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International financial integration and income inequality in a stochastically growing economy☆

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ABSTRACT

We employ a stochastic growth model to study the impact of international financial globalization on income inequality. A key element is that financial frictions facing the economy pertain to both lending and borrowing abroad, and the process of financial liberalization is specified in terms of reducing these frictions. We emphasize two key channels through which liberalization affects inequality. The first is by reducing the costs of investing and borrowing abroad. Since these activities favor the wealthy, they tend to increase inequality. But, in addition, these two forms of liberalization have sharply contrasting effects on domestic activity causing contrasting impacts on inequality. Numerical simulations suggest that income inequality is more sensitive to financial liberalization that favors foreign investment than if it is directed to reducing foreign borrowing costs. The simulations also suggest that the overall liberalization that occurred during 1970–2015, accounted for a significant fraction of the increase in income inequality experienced over that period. The main findings are broadly supported by the empirical evidence using the most recent data for a sample of 96 countries for the period 1970–2015.

1. Introduction

Growing income inequality is an issue of increasing concern to economists and policymakers. Empirical evidence shows that during recent years inequality has increased in many countries, across the spectrum of development.[1] For example, in China the Gini coefficient increased from 0.291 in 1981, to 0.327 in 1990, and 0.474 in 2012. In the United States the Gini coefficient was 0.394 in 1970, 0.428 in 1990, and 0.48 in 2014.[2] Concurrently, cross-border holdings of gross financial assets and liabilities have increased enormously, especially during the period from the mid-1990s to 2007. In 1970 the world-wide ratio of the stock of external assets and liabilities to *GDP* was around 45%. It approximately doubled to 100% by 1987, and then accelerated to around 200% in 1998 and 400% in 2007 (Lane and Milesi-Ferretti, 2007, 2017). This development has also been associated with dramatic changes in the net external financial positions of many countries.[3] Recent research suggests that the growth in cross-border holdings of capital in terms of world GDP has slowed substantially, but the levels remain very high (Lane and Milesi-Ferretti, 2017). These developments naturally raise the question of the nature of the link (if any) between the process of financial liberalization and the growing income inequality. The objective of this paper is to develop a rigorous model directed at addressing this important issue.

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[1] See Milanovic (2016) or *World Inequality Lab (2018)*, for instance.

[2] Data is from "All the Ginis" database, as described in Section 6.

[3] Most notably in Greece, Portugal, Spain, the United States, and the United Kingdom.

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The impact of globalization associated with trade openness on income inequality has received increasing attention. This literature is extensive and in the late 1990s gained enormous impetus, which has continued.[4] In contrast, the consequences of the recent dramatic increase in the cross-border holdings of both assets and liabilities for inequality has received only relatively sparse attention.

Of the existing literature, the paper to which this is most closely related is the empirical study by Jaumotte et al. (2013). They find that trade globalization (as measured by the ratio of exports and imports to GDP) is associated with less income inequality, while financial globalization (as measured by the ratio of cross-border assets and liabilities to GDP), and foreign direct investment especially (as measured by the ratio of inward foreign direct investment stock to GDP), in contrast, is associated with more inequality. They also find technological progress to be a significant force driving inequality. These results are obtained using data from 51 countries (20 developed and 31 developing) over 1981–2003, based on an extended version of the World Bank *Povcal* database.[5] One drawback of their study is their mixed use of inequality data based on both income and consumption surveys, depending upon availability, which, however, are not directly comparable, given that consumption-based Gini coefficients tend to show lower inequality.[6]

Other related studies include Bergh and Nilsson (2010), who showed that globalization, as measured by freedom to trade internationally (trade taxes, tariff rates and trade barriers, and capital market controls), increases inequality. This study includes 79 countries over the period 1970–2005 and is based on the Standardized World Income Inequality Database (SWIID) compiled by Solt (2009). Bumann and Lensink (2016) have recently shown that financial liberalization (as measured by financial depth through capital account liberalization) reduces inequality, for five-year panel covering 106 countries over the time period 1973 to 2008. Their study is based on the dataset compiled by Galbraith and Kum (2005), where capital account liberalization is measured as Chinn and Ito (2008), and financial depth is captured by the ratio of private credit over GDP.[7] Recent research by Furceri and Loungani (2018) has found that capital account liberalization [as measured by Chinn and Ito, 2008] increases the Gini measure of inequality, based on panel data estimates for 149 countries from 1970 to 2010 under the SWIID.

In contrast to these papers, which are almost entirely empirical, our objective is to analyze the impact of financial liberalization on income inequality within a more formally structured general equilibrium framework. Our analysis comprises three components. The first is the development of the underlying stochastic equilibrium, the main objective of which is to identify the channels through which financial liberalization impinges on income inequality. However, the complexity of the model necessitates its numerical analysis, and the second phase of our analysis is its calibration and a quantitative assessment of the relationship. Finally, we subject the main theoretical and quantitative results of the model to extensive empirical testing.

The basic theoretical framework we employ is an extension to a small open economy of the stochastic growth model developed by García-Peñalosa and Turnovsky (2006a), used to analyze the impact of risk volatility on income distribution in a closed economy. In our view it is important to employ a stochastic framework. This is because the heart of international financial liberalization concerns its impact on agents' portfolio choices as they balance off the risks and returns on investments worldwide, and this issue can really be studied adequately only in a stochastic setting.

A key feature of the model is that the domestic economy has restricted access to international financial markets. It is able to lend and borrow abroad simultaneously, but in either case it is subject to financial frictions that are reflected in costs that increase with its position in the relevant market. By being able to borrow and lend abroad simultaneously, whether the country is a net creditor (positive net international financial assets) or a net debtor (negative net international financial assets) is determined endogenously and an economy's net asset position can switch, as has periodically occurred. In recognition of the diversity of experiences with respect to net financial assets, in our numerical analysis we distinguish between creditor and debtor economies, which indeed are impacted differentially by financial liberalization.

Financial liberalization is manifested as a reduction in the costs associated with trading in international financial markets. Introducing independent frictions (and corresponding financial liberalization) associated with foreign lending and borrowing reflects the reality that the reasons countries impose controls on capital outflows (lending abroad) are essentially independent of those imposed on capital inflows (borrowing abroad). The former are motivated by concerns such as avoiding downward pressure on the exchange rate and keeping domestic savings at home, while the rationale for the latter include avoiding upward pressure on the exchange rate, and protecting domestic capital markets and specific industrial sectors.[8]

The main insight of the theoretical framework is to identify the channels whereby financial liberalization influences income inequality. First, there are the direct portfolio adjustments associated with the liberalization. To the extent that these increase the returns to investing abroad or reduce the costs of borrowing from abroad, since these activities are pursued by the more affluent members of society, they will increase income inequality. But, in addition the two forms of liberalization have sharply contrasting effects on domestic activity, and their consequences also need to be taken into account. Reducing the cost of investing abroad tends to divert resources from the domestic economy, reducing employment, raising the wage, reducing the return to domestic capital, and providing an offsetting ameliorating effect on the increase in income inequality. In contrast, reducing the cost of borrowing stimulates the domestic economy, raising employment, reducing the real wage, increasing the return to capital, and increasing inequality.

Calibrating the model to match the changes in the portfolio shares over the 1970–2015 period of globalization, we find that financial liberalization favoring investment abroad has a bigger impact on income inequality than does reduced borrowing costs, which may have actually reduced inequality. However, our numerical simulations suggest that, taken together, the overall effect of financial liberalization has been to increase income inequality, in both creditor and debtor economies.

In the last part of the paper we conduct a comprehensive empirical test of the model and its implications using the most recent data for a sample of 96 countries over the period 1970–2015 (or 70 countries for the period 1990–2015, due to limited data availability for some control variables). To do so, we first show that our representations of financial liberalization in terms of reduced borrowing and lending costs is always

[4] Some key studies include Feenstra and Hanson (1996) and Borjas et al. (1997). Epifani and Gancia (2008) find that trade globalization increases inequality, while Goldberg and Pavcnik (2007) find that trade globalization has increased inequality in developing countries. Helpman et al. (2017) show that trade affects wage inequality through between-firms differences in wages, and Antràs et al. (2017) find that trade integration leads to an increase in inequality in the distribution of disposable income, despite taxation being progressive, which they employ to evaluate its impact on welfare. See also Winters et al. (2004) for a survey on the impact of trade liberalization on poverty.

[5] See Chen and Ravallion (2004, 2007). *Povcal* database is supplemented by the *Luxembourg Income Study* database.

[6] Consumption-based Gini coefficients are typically employed in developing countries where income distribution is difficult to measure (Jaumotte et al., 2013, p. 276). In Section 4.2 below we demonstrate how the consumption-based Gini coefficient understates the income Gini coefficient.

[7] See De Haan and Sturm (2017) for a recent survey and evidence on finance and inequality, and Claessens and Perotti (2007) for a survey on the impact of financial development (as measured by stock market capitalization, financial intermediation deepening, and so on) on inequality.

[8] This issue is discussed at length by Bakker and Chapple (2002), who compare the liberalization experiences for several advanced economies. The case of New Zealand offers one of the most celebrated examples of wholesale financial liberalization and is discussed in detail by Easton (1989).

associated with increased international financial integration, expressed as the sum of the portfolio shares of wealth devoted to foreign assets and liabilities. Using this measure as a proxy for financial liberalization, we find that the main theoretical results for the model are broadly supported by the empirical evidence, providing compelling support for a causal relationship between international financial integration and increased income inequality. Evidence for nonlinear effects of financial integration are also supported. Disaggregating our measure of international financial integration into its separate components (assets and liabilities) yields less conclusive results, but are nevertheless suggestive of the idea that financial liberalization directed at foreign lending have different implications than those directed at borrowing.

Finally, we note some measurement issues relevant to the empirical implementation of the model. First, there are different measures of income inequality, the most widely used being the Gini coefficient. Second, there are different Gini coefficients, depending on the specific income measure. Thus, the Gini coefficient can be expressed in net or gross terms, it can be based on income or consumption data, or it can be provided by individuals or households. Third, the Gini coefficient varies substantially depending on the sources of data employed to calculate it. Choosing the right database involves trade-offs, concerning the accuracy and comparability of the data, and the size of the sample. Thus, we find Gini coefficients based on actual household surveys and estimates based on regressions or other methods. The former are typically preferred to the latter, because, being based on actual data, are usually more accurate. However, this also usually means a smaller sample size. The best source for actual data on inequality is probably "All the Ginis" (ATG henceforth) database, compiled by Branko Milanovic (since 2004) to "standardize" Gini coefficients, due to its coverage and comparability from different sources among countries.[9] The best source for other types of estimates is probably the SWIID, produced by Solt (2009, 2015).[10] We choose the ATG database, for being based on actual data. In addition, it allows us to capture conveniently differences in sources through dummies.[11]

The remainder of the paper proceeds as follows. Section 2 relates our analytical approach to the relevant literature. Section 3 sets out the basic model, while Section 4 derives the measure of income inequality and how it is impacted by financial liberalization. Section 5 describes the numerical simulations of the equilibrium stochastic model. The empirical implementation of the model is described in Sections 6 and 7, while Section 8 concludes. The Appendix provides many of the technical details and other supporting information.

2. Relationship to the literature

The framework we employ is a stochastic endogenous growth model with elastic labor supply, where agents have heterogeneous income, stemming from initial distributions of asset endowments and the differential labor supplies that these induce. For simplicity we abstract from the government.

Our analytical approach is related to three main bodies of literature. First, it embeds the stochastic growth model within the framework analyzing international portfolio choice. In this respect it is in the tradition of the early seminal work of Stulz (1981), Adler and Dumas (1983), Branson and Henderson (1985), and more recently, Stulz (1995). But in contrast to those earlier contributions, which treated asset returns as given, our analysis endogenizes these returns in ways discussed below. In distinguishing between debtor and lender countries, our analysis is also related to the more recent contributions of Kraay and Ventura (2000), Kraay et al. (2005). Like all these contributions, we adopt the stochastic specification using continuous time. While this enables the equilibrium to be presented in a very transparent and intuitive way, it is associated with other less appealing characteristics. Most notably, the methods are tractable only under restrictive conditions, requiring stationarity. The early literature achieves this by treating asset returns as given, we do so by imposing technological assumptions that ensure that the equilibrium is a stochastic balanced growth path.

The second related body of literature pertains to the sources of heterogeneity, which are the underlying cause of inequality. Broadly, one can identify two approaches to what is evolving into a burgeoning literature. The first is the so-called "representative consumer theory of distribution", as it was named by Caselli and Ventura (2000), which in effect introduces heterogeneity coupled with complete markets, with all agents having identical access to all markets. If, in addition, agents' preferences are homogeneous, and if endowments are the key source of heterogeneity, the macroeconomic equilibrium and distribution have a simple recursive structure. First, summing over individuals leads to a macroeconomic equilibrium in which aggregate quantities and the resulting factor returns are determined independently of any distributional aspects. With all agents having equal unimpeded access to these economy-wide derived factor returns, the distributions of these aggregates quantities across individuals can then be determined. This is the approach we shall adopt and it stands in sharp contrast to the "incomplete markets approach" in which idiosyncratic shocks and other sources of market incompleteness play a central role; see e.g. Bénabou (1996), Krusell and Smith (1998), and Heathcote et al. (2009).[12]

Our paper is also related, albeit indirectly, to the growing literature focusing on the top (usually 0.1%, 1% or 10%) of the income distribution. High end income has been found to have increased in recent years, and has been accompanied by a relative increase in top income shares (i.e. fatter Pareto tail); see, e.g., Piketty and Saez (2003), Atkinson et al. (2011), Gabaix et al. (2016), and Saez and Zucman (2016). To explain this, the literature has traditionally employed general equilibrium models with incomplete markets and idiosyncratic uninsurable labor income; see e.g. Bewley (1986), Huggett (1993), and Aiyagari (1994). Given the limited success of this literature in addressing recent empirical evidence, research has also considered the role played by the heterogeneity in returns to financial and physical capital; see, e.g., Benhabib et al. (2011), Benhabib and Bisin (2016), Gabaix et al. (2016), and Fagereng et al. (2018).

In contrast, our paper is focused on the impact on income inequality more "broadly" defined, based on the usual Gini coefficient, rather than the more "narrowly" defined top income inequality. This is a reasonable choice, given that the purpose of this paper is to analyze the impact of international financial integration on income inequality, which presumably would impact the complete distribution of income, and not just the distribution of top income. Alvaredo (2011) shows under which conditions and how both measures of inequality, Gini coefficient and top 1% inequality, are related.

We fully acknowledge that the model is a stylized one and that key characteristics such as common costs of investing and borrowing across agents and the balanced growth equilibrium are seemingly strong. Nevertheless, we feel that its tractability justifies it as a convenient vehicle for highlighting the crucial mechanisms in a transparent way. Furthermore, following the seminal work of Kaldor (1961) and its recent updates by Jones and Romer (2010) and Jones (2016), Grossman et al. (2017) has emphasized the *relevance* of a balanced growth path framework. as evidenced by the stability of average growth rates, the ratio of

[9] Nine different databases form part of ATG database, where the Luxembourg Income Study (LIS) is considered the best source. See Ravallion (2015) for an excellent review of LIS. Solt (2008) considers the LIS as the "gold standard of cross-nationally comparable inequality data". However, the LIS mainly covers only data for developed countries.

[10] See Jenkins (2015), and Badgaiyan et al. (2015) for recent reviews.

[11] Recent research provides excellent reviews of these databases; see e. g. Ferreira et al. (2015).

[12] Well known studies by Alesina and Rodrik (1994), Persson and Tabellini (1994) suggest how inequality may arise from differential political power. While this is somewhat distant from the approach adopted here, one can plausibly argue that the degree of financial liberalization may well reflect the outcome of political negotiations.

physical capital to output, and the shares of labor and capital in total factor payments extending over long periods of time.

3. Small open economy with heterogeneous agents

We now set out the specifics of the model

3.1. Technology and factor payments

The economy consists of a fixed number of firms indexed by j. The representative firm produces a tradeable output in accordance with the stochastic Cobb-Douglas production function

$$dY_j = Q(L_jK, K_j)(dt + du_Y) \equiv A[L_jK]^{\alpha}K_j^{1-\alpha}(dt + du_Y) \tag{1a}$$

where K_j denotes the individual firm's capital stock, L_j denotes the individual firm's employment of labor, K is the average stock of capital in the economy, a proxy for the economy-wide stock of knowledge, so that L_jK measures the efficiency units of labor employed by the firm. The term $du_Y \equiv \sigma_Y dz$, where dz is a standard normal Wiener process, is a proportional economy-wide productivity shock. Accordingly, the stochastic increments are temporally independent and normally distributed, with mean zero and variance $\sigma_Y^2 dt$ over the instant dt. The stochastic production function exhibits constant returns to scale in the private factors, — labor and the private capital stock.[13]

All firms face identical production conditions and are subject to the same realization of an economy-wide stochastic shock. Hence they will all choose the same level of employment and capital stock. That is, $K_j = K$ and $L_j = L$ for all j, where L is the average economy-wide level of employment. The average capital stock yields an externality such that in equilibrium the aggregate (average) production function is linear in the aggregate capital stock, as in Romer (1986), namely

$$dY = AL^{\alpha}K(dt + \sigma_Y dz) \equiv \Omega(L)K(dt + du_Y) \tag{1b}$$

where $\Omega(L) \equiv AL^{\alpha}$ and $\Omega'(L) > 0$.[14]

We assume that the wage rate, x, over the period $(t, t + dt)$ is determined at the start of the period and is set equal to the expected marginal physical product of labor over that period. The total rate of return to labor over that interval is thus non-stochastic, namely

$$dX = xdt = \left(\frac{\partial Q}{\partial L_j}\right)_{K_j=K, L_j=L} dt \tag{2a}$$

where $x = \alpha\Omega(L)L^{-1}K \equiv \alpha AL^{\alpha-1}K \equiv \omega(L)K$ and $\omega'(L) = \alpha(\alpha - 1)AL^{\alpha-2} < 0$.

The gross private rate of return to capital over the interval $(t, t + dt)$ is thus determined residually, and assuming that capital depreciates at the constant rate δ, the net return to capital, dR_K is given by

$$dR_K = \frac{dY - LdX}{K} - \delta dt \equiv r_K dt + du_K \tag{2b}$$

where $r_K \equiv \left(\frac{\partial Q}{\partial K_j}\right)_{K_j=K, L_j=L} = (1-\alpha)\Omega(L) - \delta$, $r_K'(L) = \alpha(1 - \alpha)AL^{\alpha-1} > 0$ and $du_K \equiv \Omega(L)du_Y$.

These two equations assume that the wage rate, x, is fixed over the time period $(t, t + dt)$, so that the return on capital absorbs all output fluctuations. The rationale for this assumption is that in industrial economies wages are typically fixed ex ante, while the return to capital is largely determined ex post, and thus absorbs most of the fluctuations in profit.[15] From (2a) and (2b) we see that the equilibrium return to capital is independent of the stock of capital while the wage rate is proportional to the average stock of capital, and therefore grows with the economy. In addition, more employment raises the productivity of capital but lowers that of labor, with important consequences for the impact of financial liberalization on inequality.

3.2. Consumers

The economy is populated by a mass 1 of infinitely-lived consumers, indexed by i. Agents can invest domestically, invest abroad, or borrow from abroad. They are identical in all respects except for their initial wealth, $W_{i,0}$ which comprises their holding of capital, $K_{i,0}$ foreign bonds, $B_{i,0}$, and their foreign borrowing (debt), $D_{i,0}$. Since the economy is growing we focus on the individual i's relative wealth, $w_i(t) \equiv W_i(t)/W(t)$, and his relative holding of capital, foreign bonds, and foreign debt, $k_i(t) \equiv K_i(t)/K(t)$, $b_i(t) \equiv B_i(t)/B(t)$, $d_i(t) \equiv D_i(t)/D(t)$ where $W(t)$, $K(t)$, $B(t)$ and $D(t)$ denote the corresponding economy-wide average quantities.

The focus of our analysis is on the degree of access that the domestic economy has to international financial markets, how this is impacted by globalization, and the consequences for the domestic economy, specifically the degree of income inequality. These financial frictions take the form of various controls, such as transactions taxes and costly bureaucratic regulations that impede the flows of capital into and out of the economy. They are reflected in lending and borrowing cost functions that are assumed to be strictly increasing and convex in the nation's aggregate position in the corresponding world financial market, relative to total domestic wealth, W, and are taken to be exogenous to the atomistic investor.[16]

The real rate of return on lending abroad, expressed in terms of the traded good as numeraire, dR_B, is:

$$\begin{gathered} dR_B = r_B dt + du_B \equiv \left[i_B{}^* - \varphi_B\left(\rho_B \frac{E_B B}{W}\right)\right]dt + du_B \\ \varphi_B(0) = 0, \varphi_B'\left(\rho_B \frac{E_B B}{W}\right) > 0, \varphi_B''\left(\rho_B \frac{E_B B}{W}\right) > 0 \end{gathered} \tag{3a}$$

where i_B^* denotes the return to investing abroad in a frictionless world, E_B is the price of the foreign asset in terms of the traded good as numeraire, and du_B is the stochastic component. The convexity of the relationship reflects the notion that financial frictions associated with investing abroad entail increasing costs. Thus, the degree of financial integration varies inversely with ρ_B, and in the limiting case $\rho_B = 0$, when $r_B = i_B^*$, the country has unrestricted access to foreign lending opportunities.

The real cost of borrowing abroad is expressed analogously by

$$\begin{gathered} dR_D = r_D dt + du_D \equiv \left[i_D{}^* + \varphi_D\left(\rho_D \frac{E_D D}{W}\right)\right]dt + du_D \\ \varphi_D(0) = 0, \varphi_D'\left(\rho_D \frac{E_D D}{W}\right) > 0, \varphi_D''\left(\rho_D \frac{E_D D}{W}\right) > 0 \end{gathered} \tag{3b}$$

[13] While introducing volatility in this way may seem restrictive, if we look at the data reported in Table 2, we observe that domestic income volatility is very stable for the whole period 1970–2015. External volatility seems to be rather stable for the most recent period, although less so before 1990. However, given that our main focus is on the most recent period, our assumption would seem to be a reasonable approximation to real world patterns.

[14] We should note that our representation of output as a Wiener process follows the tradition dating back to the seminal work of Merton (1969, 1971, 1975) and Eaton (1981). While it does imply the possibility of Y becoming negative, for several reasons we do not view this as being of serious practical concern. The dynamic properties of Wiener processes are well documented and the probability of this occurring within a relevant time frame is negligible. For our parameterization, $\sigma_Y^2 = 0.0016$, one can show that normalizing initial $Y_0 = 1$, the probability of this occurring within 100 years is around 0.012; see Karlin (1966, p. 279). Second, Wälde (2011) has shown how this problem can be avoided by a modest re-specification of the production function (although in some instances other issues are raised). Third, the production function, per se, plays only a limited role, that being to motivate the rates of return to labor and capital as specified in (2a) and (2b).

[15] This assumption is certainly consistent with the US experience over many years.

[16] Foreign lending/borrowing constraints of the form (3a), (3b) have a long tradition in international finance. They were first introduced by Bardhan (1967), who expressed the borrowing premium in terms of the absolute level of debt. Many variants, based on various forms of normalization of the debt level, have been employed. Empirical evidence supporting these functions is provided by Edwards (1984) and more recently by Chung and Turnovsky (2010).

where i_D^* is the riskless rate of borrowing abroad. Likewise, ρ_D parameterizes the degree of financial integration associated with borrowing from abroad.

Thus, our framework incorporates two distinct measures of the degree of financial integration. We view this as important, for at least two reasons. First, as noted, the reasons for imposing controls on capital outflows are quite distinct from the reasons for restricting capital inflows. In addition, the imposition and/or removal of capital controls typically involves two jurisdictions – the borrowing country and the lending country. Hence, our formulation enables us to compare financial liberalization which facilitates lending abroad, from that which increases access to borrowing from abroad. An important element of this is their contrasting effects on domestic economic activity, which in turn have distributional consequences.

The two stochastic components du_B, du_D are temporally independent and normally distributed. They satisfy $E(du_B)^2 = \sigma_B^2 dt$; $E(du_D)^2 = \sigma_D^2 dt$ and are assumed to be exogenously given to the small open economy. In addition, while the stochastic components may in part reflect stochastic movements in the exchange rate, we assume that the risks associated with investing abroad and borrowing abroad are independent so that du_B, du_D are uncorrelated. We further assume, also for simplicity, that these external shocks are uncorrelated with the domestic productivity shock du_Y.

The representative consumer's asset and liability holdings are subject to the wealth constraint

$$K_i + E_B B_i - E_D D_i = W_i \tag{4}$$

where W_i is real wealth, expressed in units of the numeraire. Normalizing by W_i this constraint can be expressed in term of the individual's portfolio shares $n_{K_i} \equiv K_i/W_i$, $n_{B_i} = E_B B_i/W_i$, $n_{D_i} = E_D D_i/W_i$

$$n_{K_i} + n_{B_i} - n_{D_i} = 1 \tag{4′}$$

Each agent has one unit of time that can be allocated to labor, L_i, or to leisure, $F_i = 1 - L_i$ ("free time"). In addition, he is assumed to consume output over the instant dt at the nonstochastic rate $C_i(t)dt$ out of income generated by these asset holdings and his nonstochastic labor income, $L_i\omega(L)Kdt$.

Thus, the agent's objective is to select his portfolio of assets, the rate of consumption, and leisure to maximize expected lifetime utility, represented by the isoelastic utility function.[17]

$$E_0 \int_0^\infty \frac{1}{\gamma}\left(C_i F_i^{\eta}\right)^{\gamma} e^{-\beta t} dt \qquad -\infty<\gamma<1;\eta,\theta>0;\gamma\eta,\gamma\theta<1 \tag{5a}$$

subject to the wealth constraint, (4′), and the stochastic wealth accumulation equation

$$dW_i = \left[L_i\omega(L)\frac{n_K}{w_i} + r_K(L)n_{K_i} + r_B(\rho_B n_B)n_{B_i} - r_D(\rho_D n_D)n_{D_i} - \frac{C_i}{W_i}\right]W_i dt + W_i\left[n_{K_i}\Omega(L)du_Y + n_{B_i}du_B - n_{D_i}du_D\right] \tag{5b}$$

where $w_i \equiv W_i/W$ is the share of individual i′s domestic wealth in the total stock of wealth, and $n_K \equiv K/W$, $n_B \equiv E_B B/W$, $n_D \equiv E_D D/W$, denote aggregate portfolio shares, where $n_K + n_F - n_D = 1$, which the individual takes as given. Recalling (2) and (3) we have

$$\omega'(L)<0; r_K'(L)>0; r_B'(\rho_B n_B)<0; r_B''(\rho_B n_B)<0; r_D'(\rho_D n_D)>0; r_D''(\rho_D n_D)>0 \tag{5c}$$

Through the equilibrium wage rate, the individual's rate of wealth accumulation depends upon aggregate wealth.[18] This renders the agent's optimization a two-state variable problem, the two states being the agent's individual wealth, W_i, which is under his direct control, and the aggregate stock of wealth, W, the evolution of which follows (A.2c), and which the individual takes as exogenous. The formal solution to this two-state variable problem is provided in Appendix A.1.[19]

3.3. Macroeconomic equilibrium

Given the homogeneity of the utility function, and with all agents facing identical rates of return and stochastic conditions, in macroeconomic equilibrium all agents choose identical portfolio shares, which therefore coincide with the aggregate shares, namely

$$n_{K_i} = n_K,\; n_{B_i} = n_B,\; n_{D_i} = n_D \tag{6}$$

This further implies that for each individual

$$k_i = b_i = d_i = w_i \tag{7}$$

so that each agent i's relative share of each of the assets and liabilities is the same across the assets and equal to his relative wealth. Furthermore, the macroeconomic equilibrium derived in the Appendix is a balanced growth path along which all individual quantities and aggregate quantities grow at the common stochastic rate

$$\frac{dW}{W} = \frac{dK}{K} = \frac{d(E_B B)}{E_B B} = \frac{d(E_D D)}{E_D D} = \frac{dW_i}{W_i} = \frac{dK_i}{K_i} = \frac{d(E_B B_i)}{E_B B_i} = \frac{d(E_D D_i)}{E_D D_i} \equiv \psi dt + du_W \tag{8}$$

where the mean growth rate, ψ, is defined below, and $du_W \equiv \Omega(L) n_K du_Y + n_B du_B - n_D du_D$. As a result, individuals' relative asset holdings and shares of wealth, k_i, b_i, d_i, w_i remain unchanged along the equilibrium growth path. In particular, each agent's relative wealth remains constant at its initial exogenously given level.

Thus, the macroeconomic equilibrium conditions are (see Appendix A.1):

$$n_B = \frac{[r_B(\rho_B n_B) - r_D(\rho_D n_D)]\Omega^2(L)\sigma_Y^2 - [r_K(L) - r_B(\rho_B n_B)]\sigma_D^2}{(1-\gamma)D} + \frac{\Omega^2(L)\sigma_Y^2\sigma_D^2}{D} \tag{9a}$$

$$n_D = \frac{[r_B(\rho_B n_B) - r_D(\rho_D n_D)]\Omega^2(L)\sigma_Y^2 + [r_K(L) - r_D(\rho_D n_D)]\sigma_B^2}{(1-\gamma)D} - \frac{\Omega^2(L)\sigma_Y^2\sigma_B^2}{D} \tag{9b}$$

$$n_K = \frac{[r_K(L) - r_B(\rho_B n_B)]\sigma_D^2 + [r_K(L) - r_D(\rho_D n_D)]\sigma_B^2}{(1-\gamma)D} + \frac{\sigma_D^2\sigma_B^2}{D} \quad (= 1 - n_B + n_D) \tag{9c}$$

$$\frac{C}{W} = \frac{\omega(L)n_K}{\eta}(1-L) \tag{9d}$$

$$\psi = [\Omega(L) - \delta]n_K + r_B(\rho_B n_B)n_B - r_D(\rho_D n_D)n_D - \frac{C}{W} \tag{9e}$$

$$\psi = \frac{r_K(L)n_K + r_B(\rho_B n_B)n_B - r_D(\rho_D n_D)n_D - \beta}{1-\gamma} - \frac{\gamma}{2}\sigma_W^2 \tag{9f}$$

$$\sigma_W^2 = [\Omega(L)n_K]^2\sigma_Y^2 + (n_B)^2\sigma_B^2 + (n_D)^2\sigma_D^2 \tag{9g}$$

where: $D \equiv [\Omega(L)^2\sigma_Y^2(\sigma_D^2 + \sigma_B^2) + \sigma_D^2\sigma_B^2]$ and $\omega(L)$, $\Omega(L)$, $r_K(L)$, $r_B(\rho_B n_B)$, $r_D(\rho_D n_D)$, are as specified previously in (2a), (2b), (3a), (3b), and (5c).

[17] The restrictions on the elasticities γ and η in (5a) are to ensure that the utility function is concave in C_i and F_i.

[18] To see this recall that labor income as written in (5b) $= L_i\omega(L)K = L_i\omega(L)n_K W = L_i\omega(L)n_K(w_i)^{-1}W_i$.

[19] For some background on the solution method applied in the Appendix, see e.g. Turnovsky (1997, Chaps. 9-11), which is simply reporting relevant standard results from continuous time stochastic optimization; see Malliaris and Brock (1982).

Eqs. (9a)–(9c) are the direct analogues to the stochastic portfolio equilibrium (3.60) as set out by Branson and Henderson (1985, p. 796). In their scenario, asset returns were fixed, in which case these equations jointly determine the three portfolio shares. In our case, the domestic return to capital depends upon labor supply, which means that portfolio shares n_K, n_B, and n_D are determined as part of the general equilibrium, (9a)-(9g), together with the aggregate consumption-wealth ratio, C/W, labor supply, L, mean growth rate, ψ, and aggregate volatility, σ_Y^2. In addition, labor market equilibrium implies aggregate leisure, $F = 1 - L$. These equilibrium quantities are functions of the basic structural parameters, including the measures of financial market flexibility, ρ_B, ρ_D, domestic volatility, σ_Y^2, and foreign volatility σ_B^2, σ_D^2.

Several points regarding the equilibrium system (9) merit comment. First, (9d) reflects the marginal rate of substitution between consumption and leisure. With aggregate wealth being generated by the geometric Brownian motion process, (8), provided $W(0) > 0$, then $W(t) > 0$ at all points of time (see (A.19)), ensuring that $C(t) > 0$. Second, (9e) describes the mean growth rate of wealth, and its components, as implied by (8). This is essentially the balance of payments equilibrium along the balanced growth path.[20] Third, (9f) yields the mean growth rate of consumption, consistent with the equilibrium C/W ratio, (9d) being non-stochastic. Finally, and most importantly, these aggregate equilibrium quantities are *independent* of any distributional elements. This is the manifestation of the representative consumer theory of distribution that we are exploiting.

We shall focus on equilibria in which portfolio allocations n_K, n_B, n_D are all positive, subject to the allocation constraint (A.2b). Whether the country is a net creditor or a net debtor is an endogenous outcome, depending upon the equilibrium rates of return. Specifically, a country will be a net creditor (debtor) if and only if $n_B > n_D$ ($n_D > n_B$).[21] Taken in conjunction with the restrictions $n_B > 0$, $n_D > 0$ this condition can be expressed in terms of inequalities between the rates of return r_K, r_B, r_D. The underlying intuition is clearest if one abstracts from domestic risk, setting $\sigma_Y^2 = 0$, in which case the following conditions obtain:

$$\text{Creditor}: \qquad r_B > \bar{r} \equiv \frac{r_D\sigma_B^2 + r_B\sigma_D^2}{\sigma_D^2 + \sigma_B^2} > r_K > r_D \tag{10}$$

$$\text{Debtor}: \qquad r_B > r_K > \bar{r} \equiv \frac{r_D\sigma_B^2 + r_B\sigma_D^2}{\sigma_D^2 + \sigma_B^2} > r_D \tag{11}$$

Thus the critical determinant is the rate of return on domestic investment, r_K, relative to the risk-weighted average, $\bar{r}$, of the foreign borrowing and lending rates. If r_K is less than $\bar{r}$ and approaches r_D (cf. (10)), domestic investors will have declining incentive to borrow from abroad and increasing incentive to invest abroad, with its higher return. In the limiting case, $r_K = r_D$, with $\sigma_Y^2 = 0$ and domestic investment being riskless, there is no incentive to borrow internationally, $n_D = 0$ (cf. (9b)) and the nation will allocate its investments between domestic capital and foreign assets, and hence be a net creditor. At the other extreme if r_K exceeds $\bar{r}$ and approaches r_B, being riskless it dominates investing abroad, $n_B = 0$, and the economy will find it profitable to finance part of its domestic investment by borrowing abroad and thus becoming a net debtor, $n_D > 0$.

The fact that the equilibrium is a stochastic balanced growth is a consequence of the “AK” technology that is driving the constant growing wage rate, coupled with the constant productivity of capital. This represents both an advantage and a limitation of the continuous time stochastic framework that we are employing. The advantage is that the balanced growth equilibrium renders the liberalization mechanisms very transparent. On the other hand, the fact that agents' relative wealth remains unchanged over time is clearly a limitation. But it is important to emphasize that this property is also characteristic of the *non-stochastic* model that adopts the AK technology, such as Romer (1986). The reason is that the equilibrium is also a balanced growth path, with heterogeneous agents all accumulating wealth at the same deterministic rate, leaving their respective relative wealth unchanged. For an example of this see García-Peñalosa and Turnovsky (2006b).

To generate changes in wealth inequality we require that a structural change generates transitional dynamics. This would be the case if the aggregate production function had diminishing returns to capital, giving rise to changing returns to capital and labor; see Turnovsky and García-Peñalosa (2008). The problem is that the continuous-time stochastic structure that we are employing will almost certainly not have a closed-form solution, causing us to lose all the transparency it offers.[22]

4. Income inequality

To derive the distribution of income we consider individual i. The income for this individual comprises: (i) income from labor, (ii) income from domestic capital, (iii) income from foreign interest, less (iv) interest owed on foreign debt and is given by $dY_i = \omega(L)L_iKdt + K_idR_K + E_BB_idR_B - E_DD_idR_D$, while average economy-wide net income is $dY = \omega(L)LKdt + KdR_K + E_BBdR_B - E_DDdR_D$. The ratio dY_i/dY serves as a natural measure of the relative income of individual i. However, this involves the ratio of the stochastic components of the returns, incorporated in the terms dR_J ($J = K, B, D$) and is impractical. Accordingly, we choose to measure the distribution of income by the expected relative income, $y_i \equiv E(dY_i)/(dY)$, where $E(dY_i) = [\omega(L)L_iK + r_KK_i + r_BE_BB_i - r_DE_DD_i]dt$ and $E(dY) = [\omega(L)LK + r_KK + r_BE_BB - r_DE_DD]dt$.

In Appendix A.4 we show that this measure of mean relative income of individual i is related to his relative wealth by

$$y_i - 1 = \left(1 - \frac{\alpha}{(1+\eta)L([1-\delta/\Omega(L)] + s_B - s_D)}\right)(w_i - 1) \tag{12}$$

where $s_B \equiv r_Bn_B/(\Omega(L)n_K)$, $s_D \equiv r_Dn_D/(\Omega(L)n_K)$ denote, respectively, the ratios of foreign interest income earned, and interest payments owed on foreign loans, to domestic GDP.

Recognizing that with wealth being accumulated at a common rate by all agents, relative wealth, w_i remains unchanged at its initial level, $w_{i,0}$. Applying (12) across all agents, we see that income inequality, as measured by the coefficient of variation of income, CV_Y is expressed by the following ratio of the unchanging initial wealth inequality, $CV_{W,0}$:

$$\frac{CV_Y}{CV_{W,0}} = \left(1 - \frac{\alpha}{(1+\eta)L([1-\delta/\Omega(L)] + s_B - s_D)}\right) \tag{13}$$

implying that $CV_Y < CV_{W,0}$, consistent with the empirical evidence.

Thus the effects of structural changes such as financial liberalization on the equilibrium degree of income inequality is

$$d(CV_Y) = (CV_{W,0} - CV_Y)\left\{\left(\frac{ds_B - ds_D}{([1-\delta/\Omega(L)] + s_B - s_D)}\right) + \frac{dL}{L}\left(1 + \frac{(\delta\alpha/\Omega(L))}{([1-\delta/\Omega(L)] + s_B - s_D)}\right)\right\} \tag{14}$$

Hence, structural changes all impact income inequality via their effects on: (i) the share of GDP earned from the economy's foreign investments, s_B; (ii) the share of GDP owed from the country's foreign

[20] See e.g. Turnovsky (1997, Chapter 9). As a technical point we note that pending initial endowments the instantaneous attainment of the balanced growth equilibrium may require an initial jump in the asset prices $E_B(0)$, $E_D(0)$, familiar from the rational expectations literature. See Grinols and Turnovsky (1994) for an example in a continuous time stochastic open economy model.

[21] It is possible to obtain equilibrium portfolio shares $n_B < 0$, $n_D > 0$. This reflects a situation in which the configuration of rates of return is such that the country wishes only to borrow from abroad.

[22] The only case known to yield a closed form solution is if the intertemporal elasticity of substitution equals the inverse of the share of capital in production; see Smith (2007). However, this is an uninteresting case, since with the latter being around 0.4, this implies an elasticity of around 2.5, which wildly contradicts the empirical estimates (typically <1).

borrowing, s_D; and (iii) the impact on the labor supply, L. Specifically we obtain the following;

Proposition 1. Income inequality increases with the share of GDP earned from foreign investments, decreases with the share of GDP owed on its foreign borrowing, and increases with labor supply.

Intuitively, since investment is carried out more extensively by more affluent agents, an *increase* in the share of *GDP* earned on foreign investments, or a *decrease* in the costs of foreign borrowing will lead to an increase in income inequality. In addition, since an increase in labor supply will reduce the wage rate, which benefits relatively more the less affluent, and raises the return to capital, which benefits more the more affluent, this too will raise income inequality. Moreover, we should note that in addition to this direct effect evident from (14), labor supply has indirect effects through its impact on GDP and the impact on the share of foreign investment returns and borrowing costs, s_B and s_D.

Finally, we may note that (13) can be interpreted as decomposing income inequality into (i) the underlying wealth inequality and (ii) the differential income that this generates across agents. For a more general production structure in which wealth inequality evolves over time, the right hand side of (14) would include the term $(CV_Y/CV_W)d(CV_W)$ that reflects this evolution. However, for the AK technology we are employing this latter effect is absent. To the extent that this factor is important, (14) understates the impact of any structural changes on income inequality that increase wealth inequality, and overstates it otherwise. However, in light of empirical evidence suggesting that (i) wealth inequality changes more sluggishly than does income inequality, and (ii) CV_Y is substantially less than CV_W, suggests that the error committed by neglecting this term may be small.[23]

4.1. Financial liberalization

We will investigate the impact of financial liberalization on income inequality in detail by means of the simulations to be discussed in Section 5. There we will find that financial liberalization, in the form of reducing ρ_B, and therefore directed toward stimulating investing abroad, will increase s_B significantly, thereby increasing income inequality substantially. But it will also tend to divert investment away from the domestic economy, reducing employment, and raising the wage rate which will tend to offset the increase in inequality, although only partially. In contrast, reducing ρ_D and borrowing costs tends to encourage borrowing to such a degree that s_D actually increases, thereby reducing inequality. At the same time, it will tend to increase domestic investment, stimulate employment, and increase income inequality. These effects turn out to be largely offsetting, so that the net effect is a small reduction in income inequality.

Thus, financial liberalization impinges on the economy through two channels; first through the portfolio asset adjustment, and second through the consequences of this for domestic activity. In the latter process, the two types of financial liberalization impact in sharply contrasting ways. To gain further insight we shall (i) abstract from domestic volatility, setting $\sigma_Y^2 = 0$, and (ii) assume initially that labor is supplied inelastically at $L = \bar{L}$. In that case, (9a) and (9b) simplify to

$$n_B = \frac{r_B(\rho_B n_B) - r_K(\bar{L})}{(1-\gamma)\sigma_B^2} \tag{15a}$$

$$n_D = \frac{r_K(\bar{L}) - r_D(\rho_D n_D)}{(1-\gamma)\sigma_D^2} \tag{15b}$$

from which we can readily show:

$$-\frac{dn_K}{d\rho_B} = \frac{dn_B}{d\rho_B} = \frac{r'_B n_B}{(1-\gamma)\sigma_B^2 - r'_B\rho_B} < 0, \quad \frac{dn_D}{d\rho_B} = 0 \tag{16a}$$

$$\frac{dn_K}{d\rho_D} = \frac{dn_D}{d\rho_D} = -\frac{r'_D n_D}{(1-\gamma)\sigma_D^2 + r'_D\rho_D} < 0, \quad \frac{dn_B}{d\rho_D} = 0 \tag{16b}$$

It then follows from (16a) that financial liberalization in the form of reducing the costs of investing abroad (i.e. reducing ρ_B) will stimulate foreign investment, at the expense of domestic investment, with no impact on the level of foreign borrowing. Likewise, reducing foreign borrowing costs (i.e. reducing ρ_D), will increase borrowing from abroad, which is used to finance domestic investment, with no impact on investment abroad. The key observation is that the two forms of financial liberalization have sharply contrasting impacts on the domestic capital stock, and therefore on domestic activity. Financial liberalization on the lending side, by diverting resources away from the domestic economy has a contractionary effect; liberalization on the borrowing side stimulates the domestic economy.

To see the contrasting effects of these forms of liberalization on income inequality we use (16a) and (16b) to obtain:

$$\frac{ds_B/d\rho_B}{s_B} = \frac{r'_B}{(1-\gamma)\sigma_B^2 - r'_B\rho_B}\left[1 + \frac{n_B(1-\gamma)\sigma_B^2}{r_B} + \frac{n_B}{n_K}\right] < 0 \tag{17a}$$

$$\frac{ds_D/d\rho_D}{s_D} = \frac{r'_D}{(1-\gamma)\sigma_D^2 + r'_D\rho_D}\left[-1 + \frac{n_D(1-\gamma)\sigma_D^2}{r_D} + \frac{n_D}{n_K}\right] \tag{17b}$$

The first two terms in parentheses are the foreign portfolio adjustments resulting from the liberalization, while the third reflects the impact on domestic capital and hence on domestic activity. From (17a) we see that liberalization with respect to lending abroad (reducing ρ_B) clearly increases foreign investment earnings ($r_B n_B$). In addition, by diverting resources from domestic activity it reduces the share of domestic capital, so that the share of GDP earned by foreign investment earnings increases. Accordingly, s_B increases, which favoring the wealthy, tends to increase income inequality.

Reducing ρ_D has more ambiguous effects. While it will reduce the unit costs of borrowing it will encourage more foreign borrowing so that foreign interest payments ($r_D n_D$) may either rise or fall. In addition, by stimulating domestic activity it raises GDP so that the share of foreign interest paid declines. The overall effect on s_D is ambiguous, depending upon the relative strengths of these offsetting effects, with correspondingly ambiguous impact on income inequality. These patterns will be apparent from the numerical simulations to be discussed in Section 5 below.

These effects are compounded by the endogenous response of labor, which also need to be taken into account, causing (16) to be modified to:

$$\frac{dn_B}{d\rho_B} = \frac{r'_B n_B - r'_K dL/d\rho_B}{(1-\gamma)\sigma_B^2 - r'_B\rho_B}; \quad \frac{dn_D}{d\rho_B} = \frac{r'_K dL/d\rho_B}{(1-\gamma)\sigma_D^2 + r'_D\rho_D}; \quad \frac{dn_K}{d\rho_B} = \frac{dn_D}{d\rho_B} - \frac{dn_B}{d\rho_B} \tag{18a}$$

$$\frac{dn_D}{d\rho_D} = \frac{-r'_D n_D + r'_K dL/d\rho_D}{(1-\gamma)\sigma_D^2 + r'_D\rho_D}; \quad \frac{dn_B}{d\rho_D} = \frac{-r'_K dL/d\rho_D}{(1-\gamma)\sigma_B^2 - r'_B\rho_B}; \quad \frac{dn_K}{d\rho_D} = \frac{dn_D}{d\rho_D} - \frac{dn_B}{d\rho_D} \tag{18b}$$

It is straightforward to show (and intuitive) that under weak conditions a decrease in domestic capital will tend to decrease employment

[23] Evidence on wealth inequality is sparse, but data provided in the *World Inequality Report 2019 (World Inequality Lab, 2018)* provides some tentative support for this view. Also, numerical simulations analyzing the distributional consequences of foreign transfers suggest that wealth inequality responds more intensively to transfers that impact directly the economy's productive capacity and only modestly otherwise; see Bouza and Turnovsky (2012). Since the process of financial liberalization has only an indirect effect on production, one can conjecture that its impact on wealth inequality is also likely to be weak.

and vice versa. Thus, a reduction in the cost of investing abroad, ρ_B, by reducing n_K, will reduce employment. This will reduce the return to domestic capital, inducing a further reallocation of wealth. Specifically, the reduction in employment will reduce both investment in domestic capital and borrowing from abroad, encouraging more lending abroad. In the case of reduced foreign borrowing cost, ρ_D, the corresponding increase in employment will have the opposite effects; a further stimulus to domestic investment, financed by more foreign borrowing and less foreign investment.

The adjustment of labor in response to liberalization will impinge on inequality through two main channels, one being indirectly through its effect on s_B and s_D. To incorporate this component the expressions (17a), (17b) would need to be modified by the inclusion of $-\alpha(dL/d\rho_B)L^{-1}$ and $-\alpha(dL/d\rho_D)L^{-1}$, respectively. Liberalization would could cause the former to increase s_B, and the latter to decrease s_D, in both cases contributing to an increase in inequality, in accordance with Proposition 1. But in addition, there are direct effects, as indicated in (14), and these operate in conflicting ways. Financial liberalization in the form of reduced foreign investment costs, by reducing employment, raises the wage rate, reduces the return to capital, and decreases inequality. By contrast, liberalization in the form of reduced foreign borrowing costs by increasing employment, reducing the wage rate and increasing the return to capital increases inequality.

The key insight to be obtained from this comparison is that these two forms of financial liberalization have important consequences for domestic economic activity. These effects are contrasting and need to be taken into account in assessing their impact on income inequality.

For simplicity, we have assumed that investing and borrowing costs are common across all agents. As noted, this is a potentially restrictive assumption, and we therefore briefly consider the likely implications of its relaxation. To do so, we assume that richer agents, having more bargaining power than do poorer agents, incur lower costs with respect to their international transactions. A likely consequence of this is that the share of their respective portfolios allocated to foreign assets/liabilities will be larger. That is, n_B/n_K and n_D/n_K will be larger for wealthier agents, causing their respective shares, s_B and s_D, to be larger as well. A proportionate reduction in the costs of investing abroad, (reducing ρ_B) will tend to favor richer agents, thereby further increasing their relative share, s_B, and income inequality, and reinforcing the result in (17a). On the other hand, a proportionate reduction in the cost of borrowing (reducing ρ_D) will also favor richer agents. But since they are induced to incur larger borrowing costs, the overall net effect on their borrowing costs,s_D, relative to that of poorer agents is ambiguous, again consistent with (17b). These examples suggest that the assumption of common transactions costs is not as serious a limitation as it may appear at first sight.

4.2. Consumption inequality

As already noted, due to data limitations it is sometimes necessary to employ consumption inequality as a proxy for income inequality in the empirical analysis. To see the potential bias involved and an appropriate correction that might be made, it is useful to examine the relationship between these two alternative forms of inequality. To determine this, we see from (A.10a) and (A.10b) that relative consumption of agent i, $c_i \equiv C_i/C = F_i/F$ and combining this with (A.24), we obtain

$$c_i - 1 = \frac{1}{F}\left(F - \frac{\eta}{1+\eta}\right)(w_i - 1) \tag{19}$$

Integrating across agents, this implies the following measure of consumption inequality

$$CV_C = \frac{1}{F}\left(F - \frac{\eta}{1+\eta}\right)CV_{W,0} \tag{20}$$

Combining this equation with (A.21) one can show that for plausible parameter values $CV_C < CV_Y$.[24] Moreover, in the empirical implementation which employs logarithms of the inequality measures, (20) implies $\ln CV_C = \ln CV_Y - \zeta$, where ζ is a constant, thereby justifying the introduction of a constant dummy variable in observations where consumption inequality is employed.

5. Numerical simulations

To obtain further insights into the impact of financial liberalization on income inequality, we perform extensive simulations.

5.1. Calibration

Tables 1 and 2 summarize some key statistics, which serve to motivate our numerical analysis. These, and the subsequent empirical estimation, extend over the period 1970–2015, during which the number of countries providing the requisite data grew. Because the range of external asset positions experienced by different economies varies so dramatically, we choose to distinguish between creditor and debtor countries. Moreover, within each category there are significant differences in the composition of their respective portfolios, and accordingly we focus on the *median* economy in both cases. Thus, in 1970 our sample set comprised 58 countries of which 11 were creditors, meaning that they have a positive net asset position ($n_B > n_D$), while the remaining 47 were net debtors. By 2015 the sample increased to 96 countries, comprising 30 creditors and 66 debtors. Throughout the 45 years debtors consistently significantly outnumber creditors.[25]

From Table 1 we see that between 1970 and 2015 the median creditor economy increased its portfolio share of external assets from 11.3% to 60%, and its external liabilities from 7.9% to 47.9%. For debtor countries the corresponding increases were from 4.8% to 37.3% and 17.1% to 72.2%, a relatively larger increase in foreign liabilities by virtue of being debtors. These changes in portfolio shares are clear evidence of the dramatic impact of globalization on investment patterns. We also report the portfolio shares for 1990. With the increase in total international assets and liabilities for creditors and debtors over the period 1990–2015 exceeding that for 1970–1990, these patterns confirm the acceleration in liberalization that occurred around 1990; see Lane and Milesi-Ferretti (2007).[26]

The first two columns of Table 2 summarize 5 year averages of domestic income and external volatility from 1980 to 2015, measured as coefficients of variation. Domestic volatility has been relatively stable at around 4%, while external volatility which averaged around 13.5%, with substantial variability, over the first 20 years, declined to a more stable 8.5% after 2000. The average Gini coefficients for creditor and debtor nations suggest some fluctuations in the earlier period, and more steady increase, particularly for debtor countries, during more recent years.[27]

Table 3 specifies the basic parameters. The production and preferences are conventional and common to both the creditor and debtor nation. Specifically, the productive elasticity of labor, $\alpha = 0.6$, the depreciation rate, $\delta = 0.06$, and the rate of time preference, $\beta = 0.04$, are all standard. Together with $A = 0.65$, they are the key determinants of the pre-liberalization capital-output ratios of around 3 and growth rate of 1.14% and 1.24% for the creditor and debtor economies, respectively. They also yield real rates of return for the various assets which

[24] For the pre-financial liberalization benchmark this implies $CV_C = 0.20CV_Y$

[25] Note that $NFA \equiv n_B - n_D$ denotes "Net Foreign Assets" and $IFI \equiv n_B + n_D$ denotes "International Financial Integration". Also, countries switched positions, creditors becoming debtors, the most notable example being the United States.

[26] A second reason for reporting the figures for 1990 is that the period 1990–2015 matches the period over which some of our empirical estimations were conducted, enabling us to better relate the numerical simulations to the empirical evidence.

[27] The average for the Gini coefficients are 32.0 (creditors) and 34.2 (debtors).

Table 1
Portfolio shares (median economy).

	Ext. financial assets: n_B	Ext. financial liabilities: n_D	Domestic capital: n_K	*NFA*	*IFI*
Creditor Countries					
1970	0.114	0.079	0.965	0.035	0.193
1990	0.421	0.222	0.801	0.199	0.643
2015	0.600	0.479	0.879	0.121	1.079
Debtor Countries					
1970	0.048	0.171	1.123	−0.123	0.219
1990	0.141	0.385	1.244	−0.244	0.526
2015	0.373	0.722	1.349	−0.349	1.095

In 1970 11 countries were creditors, 47 were debtors; in 2015 30 countries were creditors and 66 were debtors.

Table 2
Some basic statistics.

	Domestic income volatility	External volatility	Average Income Gini Creditor	Average Income Gini Debtor
1970–74			34.24	34.68
1975–79			30.74	28.78
1980–84	0.0466	0.1471	30.86	33.30
1985–89	0.0503	0.1718	31.24	31.43
1990–94	0.0505	0.1000	30.17	33.88
1995–99	0.0385	0.1282	28.78	33.67
2000–04	0.0394	0.0870	35.11	36.16
2005–09	0.0387	0.0862	34.35	37.78
2010–15	0.0406	0.0850	32.67	38.79

Table 3
Benchmark parameter values.

Production	$A = 0.65, \alpha = 0.60, \delta = 0.06$
Preferences	$\gamma = -1.5, \eta = 1.75, \beta = 0.04$
Volatility	$\sigma_Y = 0.04, \sigma_D = 0.10, \sigma_B = 0.10$
Riskless Foreign Borrowing rate	$i_D^* = 0.03$
Basic Return on Foreign Investment	$i_B^* = 0.09$
Borrowing/lending premiums Creditor country	1970 : $\rho_D = 0.435,\ \rho_B = 0.175$ 2015 : $\rho_D = 0.0470,\ \rho_B = 0.0167$
Borrowing/lending premiums Debtor country	1970 : $\rho_D = 0.197,\ \rho_B = 0.416$ 2015 : $\rho_D = 0.0296,\ \rho_B = 0.0296$
Forms for lending and borrowing functions	$r_B = i_B^* - [\exp(\rho_B n_B) - 1]$ $r_D = i_D^* + [\exp(\rho_D n_D) - 1]$

are of the order of 6.5–7%. The elasticity of leisure in utility, $\eta = 1.75$, and $\gamma = -1.5$, are non-controversial and are the key determinants of the equilibrium allocation of leisure of around 0.70, which implies a Frisch elasticity of labor supply of around 1.1.[28] Comparing the alternative pre-liberalization and post-liberalization equilibria in Table 4, we see that there is relatively little variation in their production characteristics, the most notable being that liberalization has contributed to substantially to growth, especially for the debtor economy.

Our calibration of the foreign lending and borrowing functions enables us to match the equilibrium portfolio shares remarkably closely, as can be seen by comparing the first four columns of Table 4 with Table 1. The last two columns suggest that the reallocation of investments through financial liberalization has increased income inequality (as measured by the coefficient of variation) 0.045 for creditor economies and 0.018 for debtor economies, resulting in increases in average welfare (as measured by equivalent increases in initial capital) of 8.3% and 3.7% respectively. We also see that during the early phase of the liberalization virtually all of the welfare gains and the accompanying increase in income inequality were experienced by the creditor economy, with some catchup by the debtor economy during the latter stages.

5.2. Increased financial liberalization

To provide insight into the contrasting roles played by liberalizing foreign lending from borrowing, Table 5 summarizes the partial effects of each in turn. Thus Row 2 in both panels of Table 5 introduces liberalization in only foreign *lending*. In both the creditor and debtor economy the result is to stimulate its lending abroad. In fact, if this were the only change, the initial debtor economy would now switch and become a creditor economy! In both cases there would be a substantial reduction in the share of domestic capital, leading to a substantial reduction in employment. In the case of the creditor country its increase in foreign lending would be sufficient to permit it to also increase its borrowing. The net effect is that in both economies the increase in s_B dominates the increase in s_D, together with the decline in L, so that these responses would cause a substantial increase in income inequality of 0.083 and 0.088 respectively, in the creditor and debtor economies.

Row 3 addresses the reverse scenario, where the liberalization occurs with respect to foreign *borrowing*. In this case, both economies would reduce their foreign investment, increase their foreign borrowing, and reallocate their portfolio toward domestic capital. Now the initial creditor economy would become a debtor. The switch toward more domestic capital would increase employment, the effect of which would be to partially offset the reduction in income inequality associated with the reduction in s_B and increase in s_D. Income inequality in the creditor economy would decline by 0.016 and by 0.007 in the debtor economy. However, these effects are minor and are clearly dominated by liberalization in lending, so that the overall impact is a clear increase in inequality across both creditor and debtor economies.

The specification of the dependent variable in terms of the logarithm of the Gini coefficient in the empirical evidence reported in Section 6 below suggests that the impact of financial liberalization is highly nonlinear, with the impacts increasing with the size of the change. To examine this, the fourth row of Table 5 reports the changes corresponding to the situation where ρ_B, ρ_D undergo 50% of their eventual respective changes, as specified in Row 5. Focusing on ρ_B in the case of the creditor economy, it is clear that the effects of reducing it by 0.079 from 0.175 to 0.096 is much weaker than reducing it further by the identical amount from 0.096 to 0.0167. For example, the first half of the liberalization increases IFI by 0.135 and income inequality by just 0.004, while the second half increases IFI by 0.754 and income inequality by 0.041. This pattern prevails throughout.

These numerical results suggest the following:

Hypothesis 1. *Income inequality is more sensitive to financial liberalization that favors investment abroad than it is to liberalization that reduces foreign borrowing costs. Balanced liberalization that reduces both foreign borrowing and investment costs will increase income inequality. The impacts are highly nonlinear, with larger changes having more than proportionately larger impacts.*

6. Data sources and empirical implementation

The data on updated international investment positions have been obtained from Lane and Milesi-Ferretti (2007) and its update.[29] Total external assets and liabilities include the stock of direct investment plus portfolio equity, portfolio debt investment, other investment assets (e.g., general government, banks), reserve assets (minus gold) and financial derivatives. The net foreign asset position (NFA) is equal to total external assets minus total

[28] This estimate lies within the range (1–2) adopted in macroeconomic simulations; see Keane and Rogerson (2012). The inconsistency between the aggregate values and the smaller estimates obtained from micro data is an issue currently occupying the attention of labor economists. Keane and Rogerson (2012) offer a reconciliation that credibly supports the range typically adopted in macroeconomic simulations.

[29] March 2017 version.

Table 4
Financial liberalization 1970–2015

	n_B	n_D	n_K	*NFA*	*IFI*	r_B %	r_D %	r_K %	*L*	*Y/K*	ψ %	CV_Y	*Av Welfare*
A. Creditor Economy													
Pre-financial liberalization (1970) $\rho_D = 0.435, \rho_B = 0.175$	0.114	0.079	0.965	0.035	0.193	6.98	6.50	6.73	0.304	0.318	1.14	0.127	−245.7
Early financial liberalization (1990) $\rho_D = 0.1072, \rho_B = 0.0319$	0.421	0.222	0.801	0.199	0.643	7.48	5.87	6.46	0.293	0.311	1.39	0.156	−225.7 (+5.83%)
Post-financial liberalization (2015) $\rho_D = 0.0470, \rho_B = 0.0167$	0.602	0.480	0.878	0.122	1.082	7.99	5.28	6.52	0.296	0.313	2.06	0.172	−218.1 (+8.27%)
B. Debtor Economy													
Pre-financial liberalization (1970) $\rho_D = 0.197, \rho_B = 0.416$	0.048	0.171	1.123	−0.123	0.219	6.98	6.43	6.91	0.311	0.323	1.24	0.116	−254.4
Early financial liberalization (1990) $\rho_D = 0.0763, \rho_B = 0.120$	0.141	0.385	1.244	−0.244	0.526	7.30	5.98	7.00	0.315	0.325	1.52	0.116	−254.8 (−0.10%)
Post-financial liberalization (2015) $\rho_D = 0.0296, \rho_B = 0.0296$	0.373	0.721	1.348	−0.348	1.094	7.89	5.16	7.02	0.316	0.326	2.39	0.134	−241.0 (+3.69%)

external liabilities. Capital stocks have been obtained from International Monetary Fund's "Investment and Capital Stock Dataset, 1960-2015".[30] To obtain comparable nominal domestic capital stocks, capital-output ratios have been calculated first from their values in real terms, and then these ratios have been multiplied by current GDP from the World Bank's World Development Indicators (WBWDI) to obtain the stocks of domestic capital in current US dollars. Domestic wealth is then obtained by adding to this the net foreign asset position. The remaining variables are provided directly by the WBWDI, except for the variable capturing "technology". Technological progress is captured by the contribution of capital services provided by ICT assets to GDP growth as a share of the contribution of total capital services to GDP growth, which is provided by the "Total Economy Database" produced by The Conference Board (TCB).[31]

Data describing inequality can be obtained from different sources based on different methodologies. As noted in the introduction, we employ inequality data based on Milanovic's "All the Ginis" (ATG) database.[32] ATG reports Gini coefficients based on three alternative measures. First, the Gini coefficient can be an income- or consumption-based measure. Second, it can be based on data provided by individuals or households. Third, the Gini coefficient can be obtained from gross (before tax) or net (after tax) income. Thus we take as the benchmark case the most common concept of the Gini coefficient, which is based on individual income data, and expressed in net terms. We then introduce dummy variables to take into account differences in Gini coefficients due to different methodologies. Thus, if the Gini coefficient is consumption-based, then dummy $Dc = 1$, but $Dc = 0$ otherwise (*i. e*., income based). If Gini coefficient is household-based, then dummy $Dh = 1$, but $Dh = 0$ otherwise (*i. e*., individual-based). Finally, if Gini coefficient is based on gross terms, then dummy $Dg = 1$, but $Dg = 0$ otherwise (*i. e*., based on net terms).[33] These dummy variables would capture differential level-effects of financial globalization on inequality, which would add more accuracy to the estimation.

In addition we also introduce country and year fixed effects to capture further possible differences across countries and years. Note that we use annual data to maximize the sample size and to estimate parameters more precisely.[34] We further include three control variables: (i) the level of output per capita, (ii) the degree of trade openness (measured as the sum of exports and imports with respect to GDP) and (iii) "technology" (measured as the contribution of capital services provided by ICT assets to GDP growth as a share of the contribution of total capital services to GDP growth).

After organizing these variables, we obtain a panel dataset encompassing 96 countries, listed in Appendix A.5, over the period 1970 to 2015. Allowing for missing data this yields a sample of 1213 observations. However, when the ICT control variable is introduced, the dataset is reduced to 70 countries from 1990 to 2015, indicated below. In this case we show the estimates for the shorter period as well as for the complete period (without this control), in part as a robustness check.

7. Empirical estimates

We now turn to the test of the impact of international financial integration on income inequality, suggested by Hypothesis 1. The first issue to address is how this process is to be represented. In our formal and numerical analysis we have specified financial liberalization in terms of decreases in the slopes of the lending and borrowing cost functions, ρ_B, ρ_D, but these are unobservable. From Tables 4 and 5 we see that financial liberalization in the form of reducing these costs is always associated with an increase in the country's international financial integration position (*IFI*) as specified by the sum of its total external assets plus total external liabilities, i.e. $IFI = (IFA + IFL)$. Hence this widely adopted measure serves as a natural measure of the degree of financial integration. In addition, since our numerical simulations suggest that financial liberalization with respect to foreign lending and borrowing have different impacts on the economy, as a second measure we introduce the two components, *IFA*, *IFL* separately, rather than as their sum.

In both cases these financial variables follow the specification adopted in our theoretical framework and numerical simulations and are expressed as a share of domestic wealth. However, most of the empirical studies measure these variables relative to *GDP* See Lane and Milesi-Ferretti (2003), for instance. We have also performed the regressions using this alternative normalization. The results are reported in Table A.1 in the Appendix and are virtually identical to those reported in Table 6.

The formal hypotheses measure income inequality by the coefficient of variation. This contrasts with the income Gini coefficient, which as noted is the conventional published measure of inequality. As Atkinson (1970) noted, both are acceptable measures of aggregate inequality and since under weak conditions they yield the same ranking, the Gini coefficient serves as a convenient measure of inequality to map the theory into the available data.

7.1. Results with international financial integration

To test the impact of international financial integration, *IFI*, on inequality, as measured by the logarithm of the Gini coefficient, $\ln xG_{it}$,

[30] January 2017 version. See IMF (2015, 2017).

[31] May 2017 version. See https://www.conference-board.org/ for details. Jaumotte et al. (2013) employ the percentage of ICT capital over total capital, but we are inclined to use the contribution of capital services for capturing better the impact of the contribution of ICT capital to economic activity.

[32] October 2016 version. See All the Ginis Database (2016).

[33] Note that, with respect to the ATG database, the benchmark case implies that Dc = 1, Dhh = 0, and Dg = 0.

[34] See Baltagi et al. (2009). It is convenient for this approach to allow for the dynamics in the behavior of the dependent variable, which may capture partial adjustment toward the steady state. That is why we will introduce a lagged dependent variable on the right hand side when we employ a dynamic Generalized Method of Moments (GMM) for the estimation, as we detail below. This method allows to get rid of any country specific time-invariant variable. We also employ cross section and fixed effects estimation, even though it is biased in dynamic panels. The empirical growth, and inequality, literature has usually averaged the data over horizons spanning five or ten years.

Table 5
Financial liberalization foreign borrowing vs Lending

	n_B	n_D	n_K	s_B	s_D	L	NFA	IFI	CV_Y
A. Creditor Economy									
Pre-financial liberalization									
$\rho_D = 0.435, \rho_B = 0.175$	0.114	0.079	0.965	0.026	0.017	0.304	0.035	0.193	0.127
$\rho_D = 0.435, \rho_B = 0.0167$	0.769	0.147	0.378	0.278	0.037	0.271	0.622	0.916	0.200
$\rho_D = 0.0470, \rho_B = 0.175$	0.096	0.561	1.465	0.015	0.066	0.320	−0.465	0.657	0.111
$\rho_D = 0.241, \rho_B = 0.096$	0.192	0.136	0.944	0.046	0.027	0.303	0.056	0.328	0.131
Post-financial liberalization									
$\rho_D = 0.0470, \rho_B = 0.0167$	0.602	0.480	0.878	0.175	0.092	0.296	0.122	1.082	0.172
B. Debtor Economy									
Pre-financial liberalization									
$\rho_D = 0.197, \rho_B = 0.416$	0.048	0.171	1.123	0.009	0.030	0.311	−0.123	0.219	0.116
$\rho_D = 0.197, \rho_B = 0.0296$	0.590	0.123	0.533	0.272	0.043	0.267	0.475	0.617	0.204
$\rho_D = 0.0296, \rho_B = 0.416$	0.041	0.759	1.718	0.005	0.070	0.325	−0.718	0.800	0.109
$\rho_D = 0.1133, \rho_B = 0.2228$	0.083	0.279	1.196	0.015	0.045	0.314	−0.196	0.362	0.114
Post-financial liberalization									
$\rho_D = 0.0296, \rho_B = 0.0296$	0.373	0.721	1.348	0.067	0.085	0.316	−0.348	1.094	0.134

we specify the following regression equation:

$$\ln G_{i,t} = a_0 + a_1 IFI_{i,t} + a_2 IFI_{i,t}^2 + a_3 Dc_{i,t} + a_4 Dh_{i,t} + a_5 Dg_{i,t} + u_{i,t} \qquad (21)$$

where $Dc_{i,t} = 1$, if inequality observation is consumption based, and 0 otherwise,

$Dh_{i,t} = 1$, if inequality observation is household based, 0 otherwise,

$Dg_{i,t} = 1$, if inequality observation is based on gross income, 0 otherwise

and $u_{i,\,t}$ is the error term, for country i in period t. The coefficients a_1 and a_2 capture the impact of financial globalization on inequality in the benchmark case. As our numerical simulations strongly suggest possible nonlinear effects of financial liberalization on income inequality, we include the quadratic term on financial globalization, i.e., a_2, to capture these possible non-linear effects, beyond those reflected in the use of the logarithm.

Coefficients a_3 to a_5 capture the additional (differential) impact of financial globalization on inequality due to different inequality measures, namely those based on consumption data, on households, and on gross terms, respectively.[35] Country and time dummies have also been added to the regression in most specifications.

We test the regression Eq. (21) for all values of the degree of financial globalization.[36] The results are exhibited in Table 6. The first column reports pooled estimates for the complete period 1970–2015, obtained by ordinary least squares (*OLS*), without control variables, and without country and time dummies. The significance of the coefficients on *IFI* and IFI^2 provides preliminary evidence of a positive association between increased international financial integration and increased income inequality. But, this initial equation establishes only correlation.

To establish a more definitive relationship, we introduce two modifications, fixed effects estimation (*FE*) and control variables. Fixed effect estimation allows for free correlation among the additive, unobserved heterogeneity and the explanatory variables.[37] Furthermore, despite the fixed effect estimation is somewhat restrictive because heterogeneity is assumed to be additive and to have constant coefficients; this allows robust estimates with the presence of country-specific slopes on the country-specific covariates.[38] We also add the three previously mentioned control variables and time dummies. Because of data limitations, including technology as a control variable forces us to restrict the estimation to the period 1990–2015, although this is also the most interesting period to analyze the impact of financial globalization on inequality.

The initial FE regression is shown in the second column and suggests a positive, but insignificant relationship between international financial integration and inequality. However, this does not take account of the fact that inequality is a persistent phenomenon, which means that it presumably follows some kind of autoregressive process. This suggests including a lagged dependent variable among the regressors, in addition to the fixed effects estimation, which implies that the estimates are now biased and inconsistent, although this effect may not be too large (Baltagi, 2013, p. 136). Columns (3) and (4) in Table 8 report the results for the fixed effects estimation when a lagged dependent variable is included. If we also add two control variables for the period 1970–2015 and time dummies, results become significant: more international financial integration is associated with more income inequality. Furthermore, if we also consider technology as a control variable, results for the positive relationship between financial globalization and inequality are robust to the more recent period 1990–2015. Consumption-based data seem to show less inequality, consistent with the discussion in Section 3.3, household data more inequality, whereas things are unclear for data based on gross terms, but their differential impact on inequality is insignificant in general. Higher GDP per capita seems to be associated with lesser inequality, whereas the impact of trade openness is unclear, and technology is associated with more inequality, but coefficients are not significant.

For dynamic panel data models, the Generalized Method of Moments (GMM) offers more efficient estimates than does the lagged dependent variable fixed effect model we have just discussed. Thus, to allow for possible endogeneity in the explanatory variables, we use the system GMM.[39] As is well known, when the dependent variable exhibits persistence and the number of time series observations is relatively small, first-difference GMM may suffer from some estimation bias.[40] In that case system GMM may be more efficient than first-difference GMM. Accordingly we re-estimate the regression (24). We also include one lagged value of the dependent variable to capture dynamics in those three regressions. All the results, without and with one lagged value of the dependent variable, are shown in Eqs. (5) to (8) of Table 6.[41] The system GMM estimation is accompanied by the usual diagnostic testing. The first diagnostic test investigates first- and second-order serial correlations in the disturbances. The absence of first-order serial correlation should be rejected, but the absence of a second-order serial correlation should not. Second, a Hansen test is performed for the null hypothesis that the over-identifying assumptions

35 Recall that we showed how consumption inequality understates income inequality in Eq. (20) above.

36 Note that only a few extreme values have been discarded, namely those where the net foreign asset position is lower than −150% or higher than +150% with respect to domestic wealth, because they do not seem reliable.

37 Robust standard errors are clustered by country both in the pooled and fixed effects estimation.

38 See Wooldridge (2005).

39 Arellano and Bover (1995) and Blundell and Bond (1998).

40 Arellano and Bond (1991).

41 Note that we employ one lag (two lags) of the dependent variable as instrument, which is (are) the latest one(s) that is (are) valid under the assumptions of the model, when no (one) lagged value of the dependent variable is included in the regression. The number of instruments is also shown: the number of instruments is relatively small with respect to the number of observations. Too many instruments can weaken the Hansen test of the instruments' joint validity [see Roodman, 2009a for instance]. We have employed xtabond2 command in the estimation, as developed by Roodman (2009b).

Table 6
(A) Impact of total financial openness on inequality.

Dep. Var. Inequality (in logs)	Pooled		Fixed effects	
	1970–2015 (1)	1990–2015 (2)	1970–2015 (3)	1990–2015 (4)
Lag of dependent variable			0.5313***	0.3786***
			(0.0658)	(0.0857)
IFI [a_1]	0.0485***	0.0029	0.0287***	0.0281**
	(0.0169)	(0.0113)	(0.0104)	(0.0120)
IFI^2 [a_2]	−0.0025**	−0.0005	−0.0024***	−0.0028***
	(0.0010)	(0.0006)	(0.0008)	(0.0009)
Dummy: Consumption [a_3]	−0.1386***	−0.0741**	−0.0228	−0.0407
	(0.0376)	(0.0322)	(0.0343)	(0.0386)
Dummy: Household [a_4]	0.0491	0.0474	0.0554*	0.0043
	(0.0323)	(0.0329)	(0.0306)	(0.0346)
Dummy: Gross Income[a_5]	0.2378***	−0.0049	−0.0042	0.0206
	(0.0287)	(0.0313)	(0.0273)	(0.0386)
GDP per capita	−0.0060***	−0.0016	−0.0016	−0.0013
	(0.0011)	(0.0034)	(0.0018)	(0.0023)
Trade openness	−0.0397	0.0419	−0.0345	0.0096
	(0.0381)	(0.0423)	(0.0333)	(0.0319)
ICT capital services		0.0094		0.0044
(% Total capital services)		(0.0113)		(0.0113)
Constant [a_0]	3.6427***	3.5976***	1.6817***	2.2563***
	(0.0489)	(0.0629)	(0.2407)	(0.3215)
Country/time dummies	No	Yes	Yes	Yes
R^2	0.4739	0.9109	0.9314	0.9445
No. of observations	1213	732	808	520
No. of countries	96	70	75	55

(B) System GMM estimation

Dependent variable: Inequality (in logs)	No lags		With lags	
	1970–2015 (5)	1990–2015 (6)	1970–2015 (7)	1990–2015 (8)
Lag of dependent variable			0.6841***	0.6854***
			(0.0763)	(0.1118)
IFI	0.0484***	0.0320	0.0161**	0.0161**
	(0.0167)	(0.0196)	(0.0077)	(0.0074)
IFI^2	−0.0025**	−0.0014	−0.0009	−0.0008
	(0.0010)	(0.0011)	(0.0006)	(0.0005)
Dummy: Consumption [a_5]	−0.1386***	−0.1673***	−0.0505**	−0.0519*
	(0.0373)	(0.0412)	(0.0200)	(0.0255)
Dummy: Household [a_6]	0.0491	0.0665	0.0426***	0.0171
	(0.0320)	(0.0627)	(0.0162)	(0.0184)
Dummy: Gross Income[a_7]	0.2377***	0.2371***	0.0780***	0.0756**
	(0.0285)	(0.0350)	(0.0247)	(0.0343)
GDP per capita	−0.0060***	−0.0058***	−0.0021***	−0.0019***
	(0.0011)	(0.0012)	(0.0005)	(0.0006)
Trade openness	−0.0397	−0.0910	−0.0450**	−0.0759**
	(0.0378)	(0.0689)	(0.0206)	(0.0346)
ICT capital services (% Total		0.0080		0.0199
capital services)		(0.0128)		(0.0153)
Constant [a_0]	3.6427***	3.6188***	1.1363***	1.1797***
	(0.0485)	(0.0687)	(0.2771)	(0.4135)
No. of observations	1213	732	808	520
No. of countries	96	70	75	55
No. of instruments	102	88	143	88
Hansen test	73.37	39.19	84.55	23.06
	(0.93)	(0.92)	(0.61)	(1.00)
First-order autocorrelation	−3.59	−3.33	−4.06	−3.22
	(0.00)	(0.00)	(0.00)	(0.00)
Second-order autocorrelation	−1.52	−2.05	2.59	0.84
	(0.13)	(0.04)	(0.01)	(0.40)

Panels A and B: Robust standard errors clustered by country are in parenthesis.
Panel B: *P*-values for the diagnostic testing of *GMM* are in parenthesis in the lower parts of Tables 6, 7. and A.1. No. of countries are identical across the corresponding GMM regressions
* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.

are valid, which should not be rejected. Both tests are satisfied. More importantly, we confirm the results shown above: more international financial integration seems to be positively associated with more inequality.

Taken together, the equations based on the fixed effect estimation, (3) and (4), and the corresponding GMM estimations, (7) and (8), provide compelling evidence for the importance of international financial integration as a cause of increased income inequality. In all cases the coefficient of *IFI* is significant. The coefficient of the quadratic *IFI* term is highly significant for the *FE* estimation and is also significant for the *GMM* estimates presented in the Appendix, when the *IFI* measure is normalized by *GDP*, providing a correction for the degree of nonlinearity implicit in the use of ln *G* as the dependent variable.

7.2. International financial assets and liabilities

The numerical simulations reported in Section 4 suggest that financial liberalization favoring lending abroad is likely to have differential impacts on income inequality than liberalization that encourages more borrowing. To examine this hypothesis empirically, we test the impact of international financial assets, *IFA*, and financial liabilities, *IFL*, (both expressed as a ratio of domestic wealth) on inequality with the following regression equation:

$$\ln G_{i,t} = a_0 + a_{11}IFA_{i,t} + a_{12}IFA_{i,t}^2 + a_{21}IFL_{i,t} + a_{22}IFL_{i,t}^2 + a_3Dc_{i,t} + a_4Dh_{i,t} + a_5Dg_{i,t} + u_{i,t} \quad (22)$$

Now coefficients a_{11}, a_{12} capture the (linear and quadratic) impact of the increase of financial assets, *IFA*, on countries' inequality, whereas a_{21}, a_{22} capture the (linear and quadratic) impact of the increase of financial liabilities, *IFL*, on countries' inequality. Coefficients $a_3 - a_5$ again capture the additional (differential) impact of the increase of financial assets and liabilities on inequality due to different measures of income inequality.

The results for the regression Eq. (22) are reported in Table 7 and follow the same format as those in Table 6. Overall, the results obtained by disaggregating *IFI* into its two components are less conclusive and more variable across the alternative estimation procedures. The disaggregation clearly yields better results when the estimation is over the shorter period (1990–2015), when all the financial variables are significant for the *FE* Eq. (4) and are mostly significant for the GMM estimation Eq. (8). A striking feature of the results is that coefficients of *FA* is negative while that of *FL* is positive and precisely the opposite applies to the corresponding coefficients of FA^2 and FL^2. This certainly suggests that increasing the volume of financial assets has a very different impact on inequality than does increasing liabilities. The net effect of an increase in either *FA* or *FL* depends upon its level and the amount of the change. The configuration $a_{11} < 0$, $a_{12} > 0$, $a_{21} > 0$, $a_{22} < 0$, obtained in the estimation suggests that for small changes more international financial liabilities seems to increase inequality, while more international financial assets tend to reduce inequality. For large changes, such as those reported in Table 5, these effects will be reversed. Overall, if one substitutes the actual change in *FA* and *FL*, experienced over the period 1970–2015 and reported in Table 1 into these equations one finds that the net effect is an increase in income inequality.

8. Conclusions

The latter part of the 20th century and the beginning of the 21st century have witnessed a dramatic increase in financial liberalization accompanied by a substantial increase in income inequality, experienced by rich countries and poor countries alike. This paper has employed a stochastic growth model to study the impact the impact of international financial globalization on income inequality. A key aspect of the model is that the financial frictions facing the

Table 7
(A) Impact of financial assets and liabilities on inequality.

Dep. variable: Inequality (in logs)	Pooled	Fixed effects		
	1970–2015 (1)	1990–2015 (2)	1970–2015 (3)	1990–2015 (4)
Lag of dependent variable			0.5288***	0.3465***
			(0.0674)	(0.0890)
IFA $[a_{11}]$	0.0110	−0.1330	−0.0117	−0.1472**
	(0.1012)	(0.0915)	(0.0540)	(0.0692)
IFA^2 $[a_{12}]$	0.0279	0.0227	0.0134	0.0298*
	(0.0339)	(0.0202)	(0.0142)	(0.0163)
IFL $[a_{21}]$	0.0878	0.1085	0.0671	0.1581**
	(0.0874)	(0.0800)	(0.0441)	(0.0604)
IFL^2 $[a_{22}]$	−0.0358	−0.0197	−0.0217	−0.0322**
	(0.0311)	(0.0172)	(0.0132)	(0.0145)
Dummy: Consumption $[a_3]$	−0.1410***	−0.0707**	−0.0234	−0.0357
	(0.0381)	(0.0322)	(0.0344)	(0.0381)
Dummy: Household $[a_4]$	0.0489	0.0456	0.0552*	0.0028
	(0.0325)	(0.0318)	(0.0304)	(0.0341)
Dummy: Gross Income$[a_5]$	0.2359***	−0.0045	−0.0031	0.0232
	(0.0289)	(0.0314)	(0.0275)	(0.0392)
GDP per capita	−0.0060***	−0.0007	−0.0016	−0.0002
	(0.0012)	(0.0034)	(0.0018)	(0.0023)
Trade openness	−0.0411	0.0275	−0.0364	−0.0073
	(0.0375)	(0.0410)	(0.0310)	(0.0297)
ICT capital services (% Total capital services)		0.0092		0.0035
		(0.0109)		(0.0108)
Constant $[a_0]$	3.6436***	3.5823***	1.6893***	2.3551***
	(0.0490)	(0.0632)	(0.3453)	(0.3312)
Country/time dummies	No	Yes	Yes	Yes
R^2	0.4752	0.9121	0.9316	0.9456
No. of observations	1213	732	808	520
No. of countries	96	70	75	55

(B) System GMM estimation.

Dependent variable: Inequality (in logs)	No lags		With lags	
	1970–2015 (5)	1990–2015 (6)	1970–2015 (7)	1990–2015 (8)
Lag of dependent variable			0.6882***	0.6906***
			(0.0754)	(0.1113)
IFA	0.0125	−0.0685	−0.0433	−0.0552
	(0.0991)	(0.0975)	(0.0375)	(0.0358)
IFA^2	0.0266	0.0668**	0.0301**	0.0304**
	(0.0320)	(0.0303)	(0.0126)	(0.0119)
IFL	0.0865	0.1266	0.0774**	0.0890**
	(0.0855)	(0.0889)	(0.0375)	(0.0372)
IFL^2	−0.0346	−0.0665**	−0.0323***	−0.0323**
	(0.0293)	(0.0281)	(0.0121)	(0.0115)
Dummy: Consumption $[a_5]$	−0.1409***	−0.1737***	−0.0514**	−0.0531**
	(0.0377)	(0.0420)	(0.0201)	(0.0258)
Dummy: Household $[a_6]$	0.0489	0.0667	0.0415**	0.0156
	(0.0322)	(0.0638)	(0.0160)	(0.0185)
Dummy: Gross Income$[a_7]$	0.2361***	0.2308***	0.0747***	0.0735**
	(0.0286)	(0.0346)	(0.0239)	(0.0337)
GDP per capita	−0.0060***	−0.0058***	−0.0020***	−0.0018***
	(0.0012)	(0.0013)	(0.0005)	(0.0006)
Trade openness	−0.0410	−0.0985	−0.0468**	−0.0762**
	(0.0372)	(0.0666)	(0.0214)	(0.0352)
ICT capital services		0.0084		0.0210
(% Total capital services)		(0.0126)		(0.0152)
Constant $[a_0]$	3.6435***	3.6213***	1.1201***	1.1547***
	(0.0486)	(0.0667)	(0.2732)	(0.4109)
No. of observations	1213	732	781	520
No. of instruments	106	92	147	92
Hansen test	73.37	39.03	18.75	25.22
	(0.94)	(0.95)	(1.00)	(1.00)
First-order autocorrelation	−3.59	−3.51	−4.05	−3.23
	(0.00)	(0.00)	(0.00)	(0.00)
Second-order autocorrelation	−1.52	−2.12	2.58	0.82
	(0.11)	(0.03)	(0.01)	(0.41)

economy pertain both to lending and to borrowing abroad, and the process of financial liberalization has been specified in terms of reducing these frictions.

Examining the relationship within a tightly formulated theoretical model enables us to identify channels through which financial liberalization impinges on income inequality. In this respect we find two key channels through which liberalization affects inequality. The first is by reducing the costs of investing and borrowing abroad, and since these activities favor the wealthy, they tend to increase inequality. But in addition these two forms of liberalization have sharply contrasting effects on domestic activity, which also impact inequality. Reducing the costs of foreign investment diverts resources from the domestic economy, reducing the returns to capital, raising the wage and reducing inequality, while reducing the costs of foreign borrowing has the opposite effect.

Because of the complexity of the model much of our analysis is based on a calibration in which the financial liberalization is targeted to match the change in the portfolios experienced by the median economy. Our numerical simulations suggest that income inequality is more sensitive to financial liberalization that favors foreign investment than it is to liberalization that is directed to reducing the costs of foreign borrowing. In addition, our numerical simulations suggest that the overall liberalization that occurred over the period 1970–2015, was a significant factor in the increase in income inequality experienced over that period. The numerical simulations also support the notion that the impacts of liberalization are non-linear. Overall, we have found that the main results of the model are broadly supported by the empirical evidence using the most recent data for a sample of 96 countries for the period ranging from 1970 to 2015.

These results suggest that, to the extent that an increase in income inequality is deemed undesirable, policy makers should take into account the role of cross-border movements of capital as a contributing factor. Our analysis has abstracted from the role of government, which suggests that an interesting avenue for future research is to structure policies to mitigate the adverse effects of financial globalization on inequality, without compromising the benefits that liberalization generates.

Appendix A. Appendix

A.1. Derivation of Macroeconomic Equilibrium

The representative agent's optimization problem is to choose his consumption-wealth ratio, C_i/W_i the fraction of time devoted to leisure, F_i, and portfolio shares, n_{K_i}, n_{B_i}, n_{D_i} to maximize

$$E_0\int_0^{\infty}\frac{1}{\gamma}\left(C_iF_i^{\eta}\right)^{\gamma}e^{-\beta t}dt \tag{A.1}$$

subject to his individual budget constraints

$$\begin{aligned} dW_i = &\left[(L_i)\omega(L)\frac{n_K}{w_i}+r_K(L)n_{K_i}+r_B(\rho_Bn_B)n_{B_i}-r_D(\rho_Dn_D)n_{D_i}-\frac{C_i}{W_i}\right]W_idt \\ &+n_{K_i}\Omega(L)du_Y+\left(n_{B_i}du_B-n_{D_i}du_D\right) \end{aligned} \tag{A.2a}$$

$$n_{K_i}+n_{B_i}-n_{D_i}=1 \tag{A.2b}$$

and the aggregate wealth accumulation constraints

$$\begin{aligned} dW = &\left[L\omega(L)n_K+r_K(L)n_K+r_B(\rho_Bn_B)n_B-r_D(\rho_Dn_D)n_D-\frac{C}{W}\right]Wdt \\ &+n_K\Omega(L)du_Y+n_Bdu_B-n_Ddu_D \end{aligned} \tag{A.2c}$$

$$n_K+n_B-n_D=1 \tag{A.2d}$$

Since the agent's decisions are impacted by two state variables, W_i, W, we consider a value function of the form

$$V(W_i,W,t)=e^{-\beta t}X(W_i,W)$$

the differential generator of which is

$$\begin{aligned} \Psi[V(W_i,W,t)] \equiv &\frac{\partial V}{\partial t}+\left[(L_i)\omega(L)\frac{n_K}{w_i}+r_K(L)n_{K_i}+r_B(\rho_Bn_B)n_{B_i}-r_D(\rho_Dn_D)n_{D_i}-\frac{C_i}{W_i}\right]W_iV_{W_i} \\ &+\left[L\omega(L)n_K+r_K(L)n_K+r_B(\rho_Bn_B)n_B-r_D(\rho_Dn_D)n_D-\frac{C}{W}\right]WV_W \\ &+\frac{1}{2}\left[\left(n_{K_i}\Omega(L)\right)^2\sigma_Y^2+\left(n_{B_i}\right)^2\sigma_B^2+\left(n_{D_i}\right)^2\sigma_D^2\right]W_i^2V_{W_iW_i} \\ &+\left[\left(n_{K_i}n_K\Omega(L)\right)^2\sigma_Y^2+n_{B_i}n_B\sigma_B^2+n_{D_i}n_D\sigma_D^2\right]W_iWV_{W_iW} \\ &+\frac{1}{2}\left[(n_K\Omega(L))^2\sigma_Y^2+(n_B)^2\sigma_B^2+(n_D)^2\sigma_D^2\right]W^2V_{WW} \end{aligned} \tag{A.3}$$

Thus, the individual's formal optimization problem is to choose C_i, $F_i(=1-L_i)$, n_{K_i}, n_{B_i}, n_{D_i} to maximize:

$$\frac{1}{\gamma}\left(C_iF_i^{\eta}\right)^{\gamma}e^{-\beta t}+\Psi\left[e^{-\beta t}X(W_i,W)\right]+\lambda\left(1-n_{K_i}-n_{B_i}+n_{D_i}\right) \tag{A.4}$$

Taking the partial derivatives and utilizing the constraints (A.2b) and (A.2d) yields:

$$C_i^{\gamma-1}F_i^{\eta\gamma}=X_{W_i} \tag{A.5a}$$

$$\eta C_i^{\gamma}F_i^{\eta\gamma-1}=X_{W_i}W_i\omega(L)\frac{n_K}{w_i} \tag{A.5b}$$

$$[r_K(L)-r_B(\rho_B n_B)]W_iX_{W_i}+\left[\Omega(L)^2n_{K_i}\sigma_Y^2-n_{B_i}\sigma_B^2\right]W_i^2X_{W_iW_i}+\left[\Omega(L)^2n_K\sigma_Y^2-n_B\sigma_B^2\right]W_iWX_{W_iW}=0 \tag{A.5c}$$

$$[r_K(L)-r_D(\rho_D n_D)]W_iX_{W_i}+\left[\Omega(L)^2n_{K_i}\sigma_Y^2+n_{D_i}\sigma_D^2\right]W_i^2X_{W_iW_i}+\left[\Omega(L)^2n_K\sigma_Y^2+n_D\sigma_D^2\right]W_iWX_{W_iW}=0 \tag{A.5d}$$

To proceed further we postulate the specific function $X(W_i,W)=aW_i^{\gamma-\varepsilon}W^{\varepsilon}$, the relevant partial derivatives of which are:

$$\begin{aligned}&X_{W_i}=a(\gamma-\varepsilon)W_i^{\gamma-\varepsilon-1}W^{\varepsilon};\ X_W=a\varepsilon W_i^{\gamma-\varepsilon}W^{\varepsilon-1};X_{W_iW_i}=a(\gamma-\varepsilon)(\gamma-\varepsilon-1)W_i^{\gamma-\varepsilon-2}W^{\varepsilon};\\&X_{W_iW}=a(\gamma-\varepsilon)\varepsilon W_i^{\gamma-\varepsilon-1}W^{\varepsilon-1};X_{WW}=a\varepsilon(\varepsilon-1)W_i^{\gamma-\varepsilon}W^{\varepsilon-2}\end{aligned} \tag{A.6}$$

Substituting these expressions into (A.5c) and (A.5d), we obtain:

$$[r_K(L)-r_B(\rho_B n_B)]+\left[\Omega(L)^2n_{K_i}\sigma_Y^2-n_{B_i}\sigma_B^2\right](\gamma-\varepsilon-1)+\left[\Omega(L)^2n_K\sigma_Y^2-n_B\sigma_B^2\right]\varepsilon=0 \tag{A.7a}$$

$$[r_K(L)-r_D(\rho_D n_D)]+\left[\Omega(L)^2n_{K_i}\sigma_Y^2+n_{D_i}\sigma_D^2\right](\gamma-\varepsilon-1)+\left[\Omega(L)^2n_K\sigma_Y^2+n_D\sigma_D^2\right]\varepsilon=0 \tag{A.7b}$$

Equations (A.7a), (A.7b), together with (A.2d) imply that all agents in choosing their respective portfolios are constrained by the same rates of return and identical stochastic conditions. Hence they all choose identical portfolio shares which therefore also coincide with the aggregate i.e. $n_{K_i}=n_K$ (and $n_{B_i}=n_B$, $n_{D_i}=n_D$). Thus the equilibrium portfolio shares satisfy:

$$[r_K(L)-r_B(\rho_B n_B)]+\left[\Omega(L)^2n_K\sigma_Y^2-n_B\sigma_B^2\right](\gamma-1)=0 \tag{A.8a}$$

$$[r_K(L)-r_D(\rho_D n_D)]+\left[\Omega(L)^2n_K\sigma_Y^2+n_D\sigma_D^2\right](\gamma-1)=0 \tag{A.8b}$$

together with (A.2d). Solving these equations:

$$n_{K_i}=n_K=\frac{[r_K(L)-r_B(\rho_B n_B)]\sigma_D^2+[r_K(L)-r_D(\rho_D n_D)]\sigma_B^2}{(1-\gamma)D}+\frac{\sigma_D^2\sigma_B^2}{D} \tag{A.9a}$$

$$n_{D_i}=n_D=\frac{[r_B(\rho_B n_B)-r_D(\rho_D n_D)]\Omega^2(L)\sigma_Y^2+[r_K(L)-r_D(\rho_D n_D)]\sigma_B^2}{(1-\gamma)D}-\frac{\Omega^2(L)\sigma_Y^2\sigma_B^2}{D} \tag{A.9b}$$

$$n_{B_i}=n_B=\frac{[r_B(\rho_B n_B)-r_D(\rho_D n_D)]\Omega^2(L)\sigma_Y^2-[r_K(L)-r_B(\rho_B n_B)]\sigma_D^2}{(1-\gamma)D}+\frac{\Omega^2(L)\sigma_Y^2\sigma_D^2}{D} \tag{A.9c}$$

where $D\equiv[\Omega(L)^2\sigma_Y^2(\sigma_D^2+\sigma_B^2)+\sigma_D^2\sigma_B^2]$.

Dividing (A.5b) by (A.5a)

$$\frac{C_i}{W_i}=\frac{\omega(L)n_K}{\eta}\frac{F_i}{w_i} \tag{A.10a}$$

or equivalently

$$C_i=\frac{\omega(L)n_K}{\eta}F_iW$$

and summing over the individual agents we obtain the aggregate relationship

$$\frac{C}{W} = \frac{\omega(L)n_K}{\eta} F \tag{A.10b}$$

In addition, the value function must satisfy the Bellman equation

$$\max\left\{\frac{1}{\gamma}\left(C_i F_i^{\eta}\right)^{\gamma} e^{-\beta t} + \Psi\left[e^{-\beta t} X(W_i, W)\right]\right\} = 0 \tag{A.11}$$

Using the accumulation equations (A.2a) and (A.2c) the term in parentheses can be written as

$$\begin{aligned}&\left(C_i F_i^{\eta}\right)^{\gamma} - \beta X(W_i, W) + \frac{E(dW_i)}{dt} X_{W_i} + \frac{E(dW)}{dt} X_W \\ &\quad + \frac{1}{2}\frac{E(dW_i)^2}{dt} X_{W_i W_i} + \frac{E(dW_i dW)}{dt} X_{W_i W} + \frac{1}{2}\frac{E(dW)^2}{dt} X_{WW} = 0\end{aligned}$$

Now take the partial derivative of this expression with respect to W_i noting that F_i is independent of W_i, while C_i is a function of W_i through the first-order condition (A.10a)

$$\begin{aligned}&\frac{1}{C_i}\left(C_i F_i^{\eta}\right)^{\gamma} C_{i,W_i} - \beta X_{W_i} + \frac{E(dW_i)}{dt} X_{W_i W_i} + \left\{r_K n_{K_i} + r_B n_{B_i} - r_D n_{D_i} - C_{i,W_i}\right\} X_{W_i} + \frac{E(dW)}{dt} X_{WW_i} \\ &\quad + W_i X_{W_i W_i} \sigma_w^2 + \frac{1}{2}\frac{E(dW_i)^2}{dt} X_{W_i W_i W_i} + \frac{E(dW_i dW)}{dt} X_{W_i WW_i} + W X_{W_i W} \sigma_W^2 + \frac{1}{2}\frac{E(dW)^2}{dt} X_{W_i WW} = 0\end{aligned} \tag{A.12}$$

where $\sigma_W^2 = [\Omega(L)n_K]^2 \sigma_Y^2 + (n_B)^2 \sigma_B^2 + (n_D)^2 \sigma_D^2$.

Next, consider $X_{W_i} = X_{W_i}(W_i, W)$ Taking the stochastic differential of this quantity yields

$$dX_{W_i} = X_{W_i W_i} dW_i + X_{W_i W} dW + \frac{1}{2} X_{W_i W_i W_i} (dW_i)^2 + X_{W_i WW_i} (dW_i)(dW) + \frac{1}{2} X_{W_i WW} (dW)^2$$

Taking the expected value of this expression, dividing by dt, and substituting the resulting equation along with (A.10a) into (A.12) yields

$$\left\{r_K n_{K_i} + r_B n_{B_i} - r_D n_{D_i} - \beta\right\} X_{W_i} + \left[W_i X_{W_i W_i} + W X_{W_i W}\right] \sigma_W^2 + \frac{E(dX_{W_i})}{dt} = 0 \tag{A.13}$$

Substituting the relevant partial derivatives reported in (A.6), we can express (A.13) as

$$\frac{E(dX_{W_i})}{X_{W_i} dt} = \beta - \left\{r_K n_{K_i} + r_B n_{B_i} - r_D n_{D_i}\right\} + (1-\gamma)\sigma_W^2 \tag{A.14}$$

Since the underlying AK technology and preferences ensure that the corresponding deterministic system is always on a balanced growth path in which labor supply is constant over time, we shall focus on the corresponding stochastic balanced growth path. Hence, returning to the optimality condition (A.5a), computing the stochastic differential of this relationship, and taking expected values yields:

$$\frac{E(dX_{W_i})}{X_{W_i}} = (\gamma-1) E\left(\frac{dC_i}{C_i}\right) + \frac{1}{2}(\gamma-1)(\gamma-2) E\left(\frac{dC_i}{C_i}\right)^2 \tag{A.15}$$

Along the balanced growth path C_i/W_i is constant. Hence $dC_i/C_i = dW_i/W_i = \psi_i dt + du_W$ where $du_W \equiv [\Omega(L)n_K]du_Y + n_B du_B - n_D du_D$. Thus, (A.15) can be written as

$$\frac{E(dX_{W_i})}{X_{W_i} dt} = (\gamma-1)\psi_i + \frac{1}{2}(\gamma-1)(\gamma-2)\sigma_W^2 \tag{A.16}$$

Equating (A.14) and (A.16) we obtain

$$\psi_i = \frac{r_K(L) n_{K_i} + r_B(\rho_B n_B) n_{B_i} - r_D(\rho_D n_D) n_{D_i} - \beta}{1-\gamma} - \frac{\gamma}{2}\sigma_W^2 \tag{A.17}$$

Since all agents choose the same portfolio shares, Equation (A.17) implies that all individuals have a common growth rate for both consumption, wealth, and its components.

$$\psi_i = \psi = \frac{r_K(L) n_K + r_B(\rho_B n_B) n_B - r_D(\rho_D n_D) n_D - \beta}{1-\gamma} - \frac{\gamma}{2}\sigma_W^2 \tag{A.17$'$}$$

Thus, the macroeconomic equilibrium conditions are:

$$n_B = \frac{[r_B(\rho_B n_B) - r_D(\rho_D n_D)]\Omega^2(L)\sigma_Y^2 - [r_K(L) - r_B(\rho_B n_B)]\sigma_D^2}{(1-\gamma)D} + \frac{\Omega^2(L)\sigma_Y^2\sigma_D^2}{D} \tag{A.18a}$$

$$n_D = \frac{[r_B(\rho_B n_B) - r_D(\rho_D n_D)]\Omega^2(L)\sigma_Y^2 + [r_K(L) - r_D(\rho_D n_D)]\sigma_B^2}{(1-\gamma)D} - \frac{\Omega^2(L)\sigma_Y^2\sigma_B^2}{D} \tag{A.18b}$$

$$n_K = \frac{[r_K(L) - r_B(\rho_B n_B)]\sigma_D^2 + [r_K(L) - r_D(\rho_D n_D)]\sigma_B^2}{(1-\gamma)D} + \frac{\sigma_D^2\sigma_B^2}{D} \tag{A.18c}$$

$$\frac{C}{W} = \frac{\omega(L)n_K}{\eta}(1-L) \tag{A.18d}$$

$$\psi = \Omega(L)n_K + r_B(\rho_B n_B)n_B - r_D(\rho_D n_D)n_D - \frac{C}{W} \tag{A.18e}$$

$$\psi = \frac{r_K(L)n_K + r_B(\rho_B n_B)n_B - r_D(\rho_D n_D)n_D - \beta}{1-\gamma} - \frac{\gamma}{2}\sigma_W^2 \tag{A.18f}$$

$$\sigma_W^2 = [\Omega(L)n_K]^2\sigma_Y^2 + (n_B)^2\sigma_B^2 + (n_D)^2\sigma_D^2 \tag{A.18g}$$

where D is defined by equation (A.9), and $r_K(L)$, $\omega(L)$, $\Omega(L)$, $r_B(\rho_B n_B)$, $r_D(\rho_D n_D)$ are described in (5c).

A.2. Transversality conditions

In addition the following transversality condition must hold:

$$\lim_{t\to\infty} E\left[V(W_i, W)e^{-\beta t}\right] = 0$$

To evaluate this condition, we express the dynamics of the accumulation of individual and aggregate wealth, respectively. The solutions to these equations, starting from the initial individual and aggregate wealth, $W_i(0)$ and $W(0)$ are given by the following equations

$$\begin{aligned} W_i(t) &= W_i(0)e^{\left[\psi - 0.5\sigma_W^2\right]t + u_W(t)} \\ W(t) &= W(0)e^{\left[\psi - 0.5\sigma_W^2\right]t + u_W(t)} \end{aligned} \tag{A.19}$$

Because the increments of w are temporally independent and are normally distributed, the expected value of the value function is equal to:

$$E\left[V(W_i, W)e^{-\beta t}\right] = E\left[aW_i^{\gamma-\varepsilon}W^{\varepsilon}e^{-\beta t}\right] = aW_i(0)^{\gamma-\varepsilon}W(0)^{\varepsilon}e^{\left\{\gamma\left(\psi-(1/2)(1-\gamma)\sigma_W^2\right)-\beta\right\}t}$$

The transversality condition will be satisfied if and only if:

$$\gamma\left(\psi - (1/2)(1-\gamma)\sigma_W^2\right) < \beta \tag{A.20}$$

Now substituting this condition into (A.17'), and using (A.2a), the inequality (A.19) is equivalent to:

$$\frac{C_i}{W_i} > (1-F_i)\omega(L)\frac{n_K}{w_i} \tag{A.21}$$

which states that consumption-wealth ratio for individual i must exceed his labor income. Summing over individuals this implies

$$\frac{C}{W} > (1-F)\omega(L)n_K \tag{A.21'}$$

at the aggregate level. Furthermore, combining (A.21), (A.21') with (A.10a) and (A.10b) respectively, the transversality conditions are equivalent to

$$F_i > \frac{\eta}{1+\eta},\ F > \frac{\eta}{1+\eta} \tag{A.22}$$

which guarantees convergence.

A.3. Equilibrium labor supply

In equilibrium all agents have the same expected growth rate,

$$\psi = (1-F_i)\omega(L)\frac{n_K}{w_i} + r_K(L)n_K + r_B(\rho_B n_B)n_B - r_D(\rho_D n_D)n_D - \frac{C_i}{W_i} \tag{A.23a}$$

and equal to the corresponding aggregate growth rate

$$\psi = (1-F)\omega(L)n_K + r_K(L)n_K + r_B(\rho_B n_B)n_B - r_D(\rho_D n_D)n_D - \frac{C}{W} \tag{A.23b}$$

Substituting (A.10a) into (A.23a) and (A.10b) into (A.23b), and equating (A.23a) and (A.23b) yields

$$F_i - F = \left(F - \frac{\eta}{1+\eta}\right)(w_i - 1) \text{ or } L_i - L = \left(L - \frac{1}{1+\eta}\right)(w_i - 1) \tag{A.24}$$

A.4. Derivation of relative income, (12)

From the definition of y_i and recalling the definitions of $\omega(L)$ and r_K in (2a), (2b), we have

$$y_i - 1 = \frac{\alpha\Omega(L)L^{-1}L_iK + [(1-\alpha)\Omega(L)-\delta]K_i + r_B E_B B_i - r_D E_D D_i}{\alpha\Omega(L)K + [(1-\alpha)\Omega(L)-\delta]K + r_B E_B B - r_D E_D D} - 1 \tag{A.25}$$

Dividing by W we obtain

$$y_i - 1 = \frac{\alpha\Omega(L)L^{-1}L_i n_K + [(1-\alpha)\Omega(L)-\delta](K_i/W) + r_B(E_B B_i/W) - r_D(E_D D_i/W)}{[\Omega(L)-\delta]n_K + r_B n_B - r_D n_D} - 1$$

Recalling (6) and (7) yields

$$y_i - 1 = \frac{\alpha\Omega(L)L^{-1}L_i n_K + ([(1-\alpha)\Omega(L)-\delta]n_K + r_B n_B - r_D n_D)w_i}{[\Omega(L)-\delta]n_K + r_B n_B - r_D n_D} - 1$$

Substituting for L_i from (A.24), we obtain

$$y_i - 1 = \left[1 - \frac{\alpha\Omega(L)n_K}{L(1+\eta)[(\Omega(L)-\delta)n_K + r_B n_B - r_D n_D]}\right](w_i - 1)$$

Finally, dividing by $\Omega(L)n_K$ yields

$$y_i - 1 = \left[1 - \frac{\alpha}{L(1+\eta)[(1-\delta/\Omega(L)) + s_B - s_D]}\right](w_i - 1) \tag{A.26}$$

A.5. List of Countries

1. Developed OECD countries: Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Republic of Korea, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.
2. Other high income countries: Croatia, Estonia, Hong Kong, Israel, Lithuania, Poland, Singapore, Slovak Republic, Slovenia, Trinidad and Tobago.
3. Middle income countries: Albania, Algeria, Angola, Argentina, Azerbaijan, Belarus, Belize, Bosnia and Herzegovina, Botswana, Brazil, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Gabon, Iran, Kazakhstan, Macedonia FYR, Malaysia, Maldives, Mexico, Namibia, Paraguay, Peru, Russian Federation, South Africa, Thailand, Turkey, Uruguay, Venezuela.
4. Middle-Low income countries: Bangladesh, Bhutan, Cape Verde, Djibouti, Egypt, El Salvador, Ethiopia, Guatemala, Honduras, India, Indonesia, Kenya, Lesotho, Mongolia, Morocco, Nigeria, Pakistan, Philippines, Sri Lanka, Tajikistan, Tunisia, Ukraine, Yemen, Republic of Zambia.
5. Low income countries: Burkina Faso, Central African Republic, Comoros, Nepal, Tanzania, Uganda, Zimbabwe.

Table A.1
Impact of total financial openness on inequality: IFI normalized by GDP

Dep. Var. Inequality (in logs)	Pooled	Fixed effects		
	1970-2015	1990-2015	1970-2015	1990-2015
	(1)	(2)	(3)	(4)
Lag of dependent variable			0.5376***	0.3888***
			(0.0653)	(0.0852)
IFI [a_1]	0.0351***	0.0032	0.0178***	0.0119**
	(0.0104)	(0.0066)	(0.0062)	(0.0066)
IFI^2 [a_2]	-0.0010**	-0.0002	-0.0007***	-0.0006**

Table A.1 (*continued*)

Dep. Var. Inequality (in logs)	Pooled	Fixed effects		
	1970-2015 (1)	1990-2015 (2)	1970-2015 (3)	1990-2015 (4)
	(0.0003)	(0.0002)	(0.0002)	(0.0002)
Dummy: Consumption [a_3]	-0.1402***	-0.0742**	-0.0241	-0.0426
	(0.0375)	(0.0321)	(0.0341)	(0.0387)
Dummy: Household [a_4]	0.0563*	0.0467	0.0553*	0.0041
	(0.0334)	(0.0326)	(0.0306)	(0.0349)
Dummy: Gross Income[a_5]	0.2336***	-0.0054	-0.0038	0.0205
	(0.0286)	(0.0313)	(0.0275)	(0.0389)
GDP per capita	-0.0069***	-0.0016	-0.0019	-0.0009
	(0.0013)	(0.0033)	(0.0019)	(0.0022)
Trade openness	-0.0568	0.0470	-0.0303	0.0151
	(0.0377)	(0.0441)	(0.0342)	(0.0329)
ICT capital services (% Total capital services)		0.0096		0.0044
		(0.0113)		(0.0114)
Constant [a_0]	3.6571***	3.5942***	1.6601***	2.2128***
	(0.0471)	(0.0629)	(0.2394)	(0.3206)
Country/time dummies	No	Yes	Yes	Yes
R^2	0.4795	0.9111	0.9314	0.9442
No. of observations	1213	732	808	520
No of countries	96	70	75	55

System GMM estimation

Dep. Var. Inequality (in logs)	No lags		With lags	
	1970-2015 (5)	1990-2015 (6)	1970-2015 (7)	1990-2015 (8)
Lag of dependent variable			0.6791***	0.6735***
			(0.0760)	(0.1116)
IFI	0.0351***	0.0262**	0.0117***	0.0127**
	(0.0104)	(0.0114)	(0.0040)	(0.0053)
IFI^2	-0.0010***	-0.0006**	-0.0004**	-0.0004**
	(0.0003)	(0.0003)	(0.0002)	(0.0002)
Dummy: Consumption [a_5]	-0.1403***	-0.1693***	-0.0517***	-0.0550**
	(0.0372)	(0.0411)	(0.0201)	(0.0257)
Dummy: Household [a_6]	0.0563*	0.0767	0.0459***	0.0219
	(0.0332)	(0.0660)	(0.0168)	(0.0201)
Dummy: Gross Income[a_7]	0.2336***	0.2311***	0.0792***	0.0784**
	(0.0284)	(0.0333)	(0.0248)	(0.0345)
GDP per capita	-0.0069***	-0.0067***	-0.0024***	-0.0023***
	(0.0013)	(0.0014)	(0.0006)	(0.0007)
Trade openness	-0.0568	-0.1153*	-0.0476**	-0.0807**
	(0.0373)	(0.0667)	(0.0201)	(0.0352)
ICT capital services (% Total capital services)		0.0075		0.0179
		(0.0125)		(0.0125)
Constant [a_0]	3.6571***	3.6371***	1.1544***	1.2257***
	(0.0467)	(0.0665)	(0.2758)	(0.4133)
No. of observations	1213	732	808	520
No. of countries	96	70	75	55
No. of instruments	102	88	143	88
Hansen test	80.25	40.51	108.92	24.05
	(0.84)	(0.90)	(0.07)	(1.00)
First-order autocorrelation	-3.63	-3.40	-4.07	-3.24
	(0.00)	(0.00)	(0.00)	(0.00)
Second-order autocorrelation	-1.53	-2.06	2.57	0.77
	(0.13)	(0.04)	(0.01)	(0.44)

p-values for the diagnostic testing of GMM are in parenthesis in the lower part of the table.
*: Significant at 10% level; **: Significant at 5% level; ***: Significant at 1% level.
Robust standard errors clustered by country are in parenthesis.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jinteco.2019.04.003.

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