# Multinational Production, Risk Sharing, and Home Equity Bias

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Abstract

We study the consequences of offshoring for international equity portfolios, risk sharing, and the international transmission of technology and government spending shocks. We show analytically that serving foreign markets by producing locally can substitute for international asset trade and terms of trade adjustment in delivering perfect risk sharing across countries: Offshore production implies that the consumption differential is tied to the real exchange rate even if the optimal equity portfolio is fully home-biased and the elasticity of substitution between domestic and foreign goods in consumption is different from one. Net foreign assets do not move in response to shocks. We investigate how the extent to which firms use source- versus host-country technology when producing abroad matters for the international transmission of shocks. A numerical illustration allows us to compare transparently the properties of our model to those of the alternative environment in which firms serve foreign markets by exporting.

Keywords: Home bias, international business cycles, multinational production, offshoring, risk sharing

JEL classification: F41, G11, G15

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that FDI transfers technology across borders, but also that production is subject to shocks that are specific to local technology.

We intentionally keep the model simple enough that it can be solved analytically using the technique developed by Devereux and Sutherland (2011) and Tille and van Wincoop ployment of its labor. With o shore production, the technology structure shapes the e ect of the shock on relative employment: There is no di erential in employment across countries if rms use only their own country's technology regardless of where they produce, otherwise domestic employment actually falls relative to foreign. In GLR, a relative increase in home labor e ort is also needed for home households to make up for the loss of purchasing power implied by terms of trade depreciation. By contrast, we show that o shore production with exclusive use of host-country technology implies the largest increase in the purchasing power of home incomes, which allows home households to sustain any given level of consumption with lower labor e ort. Wages mirror the dynamics of labor: In GLR, increased employment of home labor drives home wages above foreign; however, the largest increase in the wage di erential happens with o shore production and exclusive use of host-country technology.

The paper is related to several literatures. It contributes to vast literatures on risk sharing and home equity bias in international portfolios by exploring the consequences of international production. The mechanisms that ensure risk sharing between domestic and foreign consumers are key to the properties of virtually every model in modern international macroeconomics, and to the \puzzles" that these models result in or resolve in relation to the empirical evidence. Benigno and Thoenissen (2008) and Corsetti, Dedola, and Leduc (2008) are representative examples of articles that explore the consequences of risk sharing or lack thereof for the propagation of international macroeconomic uctuations. We contribute to this literature by showing that international production implies a CO-type result even in absence of goods trade, regardless of the value of substitutability between domestic and foreign goods. Our results provide transparent benchmarks for how the mechanism we focus on would impact the properties and quantitative performance of richer models that may embed it i3227(i3)-4e 8t4a4A27(y)2e 85(fo)27(e1)-401(home)-40e17(con5 Td [(the)-4e1)-reof 669 Td323(W

To the best of our knowledge, the extent to which MNCs can result in portfolios that are optimally skewed toward domestic equity has not been explored theoretically. We contribute on this front by obtaining results in a transparent, canonical setup that can provide guidance for future empirical investigations.

Last but not least, our work is related to a fast-growing literature on MNCs, portfolios, and asset prices at the intersection of international trade and international macroeconomics. Examples include Fillat and Garetto (2015), Fillat, Garetto, and Oldenski (2015), and Ramondo and Rappoport (2010). These papers explore the implications of multinational activity for asset prices (or returns) and risk sharing in models that incorporate endogenous decisions by rms on whether to engage in multinational production.[5] Ramondo and Rap-
returns) aA51

# 2 Model

This section outlines the model setup of households, governments, and firms.

## 2.1 Households and Governments

There are two countries: Home and Foreign. Each country is populated by infinitely lived, atomistic households. The world population equals the continuum $[0; 1]$. Home and Foreign households comprise the intervals $[0; a)$ and $[a; 1]$, respectively.

The representative Home household maximizes an expected intertemporal utility function that depends on consumption, $C_t$, and labor, $L_t$:

$$E_t \sum_{s=t}^{\infty} {}^{s-t} \left( \frac{C_s^{1-\frac{1}{}}}{1-\frac{1}{}} \qquad L^{1+\frac{1}{}} \right.$$

The price indices follow from the above consumption preferences. The Home price index is:

$$P_t = [aP_{Ht}^{1-\omega} + (1-a)P_{Ft}^{1-\omega}]^{\frac{1}{1-\omega}}.$$

$P_{Ht}$ and $P_{Ft}$ are the price indices for the sub-baskets of goods produced in Home by Home and Foreign firms, respectively:

$$P_{Ht} = [\tfrac{1}{a}\int_0^a p_t(z)^{1-\theta} dz]^{\frac{1}{1-\theta}} \text{ and } P_{Ft} = [\tfrac{1}{1-a}\int_a^1 p_t(z^*)^{1-\theta} dz^*]^{\frac{1}{1-\theta}},$$

where $p_t(z)$ and $p_t(z^*)$ are the prices of individual goods.[6] The Foreign price index, $P_t^*$, is similarly a function of the price of the bundle of goods produced in the Foreign country by Home firms, $P_{Ht}^*$, and the price of the bundle of goods produced in the Foreign country by Foreign firms, $P_{Ft}^*$:

$$P_t^* = [aP_{Ht}^{*1-\omega} + (1-a)P_{Ft}^{*1-\omega}]^{\frac{1}{1-\omega}}.$$

The government consumes the same consumption basket as the households. Letting $G_t$ be per capita government spending and anticipating symmetry of optimal behavior across households, $Y_t^d \equiv a(C_t + G_t)$ is the total demand for the Home country's consumption basket by all households and the government. The demand for Home firm $z$'s output by all households and the government in the Home country is $(\frac{p_t(z)}{P_{Ht}})^{-\theta}(\frac{P_{Ht}}{P_t})^{-\omega}a(C_t + G_t)$. Government spending is exogenous and wasteful. The government's budget is balanced, and spending equals a lump-sum tax on household income.

In addition to supplying labor and consuming, Home households hold shares in Home and Foreign firms. Aggregate per capita holdings of Home and Foreign firms at the beginning of period $t+1$ are denoted by $x_{t+1}$ and $x_{t+1}^*$, respectively. Similarly, Foreign households' aggregate per capita holdings of shares in Home and Foreign firms are denoted by $x_{*t+1}$ and $x_{*t+1}^*$, respectively.

The equilibrium version of the Home household's budget constraint in nominal terms is:

[6] We assume that prices are denominated in units of the relevant country's currency. Money serves the sole purpose of unit of account in our model. Therefore, we do not model the demand for cash, and we resort to a cashless environment as in Woodford (2003). Since we assume that all prices and wages are fully flexible, we will focus only on real variables in solving the model.

$$(V_t + D_t + \varepsilon_t D^*_t)x_t + (\varepsilon_t V^*_t + D^{**}_t + \varepsilon_t D^*_t)x^*_t + W_t L_t = V_t x_{t+1} + \varepsilon_t V^*_t x^*_{t+1} + P_t C_t + P_t G_t,$$

where $\varepsilon_t$ is the exchange rate (units of Home currency per unit of Foreign). We assume that all the profits generated by firms are paid to households as dividends.[7] Reflecting the multinational nature of production, $D_t$ is the profit generated by Home firms in Home, and $D^*_t$ is the profit generated by Home firms in Foreign. Similarly, $D^{**}_t$ and $D^{*}_t$ are the profits generated by Foreign firms in Foreign and Home, respectively. $V_t$ and $V^*_t$ are prices of shares in Home and Foreign firms, and $W_t$ is the Home nominal wage. Dividing by $P_t$ converts this budget constraint into units of Home consumption:

$$(v_t + d_t + d^*_t)x_t + (v^*_t + d^{**}_t + d^*_t)x^*_t + w_t L_t = v_t x_{t+1} + v^*_t x^*_{t+1} + C_t + G_t,$$

where $w_t$ is the Home real wage.

The representative Home household chooses $C_t$, $L_t$, $x_{t+1}$, and $x^*_{t+1}$. The maximization problem results in the first-order conditions:

$$L_t^{\frac{1}{\varphi}} = \frac{C_t^{-\frac{1}{\sigma}} w_t}{\chi},$$
$$C_t^{-\frac{1}{\sigma}} = \beta E_t\left[C_{t+1}^{-\frac{1}{\sigma}} R_{t+1}\right], \text{ and}$$
$$E_t\left[C_{t+1}^{-\frac{1}{\sigma}} R_{t+1}\right] = E_t\left[C_{t+1}^{-\frac{1}{\sigma}} R^*_{t+1}\right],$$

where $R_t \equiv (v_t + d_t + d^*_t)/v_{t-1}$ is the gross return from holding Home firm equity, and $R^*_t \equiv (v^*_t + d^{**}_t + d^*_t)/v^*_{t-1}$ is the gross return from holding Foreign firm equity. The first equation gives the optimal labor supply. This is the *total* Home labor supply, comprising labor supplied to both Home and Foreign firms in Home. The second equation is the Euler equation for equity in Home firms. The third equation says that, at an optimum, Home households are indifferent between holding Home and Foreign equity. Similar equations hold for the Foreign household. For example, the Euler equation for the Foreign household's holdings of shares in Home firms is $C^{*\,-\frac{1}{\sigma}}_t = \beta E_t\left[C^{*\,-\frac{1}{\sigma}}_{t+1} R^f_{t+1}\right]$; where $R^f_t \equiv (v^f_t + d^f_t + d^{f}_t)/v^f_{t-1}$ is the return measured in units of Foreign consumption (denoted by the superscript $f$). This Euler equation can be expressed in units of Home consumption as $C^{*\,-\frac{1}{\sigma}}_t = \beta E_t\left[C^{*\,-\frac{1}{\sigma}}_{t+1} R_{t+1} \frac{Q_t}{Q_{t+1}}\right]$, where $Q_t \equiv \frac{\varepsilon_t P^*_t}{P_t}$ is the real exchange rate, and returns are such that $R_t = \frac{Q_t}{Q_{t-1}} R^f_t$.

The budget constraint can be used to derive the law of motion for net foreign assets:

[7] We leave retained earnings as a topic for future research.

$$nfa_{t+1} = R_t^D \alpha_t + R_t nfa_t + y_t - C_t - G_t,$$

where net foreign assets are defined as the difference between Home holdings of Foreign equity minus Foreign holdings of Home equity (adjusted for relative population size): $nfa_{t+1} \equiv v_t x_{t+1} - \frac{1-a}{a} v_t x^*_{t+1}$. The superscript $D$ denotes the difference between Home and Foreign variables, so $R_t^D \equiv R^*_t - R_t$ is the excess return on Foreign equity. Home's gross domestic product (GDP) is $y_t \equiv d_t + d^*_t + w_t L_t$.[8]

The portfolio variable $\alpha_t$ is defined as the Home household's holdings of Foreign firm shares multiplied by the price of Foreign shares: $\alpha_t \equiv v_{t-1} x_t$. The higher $\alpha_t$, the more Foreign equity (in terms of value) Home households are holding. The portfolio held by Foreign households, $\alpha^*_t$, satisfies the market-clearing condition $\alpha^*_t = -\frac{a}{1-a}\alpha_t \equiv -\frac{a}{1-a} v_{t-1} x_t$. This means that a higher $\alpha_t$ translates into a lower $\alpha^*_t$ with Foreign households owning less Foreign equity.

A similar law of motion can be derived for Foreign net foreign assets:

$$nfa_{t+1}^f = R_t^{Df} \alpha_t^f + R_t^f nfa_t^f + y_t^f - C_t^f - G_t^f,$$

or, in units of Home consumption:

$$Q_t nfa_{t+1}^f = \frac{Q_t}{Q_{t-1}} R_t^{Df} Q_{t-1} \alpha_t^f + \frac{Q_t}{Q_{t-1}} R_t^f Q_{t-1} nfa_t^f + Q_t y_t^f - Q_t C_t^f - Q_t G_t^f.$$

Subtracting this equation from the law of motion for Home net foreign assets and imposing clearing of asset markets yields:

$$nfa_{t+1} = R_t^D \alpha_t + R_t nfa_t + (1-a)[(y_t - Q_t y_t^f) - (C_t - Q_t C_t^f) - (G_t - Q_t G_t^f)].$$

This law of motion for net foreign assets is the starting point for the derivation of the steady-state home optimal portfolio $\alpha$.

[8] We assume that firms repatriate profits to their countries of origin for distribution to domestic and foreign shareholders. Therefore, the Home firms' profits generated in the Foreign country become a part of Home's GDP while the Foreign firms' profits generated in Home become a part of Foreign's GDP. Exploring the consequences of alternative assumptions will be a topic for future work.

## 2.2 Firms

Firms are monopolistically competitive. Each rm produces a di erentiated good in the continuum $[0;1]$. Home rms, denoted by $z$, comprise the interval $[0;a)$. Foreign rms, denoted by $z$ , comprise the interval $[a;1]$.

In contrast to GLR, where rms produce domestically and serve foreign markets by exporting, rms in our model produce in both countries. They hire labor in both countries and sell products locally in the market in which they produce.

The revenue of Home rm $z$, consists of the revenue earned in Home and the revenue earned in Foreign. In units of Home currency, the revenue earned in Home is $p_t(z)Z_tL_t(z)$, because the rm employs Home labor, $L_t(z)$, with exogenous Home productivity, $Z_t$, to produce its output in the Home country. This output is then multiplied by the price charged by the rm in in Home, $p_t(z$

the MNC parent companies. Table 1 summarizes the structure of production of Home and Foreign rms in our model.

Table 1: Production structure of rms

| | Home rm $z$ | Foreign rm $z$ |
|---|---|---|
| Home country | $y_t(z) = Z_t L_t(z)$ | $y_t(z) = Z_t^{1} \; Z_t \; L_t(z)$ |
| Foreign country | $y_t(z) = Z_t Z_t^{1} \; L_t(z)$ | $y_t(z) = Z_t L_t(z)$ |

Optimally set prices equal marginal costs multiplied by constant markups. We focus on real prices expressed relative to the price index in each country in which rms operate. Home rms charge $RP_t = \frac{}{1} \frac{w_t}{Z_t}$ in the Home country (in units of Home consumption) and $RP_t = \frac{}{1} \frac{w_t}{Z_t Z_t^{1}}$ in Foreign (in units of Foreign consumption). Similarly, Foreign rms charge $RP_t = \frac{}{1} \frac{w_t}{Z_t^{1} \; Z_t}$ in Home and $RP_t = \frac{}{1} \frac{w_t}{Z_t}$ in Foreign.

In this model, no goods cross the border because the rms serve the market in each country by producing in that market. The marginal costs of producing a given good can di er between the Home and Foreign markets, and rms can charge di erent prices for the same good in the two markets. This goods market segmentation means that the law of

## 2.3 Shocks

The model includes four exogenous shocks: $G_t; G_t; Z_t$, and $Z_t$. All shocks follow AR(1) processes in logs. Since there are only two assets (shares in Home and Foreign rms), this guarantees that asset markets are incomplete.

# 3 Model Properties and Key Analytical Results

This section begins by showing properties that are useful in solving the model and interpreting its results. It then shows that, in our model, the optimal portfolio of the Home household contains no shares of Foreign equity, i.e., that optimal portfolio holdings are fully

This expression relates the GDP ratio to consumption, government spending, and technology in the two countries.

Using the de nition of the real exchange rate, the expressions for the price indices and optimal price setting, and imposing labor market clearing also makes it possible to show that relative consumption is such that:

$$\left(\frac{C_t}{C_t}\right)^{\frac{'}{}} = \left[\frac{C_t + G_t}{C_t + G_t}\right]$$

Similarly, Foreign GDP (in units of Foreign consumption) is $y_t = \frac{}{\quad 1}(w_t L_t + w_t L_t)$. Labor income then equals $\frac{1}{}y_t Q_t$ in units of Home consumption. The pro t of Foreign rms, comprising of the pro t generated in the Home and Foreign markets, $d_t + d_t$, in units of Home consumption, is then $\frac{1}{}y_t Q_t$.

The derivation of the optimal portfolio held by Home households requires obtaining an expression for the relative pro t of Home and Foreign rms, $\frac{d_t + d_t}{d_t + d_t}$. Since $\frac{d_t + d_t}{d_t + d_t} = \frac{y_t}{y_t Q_t}$, this derivation can utilize the relative GDP expression shown in Section 3.1.1.

## 3.2 Optimal Portfolio and Risk Sharing

We now turn to the properties of our model for optimal equity portfolios, risk sharing, and the dynamics of net foreign assets. The standard technique for obtaining steady-state optimal portfolios in open economy macro models, developed by Devereux and Sutherland (2011) and Tille and van Wincoop (2010), combines second-order approximation of portfolio optimality conditions with log-linear approximation of the rest of the model. As we shall see, results from log-linear approximations are su cient in the environment of our paper. The details of the solution can be found in the Technical Appendix. We present only key steps and results here.

The portfolio denoted by $_t$ is de ned in Section 2.1 as the Home household's holdings of Foreign rm shares multiplied by the price of the Foreign rm shares, $_t \quad v_{t\ 1} x_t$. Households choose the optimal portfolio in order to insure against shocks to productivity and government spending at Home and abroad: $Z_t$, $Z_t$, $G_t$, and $G_t$. Log-linearizing the law of motion for net foreign assets from Section 2.1 around a symmetric steady state with zero net foreign assets results in:

$$n\widehat{fa}_{t+1} = \frac{}{(1 \quad G)}\hat{R}^D_t + \frac{1}{}n\widehat{fa}_t + \frac{1 \quad a}{1 \quad G}\hat{y}^D_t \quad (1 \quad a)\hat{C}^D_t \quad \frac{(1 \quad a)G}{1 \quad G}\hat{G}^D_t,$$

where hats denote percentage deviations from steady state, variables without the time subscript denote steady-state levels, the superscripts $D$ denote di erences between Home and Foreign variables, and $\hat{R}^D_t$ is the excess return.[10]

[10] As GLR, we do not introduce in the model any stationarity-inducing device that would pin down endogenously the steady-state level of net foreign assets. This means that the zero net foreign asset positions

Log-linearizing the relative-consumption equation from Section 3.1.1 yields the solution for the consumption di erential as a function of relative technology and government spending:

$$\hat{c}_t^D = \frac{(1+\varphi)(1-\ )}{1-G+-}\hat{z}_t^D - \frac{G}{1-G+-}\hat{g}_t^D :$$

In turn, using this and the properties of relative GDP described above results in:

$$\hat{y}_t^D = \frac{(1-G)(1+\varphi)(1-\ )}{1-G+-}\hat{z}_t^D + \frac{G-}{1-G+-}\hat{g}_t^D ;$$

and substituting these expressions in the log-linear net foreign asset equation yields:

$$n\hat{f}a_{t+1} = \frac{1}{\ }n\hat{f}a_t + \frac{\ }{(1-G)}\hat{R}_t^D .$$

The Technical Appendix also shows that, as in Devereux and Sutherland (2011) and Tille and van Wincoop (2010), the excess return $\hat{R}_t^D$ is a linear function of unexpected innovations to relative productivity and government spending. Given  < 1, this implies that  must equal zero in order to avoid net foreign assets exploding with certainty: The optimal portfolio contains no shares of Foreign rms, indicating that 100 percent Home equity bias is optimal for Home households.[11]

This result arises because rms serve foreign markets by producing locally (rather than by producing domestically and then exporting their output). Home households can diversify risk by holding a portfolio consisting of only Home rm shares because the multinational nature of rms provides exposure not only to Home productivity and government spending shocks but also to Foreign shocks through a production function that uses Foreign labor and comprises a mix of Home and Foreign technologies when operating in the Foreign country.[12]

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is selected as a matter of analytical convenience, and net foreign assets (if they move) display a unit root. We make this modeling choice since our primary focus is on portfolio composition rather than the steady-state level of net foreign assets, and we aim to keep results and comparison with the GLR scenario fully transparent. Since steady state net foreign assets are zero, we de ne $n\hat{f}a_t \quad dnfa_t = C$.

[11]By comparison4 Td [f1135 comp 876.564a

Given = 0 and a zero initial level of net foreign assets, it follows that net foreign assets do not move in response to shocks and remain at zero in all periods. Intuitively, in a world in which countries do not trade goods (and therefore never generate future export revenues with which to repay current de cits), it is optimal | and necessary for intertemporal sustainability of otherwise-exploding net asset imbalances | never to incur movements in net foreign assets. This is consistent with the GDP ratio expression $\frac{y_t}{y_t} = \frac{C_t + G_t}{C_t + G_t}$ obtained above.

We next show that the optimality of complete Home equity bias arises because the multinational structure of production leads to perfect risk sharing via the real exchange rate. As noted above, the real exchange rate uctuates in our model because domestic and foreign consumption baskets incorporate di erent productivity contents across countries, and there is no trade in goods that would enforce the law of one price. Straightforward substitution of the expressions for price indices from Section 2.1 yields:

$$Q_t \quad \frac{"_t P_t}{P_t} = [^{a("_t P_{H\,t})^1}$$

traditional trade, if the consumption basket takes a Cobb-Douglas form, movements in the terms of trade yield the complete markets allocation in absence of any asset trade. In our model, there is no trade in goods because all consumption is produced locally, but the multinational structure of production su ces to replicate the complete markets outcome. To the best of our knowledge, this counterpart to the CO result for a world of o shore production is a novel theoretical result of our paper.[13]

# 4 Impulse Responses

The strategy used by rms to serve foreign markets and the production structure of rms a ect the responses to business cycle shocks. We illustrate this point in this Section by showing impulse responses to productivity and government spending shocks under di erent assumptions: With respect to foreign sale strategy, we compare the scenario of this paper (in which rms serve markets by producing locally) to the scenario in GLR (in which rms serve foreign markets by exporting); within the local production setup of this paper, we consider cases ranging from both Home and Foreign rms using only local technology when producing in any given country ( = 0) to the opposite extreme in which rms use only source-country technology ( = 1). We present impulse responses to a Home technology shock in Section 4.1 and a Home governmenteeending shock in Section 4.2. As in GLR, we focus on the responses of cross-country di erentials. It is well known since Aoki (1981) that the responses of country-level variables can be recovered from those of di erentials and world aggregates. We verify in the Technical Apeendix that serving foreign markets by producing locally does not imply di erences in the responses of world aggregates relative to serving foreign markets by exporting as in GLR. Put di erently, changing the structure of production and demand-ful llmentto the onewe are studying in this paper matters for how world production and consumption are allocated between the two countries but not for the overall amount of production and consumption. Hence, di erences in the behavior of

the technological improvement affects equally the effectiveness of Home and Foreign labor employed by Home firms. When  = 0 (blue line with triangles), both Home and Foreign firms use only Home technology to produce in Home, and both use only Foreign technology, $Z$ , to produce in Foreign. In this case, a positive shock to Home technology increases Home GDP relative to Foreign because there is no improvement in the effectiveness of Foreign labor, but the increase is less pronounced than in the GLR world because, in the offshore production scenario, the profitability of Home operations of Foreign firms rises. The green line with circles shows the impulse response for the intermediate case  $= 0.5$, in which firms use a combination of domestic and foreign technology when they produced abroad.

The top right panel of the figure presents the response of the real exchange rate. Frictionless trade and identical consumer preferences across countries imply purchasing power parity in GLR. Hence, the real exchange rate does not move in the GLR world, and we report the response of the terms of trade for that case. Consistent with standard intuition, Home's terms of trade depreciate to clear the goods market as the supply of Home goods increases. In our world of offshore production, there is no trade in goods that would enforce the law of one price, and domestic and foreign consumption baskets incorporate different productivity contents across countries. As a consequence, PPP does not hold, and the real exchange rate fluctuates. An improvement in Home technology is associated with real depreciation, except in the case  $= 1$: As with the absence of a GDP differential, the real exchange rate remains constant in this case because the effectiveness of Home and Foreign labor employed by Home firms is affected equally by the shock. Instead, the real exchange rate depreciates by more the more firms rely on host-country technology in overseas production. In this case, it is only the effectiveness of Home labor that is affected by the shock, but Foreign firms are using Home technology when employing Home labor. Optimal price setting in this environment implies that the Home price index falls relative to Foreign, which translates into real depreciation. As before, the intermediate case  $= 0.5$ falls between the two extremes.

The consumption differential, $C^D$ (middle left panel), varies proportionately with the real exchange rate as implied by $\widehat{C}_t^D = \widehat{Q}_t$. As we showed in Section 3.2, offshore production implies perfect risk sharing (and no movement of net foreign assets in response to shocks) even if the optimal portfolio is fully home-biased. In the incomplete-markets, GLR world of international trade, a Home technology shock causes Home consumption to rise permanently above Foreign. With offshore production, the extent to which the consumption differential moves depends on the structure of production: Equal impacts of the technology shock on the effectiveness of Home and Foreign labor ( = 1) imply no movement of the consumption differential; otherwise, Home consumption rises above Foreign, and it does so by more if host country technology is predominantly used.

The middle right panel shows the responses of employment to the shock: In GLR, improvement in Home technology implies an increase in Home employment relative to Foreign as familiar resource-shifting (even in the presence of imperfect substitutability) implies increased production in the country that has received the favorable shock and, therefore, increased employment of its labor. The effect of the shock on relative employment with offshore production depends again on the production structure: There is no differential in employment if = 1, otherwise Home employment actually falls relative to Foreign. In the standard model (GLR), a relative increase in Home labor effort is also needed for Home households to make up for the loss of purchasing power implied by terms of trade depreciation. Offshore production with exclusive use of host-country technology actually implies the largest increase in the purchasing power of Home incomes, which allows Home households to sustain any given level of consumption with reduced labor effort. In turn, this is mirrored in the behavior of the wage differential: In GLR, increased employment of Home labor drives Home wages above Foreign, but the largest increase in the wage differential happens with offshore production and = 0 — the case in which Home households enjoy the largest increase in consumption and leisure.

Finally, in GLR, an improvement in Home technology increases the value of Home equity relative to Foreign because the dividend ratio is tied to the GDP ratio, which rises. With offshore production, the ratio of total dividends generated by Home and Foreign firms measured in the same units (Home consumption) is tied to the ratio of GDPs adjusted for the real exchange rate, $\frac{y_t}{y_t Q_t}$. Hence, real depreciation implies that the ratio of total dividends generated by Home firms to those generated by Foreign ones falls in response to Home technological improvement (the more so the more Foreign firms use Home technology when producing in Home), and this translates into a lower relative value of Home equity.

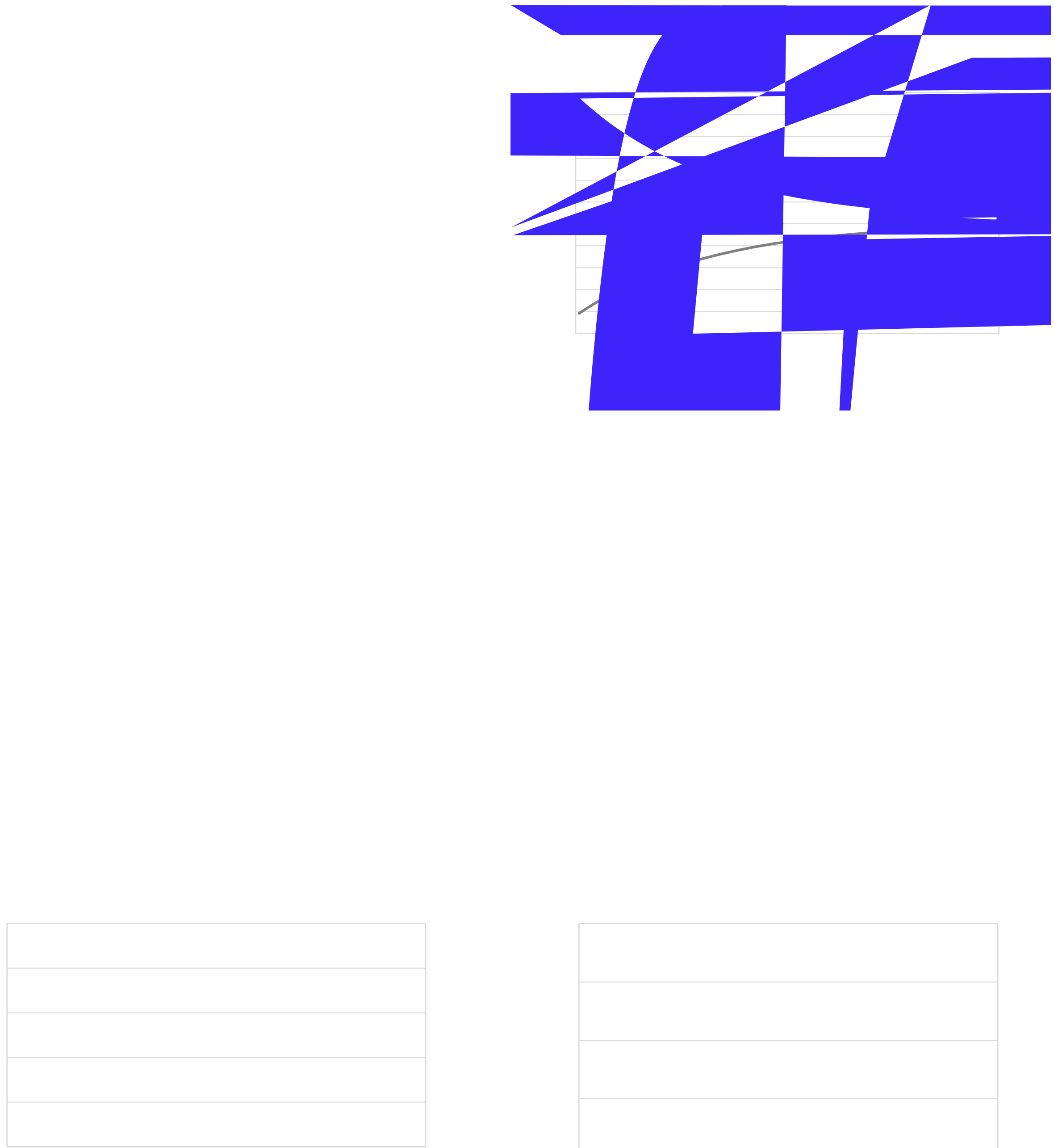
## 4.2 Government Shock

in the same direction as in GLR.

## 5 Conclusion

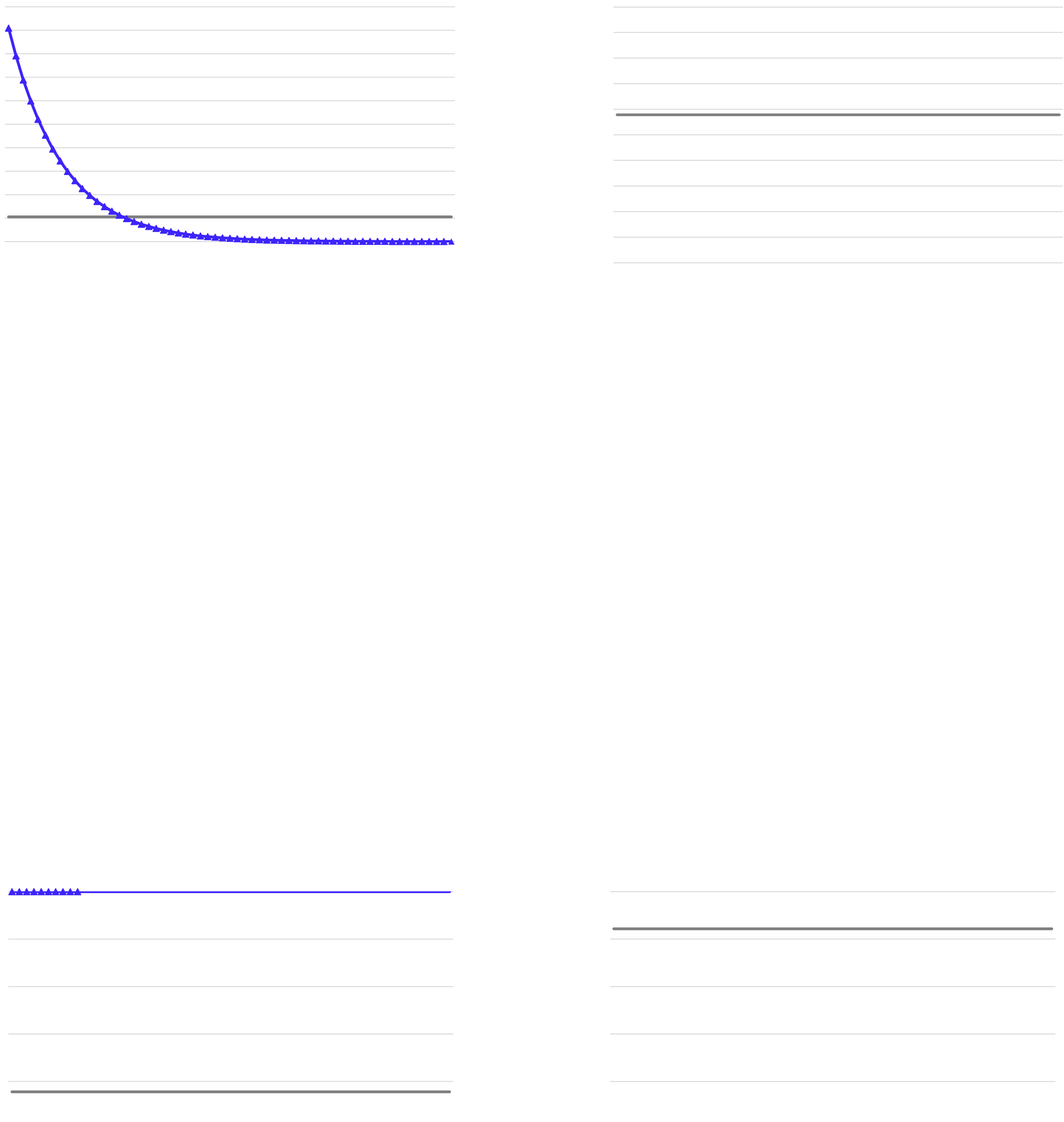
This paper studied the consequences of serving foreign markets by producing locally (o shore production) for international equity portfolios, risk sharing, and the international transmis-

Figure 1: Impulse Responses to a Relative Technology Shock, $Z^D$



This gure shows impulse responses of key variables to a 1% relative technology shock, $Z^D$. The horizontal axis represents sixty time periods. The blue (triangle), green (circle), and red (diamond) lines use values of = 0, = 0:5, and = 1, respectively. The gray line shows responses from the Ghironi et al. (2015) model for comparison.

Figure 2: Impulse Responses to a Relative Government Spending Shock, $G^D$



This gure shows impulse responses of key variables to a 1% relative government spending shock, $G^D$. The horizontal axis represents sixty time periods. The blue (triangle), green (circle), and red (diamond) lines use values of = 0, = 0:5, and = 1, respectively. The gray line shows responses from the Ghironi et al. (2015) model for comparison.

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