monacelli. 2005. "Monetary Policy and Exchange Rate Volatility in a Small Open Economy." *Rev. Econ. Studies* 72 (3): 707–34.
Giglio, S., M. Maggiori, J. Stroebel, and S. Utkus. 2019. "Five Facts about Beliefs and Portfolios." Working Paper no. 25744, NBER, Cambridge, MA.
Giovanni, J., S. Kalemli-Ozcan, M. F. Ulu, and Y. S. Baskaya. 2017. "International Spillovers and Local Credit Cycles." Working Paper no. 23149, NBER, Cambridge, MA.
Goldberg, P. K., and N. Pavcnik. 2007. "Distributional Effects of Globalization in Developing Countries." *J. Econ. Literature* 45 (1): 39–82.

Gopinath, G., E. Boz, C. Casas, F. J. Díez, P.-O. Gourinchas, and M. Plagborg-Møller. 2020. "Dominant Currency Paradigm." *A.E.R.* 110 (3): 677–719.
Gopinath, G., O. Itskhoki, and R. Rigobon. 2010. "Currency Choice and Exchange Rate Pass-Through." *A.E.R.* 100 (1): 304–36.
Gopinath, G., and B. Neiman. 2014. "Trade Adjustment and Productivity in Large Crises." *A.E.R.* 104 (3): 793–831.
Gospodinov, N., and D. Lkhagvasuren. 2014. "A Moment-Matching Method for Approximating Vector Autoregressive Processes by Finite-State Markov Chains." *J. Appl. Econometrics* 29 (5): 843–59.
Gourinchas, P.-O. 2018. "Monetary Policy Transmission in Emerging Markets: An Application to Chile." In *Monetary Policy and Global Spillovers: Mechanisms, Effects and Policy Measures*, edited by E. G. Mendoza, E. Pastén, and D. Saravia, 279–324. Santiago: Central Bank Chile.
Hassan, T. A., T. M. Mertens, and T. Zhang. 2016. "Currency Manipulation." Working Paper no. 22790, NBER, Cambridge, MA.
Hassan, T. A., and T. Zhang. 2021. "The Economics of Currency Risk." *Ann. Rev. Econ.* 13:281–307.
Hausman, J. K., P. W. Rhode, and J. F. Wieland. 2019. "Recovery from the Great Depression: The Farm Channel in Spring 1933." *A.E.R.* 109 (2): 427–72.
Itskhoki, O., and D. Mukhin. 2017. "Exchange Rate Disconnect in General Equilibrium." Working Paper no. 23401, NBER, Cambridge, MA.
———. 2021. "Mussa Puzzle Redux." Working Paper no. 28950, NBER, Cambridge, MA.
Kalemli-Özcan, S. 2019. "US Monetary Policy and International Risk Spillovers." Working Paper no. 26297, NBER, Cambridge, MA.
Kaplan, G., B. Moll, and G. L. Violante. 2018. "Monetary Policy according to HANK." *A.E.R.* 108 (3): 697–743.
Kaplan, G., and G. L. Violante. 2018. "Microeconomic Heterogeneity and Macroeconomic Shocks." *J. Econ. Perspectives* 32 (3): 167–94.
———. 2022. "The Marginal Propensity to Consume in Heterogeneous Agent Models." *Ann. Rev. Econ.* 14:747–75.
Kekre, R., and M. Lenel. 2021. "The Flight to Safety and International Risk Sharing." Working Paper no. 29238, NBER, Cambridge, MA.
Krueger, D., and F. Perri. 2006. "Does Income Inequality Lead to Consumption Inequality? Evidence and Theory." *Rev. Econ. Studies* 73 (1): 163–93.
Lilien, D. M. 1982. "Sectoral Shifts and Cyclical Unemployment." *J.P.E.* 90 (4): 777–93.
Lkhagvasuren, D. 2012. "Key Moments in the Rouwenhorst Method." Manuscript.
Loungani, P., and R. Rogerson. 1989. "Cyclical Fluctuations and Sectoral Reallocation: Evidence from the PSID." *J. Monetary Econ.* 23 (2): 259–73.
Lustig, H., and A. Verdelhan. 2007. "The Cross-Section of Foreign Currency Risk Premia and Consumption Growth Risk." *A.E.R.* 97 (1): 89–117.
Maggiori, M. 2022. "International Macroeconomics with Imperfect Financial Markets." In *Handbook of International Economics*, vol. 6, edited by G. Gopinath, E. Helpman, and K. Rogoff, 199–236. Amsterdam: North-Holland.
Maggiori, M., B. Neiman, and J. Schreger. 2017. "International Currencies and Capital Allocation." Manuscript, Harvard Univ., Cambridge, MA.
Mendoza, E. G. 1995. "The Terms of Trade, the Real Exchange Rate, and Economic Fluctuations." *Internat. Econ. Rev.* 36 (1): 101–37.
Mukhin, D. 2018. "An Equilibrium Model of the International Price System." Report, Soc. Econ. Dynamics, Minneapolis, MN.

Mundell, R. A. 1963. "Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates." *Canadian J. Econ. and Polit. Sci.* 29 (4): 475–85.
Obstfeld, M. 2007. "International Risk Sharing and the Costs of Trade." Manuscript.
Obstfeld, M., and K. Rogoff. 1995. "Exchange Rate Dynamics Redux." *J.P.E.* 103 (3): 624–60.
———. 2000. "New Directions for Stochastic Open Economy Models." *J. Internat. Econ.* 50 (1): 117–53.
Oskolkov, A. 2021. "Exchange Rate Policy and Heterogeneity in Small Open Economies." Manuscript.
Ottonello, P. 2021. "Optimal Exchange-Rate Policy under Collateral Constraints and Wage Rigidity." *J. Internat. Econ.* 131:103478.
Ottonello, P., and D. J. Perez. 2019. "The Currency Composition of Sovereign Debt." *American Econ. J. Macroeconomics* 11 (3): 174–208.
Parker, J. A., N. S. Souleles, D. S. Johnson, and R. McClelland. 2013. "Consumer Spending and the Economic Stimulus Payments of 2008." *A.E.R.* 103 (6): 2530–53.
Pilossoph, L. 2014. "Sectoral Shocks and Move Unemployment." Report, Fed. Reserve Bank New York.
Quadrini, V., and J.-V. Ríos-Rull. 2015. "Inequality in Macroeconomics." In *Handbook of Income Distribution*, vol. 2, edited by A. B. Atkinson and F. Bourguignon, 1229–302. Amsterdam: North-Holland.
Reiter, M. 2009. "Solving Heterogeneous-Agent Models by Projection and Perturbation." *J. Econ. Dynamics and Control* 33 (3): 649–65.
Rey, H. 2015. "Dilemma Not Trilemma: The Global Financial Cycle and Monetary Policy Independence." Working Paper no. 21162, NBER, Cambridge, MA.
Rogoff, K. 2006. "Impact of Globalization on Monetary Policy." Paper presented at "The New Economic Geography: Effects and Policy Implications" symposium, Jackson Hole, WY, August 24–26.
Rotemberg, J. J. 1982. "Sticky Prices in the United States." *J.P.E.* 90 (6): 1187–211.
Rouwenhorst, K. G. 1995. *Asset Pricing Implications of Equilibrium Business Cycle Models*. Princeton, NJ: Princeton Univ. Press.
Schmitt-Grohé, S., and M. Uribe. 2011. "Pegs and Pain." Working Paper no. 16847, NBER, Cambridge, MA.
———. 2018. "How Important Are Terms-of-Trade Shocks?" *Internat. Econ. Rev.* 59 (1): 85–111.
Stiglitz, J. E. 2002. *Globalization and Its Discontents*, vol. 500. New York: Norton.
———. 2017. *Globalization and Its Discontents Revisited*. New York: Norton.
Straub, L. 2018. "Consumption, Savings, and the Distribution of Permanent Income." Report, Harvard Univ., Cambridge, MA.
Subramanian, A., and M. Kessler. 2013. "The Hyperglobalization of Trade and Its Future." Manuscript.
Zhou, H. 2020. "Open Economy, Redistribution, and the Aggregate Impact of External Shocks." Report, Princeton Univ., Princeton, NJ.