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CAN CAPITAL CONTROLS PROMOTE GREEN INVESTMENTS IN DEVELOPING COUNTRIES?

by Alessandro Moro*

Abstract

Climate change poses severe challenges to economic growth and financial stability, especially in developing countries with a more carbon-intensive economy and a greater exposure to climate-related damages. This paper proposes a simple model in which an emerging open economy, characterized by the presence of a carbon-intensive and a green industry, imposes a tax on the interest paid by brown corporate bonds to foreign investors with the aim of redirecting capital to the green industry and reducing the negative environmental externality of brown firms. In this framework, capital controls have two opposite effects. On one hand, a higher tax rate has a direct negative impact on production, since it discourages capital inflows to carbon-intensive firms, thereby reducing their output. On the other hand, capital controls have an indirect positive effect through the reduction of the negative environmental externality of the carbon-intensive sector. Moreover, the analysis reveals that the optimal inflow tax is an increasing function of climate-related damage and a decreasing function of foreign and domestic investors' environmental preferences.

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Introduction[1]

The major economic and financial challenges posed by climate change have induced central banks (Carney, 2015, 2016; Brainard, 2019; Visco, 2019; Breman, 2020; Lagarde, 2021) and international financial institutions (IMF, 2019) to think about the role of appropriate policies for the mitigation of climate-related risks, in order to preserve growth and financial stability. These measures include Pigovian carbon taxes, the integration of sustainability and climate-related risks into prudential regulation and financial stability monitoring, the search for appropriate policy mixes and the development of new financial mechanisms at the international level.[2] The relevance of this topic is confirmed by the recent proposal by the International Monetary Fund's (IMF) staff of integrating climate change mitigation and transition risks into the IMF's surveillance, in particular Article IVs and financial stability assessments (FSAs), given the significant fiscal and financial stability implications of climate-related events.

In this context, as stressed by Carney (2016), a relevant issue is the design of clear policy frameworks that encourage the mobilisation of private investments to finance the transition to a low-carbon economy, especially in countries with a more carbon-intensive economy.

This topic is particularly crucial for emerging market economies (EMEs) and developing countries (Bredenkamp and Pattillo, 2010; Lindenberg, 2014; Dikau and Ryan-Collins, 2017), characterised by a more carbon-intensive economy, a higher exposure to climate-related damages and less developed domestic financial markets, which might require foreign capitals to finance the de-carbonisation of their economy. For this purpose, Rogoff (2019) proposes the creation of a World Carbon Bank as a vehicle to coordinate aid and technical transfers from advanced economies to developing countries. Rather than creating new *ad hoc* institutions, other authors propose to embed climate concerns within existing international institutions, such as the IMF, as part of their mandate to manage the international monetary and financial system. In particular, proposals regard the issuance of "green" Special Drawing Rights (SDRs) through the IMF to finance green funds (Bredenkamp and Pattillo, 2010; Ferron and Morel, 2014; Aglietta and Coudert, 2019; Ocampo, 2019).

The present paper explores an alternative and autonomous way for emerging and developing countries to finance their transition to a greener economy, i.e. through the adoption of capital control measures. In this perspective, the relevant policy question is whether capital controls, explicitly designed to discourage, on one hand, foreign inflows in traditional carbon-intensive industries and promote, on the other, green investments, can be effective in stimulating a sustainable growth in this kind of receiving economies. To the best of our knowledge, these policy measures have never been adopted by EMEs, but their effective design and implementation might become crucial as climate-related concerns gain momentum. Regarding this last point, it is important to emphasise that the international issuance of green bonds denominated in US dollars remained dominated by emerging market borrowers. In fact, issuance of international US dollar-denominated green bonds by emerging market borrowers stabilised at around

[1] The views expressed in the paper are those of the author and do not involve the responsibility of the Bank of Italy. I would like to thank Pietro Antonio Catte, Federico Cingano, Antonio Di Cesare, Valerio Nispi Landi, Francesco Paternò, Luigi Federico Signorini and two anonymous referees for very helpful comments and suggestions.

[2] For a recent review of the debate and measures aimed at the mitigation of climate-related risks within central banks' financial stability mandate, see Bolton *et al.* (2020).

USD 17 billion in 2020 (around 3 per cent of the total international issuance of bonds by EMEs) after several years of increase. Emerging market borrowers accounted for around half of total issuance of international US dollar-denominated green bonds in 2020.[3]

The proposed capital controls on foreign inflows in carbon-intensive sectors should be more appealing for emerging and developing countries than a standard carbon tax, irrespective of the origin of investors, for two reasons. Firstly, EMEs and developing countries feature underdeveloped domestic financial markets and, consequently, they rely heavily on foreign capital inflows to finance their economy. Secondly, emerging and developing countries are more exposed to the risks of climate change and therefore residents in those countries should have stronger pro-environmental preferences than foreign investors. A tax applied to foreign intermediaries should compensate their lower pro-environmental attitude and redirect foreign funds, that are quantitatively more relevant than domestic savings in EMEs and developing countries, towards green activities. However, it is worth to stress that there might be also disadvantages related to the proposed policy instrument. For instance, capital controls might be perceived as discriminatory by foreign investors, reducing the overall attractiveness of the adopting countries. Moreover, if inflow taxes are introduced by a single country in a unilateral way, they might provoke a flight of international capital flows to countries without capital controls.

In order to discuss the effectiveness of an inflow tax on foreign investments in brown firms, our analysis develops a simple and tractable model in which an emerging open economy, characterised by the presence of both a carbon-intensive industry and a green one, imposes capital controls on foreign inflows to the brown firms. The goal of these capital controls would be to redirect capital flows to the green industry and reduce the negative environmental externality of carbon-intensive firms. The analysis shows that, under plausible assumptions on the preferences of foreign investors and domestic households about intertemporal consumption smoothing and environmental concerns, capital controls are effective in promoting green investments and increasing firms' production. Hence, such differentiated capital controls can be considered as an useful policy toolkit to maximise the overall welfare of the small open economy.

In particular, capital controls are introduced in the model as a tax on capital inflows, following Gabaix and Maggiori (2015) and Basu *et al.* (2020): foreign investors must pay a tax on the capital they lend to carbon-intensive firms. In the proposed framework, capital controls have two opposite effects on the economy. On one hand, a higher tax rate has a direct negative effect on production since it discourages capital inflows to carbon-intensive firms and reduces their output. On the other hand, capital controls have an indirect positive effect through the reduction, induced by the lower size of brown capital in the economy, of the negative environmental externality of the carbon-intensive sector. In fact, it is assumed that a lower brown production reduces pollution and, consequently, the climate-related damage. The reduction of the negative environmental externality leads, in line with the literature on the economic impact of climate change, to an increase of total factor productivity in both sectors (Nordhaus 1991, 1994; Frankhauser and Tol, 2005; Dietz and Stern, 2015). In setting the optimal inflow tax, the government of the emerging economy should balance these two opposite effects in order to maximise the overall welfare of the small open economy.

[3] These figures are taken from the ECB's Report on the International Role of the Euro, June 2021, available at: https://www.ecb.europa.eu/pub/ire/html/ecb.ire202106~a058f84c61.en.html

The rest of the paper is organised as follows. Next section reviews the works that are closely related with the topic of this paper. Section 2 presents the model, describes the behaviour of its economic agents and derives the equilibrium conditions. Section 3 motivates the choice of parameter values in our preferred calibration. In Section 4, a comparative static analysis is performed with the aim of evaluating the impact of capital controls on the equilibrium values of the main model variables. Section 5 discusses the optimal choice of the inflow tax in order to maximise the total welfare and illustrates the sensitivity of results with respect to changes in parameter values. In Section 6 two extensions of the basic model are considered. The first one introduces a tax on domestic investments in the brown sector in addition to capital controls showing that, as long as foreign investors have lower pro-environmental preferences than domestic households, the tax on foreign investors should be higher than the one on domestic households in order to maximise welfare. The second extension introduces default risks in the two sectors with the aim of deriving financial stability implications. Section 7 concludes.

1. Related literature

This work is related to two distinct streams of literature: (a) the relatively recent strand of works that study the economic consequences of climate change and the relationships between climate and economic phenomena; (b) the literature on international capital mobility and the debate on capital control measures.

The long-run effects of damages related to global warming and extreme weather events have been the main focus of the early literature on the economic impact of climate change (see Nordhaus 1991, 1994; Frankhauser and Tol, 2005; Pindyck 2012, 2013; Dietz and Stern, 2015). In these papers, the effect of climate is introduced using a damage function that depends on the atmospheric temperature relative to the pre-industrial era. This damage is applied to either firms' production function or to the capital equation of motion: hence, according to this framework, the negative effect on total factor productivity (TFP) or the reduction of capital accumulation are the main channels through which climate change affects the growth of an economy (physical risks). More recently, Dietz *et al.* (2016), Bovari *et al.* (2018) and Dafermos *et al.* (2017, 2018) have extended the analysis of physical risks by examining the implication of climate change damages on financial stability: in fact, by reducing the capital and profitability of firms, climate change is likely to gradually deteriorate their liquidity, leading to a higher rate of default that could negatively affect the price of financial assets and the financial position of firms and banks. In this framework, Dafermos *et al.* (2018) evaluate the benefits of the implementation by central banks of a green quantitative easing to alleviate the climate-induced financial instability. Moreover, a parallel stream of research (Leaton, 2011; Battiston *et al.*, 2017; Stolbova *et al.*, 2018) has pointed out the risks to financial stability due to the re-valuation of the carbon-intensive industry assets, which are more exposed to shocks in the transition phase to a greener economy (transition risks).

Our work is more related to the literature on physical risks. In fact, in the proposed model it is assumed that the carbon-intensive production generates a negative externality by reducing, through a damage function, the overall output produced by the economy.

With regard to the capital controls literature, the debate on these policy instruments has been reopened by Rodrik (1998) and Krugman (1999) after the East Asian crisis of 1997, which showed how large private capital flows could be destabilizing. The main idea of this literature is that capital flows may generate either pecuniary or aggregate demand externalities that induce economic agents to borrow too much and to take excessive risks. Most of the theoretical literature that motivates capital controls has focused on pecuniary externalities (Jeanne and Korinek, 2010; Korinek, 2011). A pecuniary externality can be due, for example, to balance sheet effects that arise when a large number of borrowers start deleveraging in response to financial difficulties and their collective actions lead to a decline of the value of their assets more than the value of their liabilities. Aggregate demand externalities may be generated by capital flows whenever aggregate demand differs from aggregate supply due to sticky prices (Farhi and Werning, 2014) or sticky wages (Schmitt-Grohé and Uribe, 2016). In fact, capital flows reallocate spending between domestic and foreign agents that have different consumption baskets and, consequently, different marginal propensities to consume. Specifically, domestic agents have a higher marginal propensity to consume on domestic goods than foreigners. Capital inflows thus generally lead to an increase in domestic aggregate demand while outflows to a reduction. Therefore, in presence of nominal rigidities, capital flows can interfere with aggregate demand management.

In the presence of such externalities, capital controls, both in the form of quantity or price regulation, are welfare-improving since they induce the decision-makers to internalise the costs and benefits of international flows.[4] In a similar way, in our framework, capital controls allow to reach higher levels of well-being since carbon-intensive firms are forced to internalise the environmental consequences of their production paying in equilibrium a higher rate of returns on foreign borrowing.

2. Model

In this paper a small open economy is considered over two periods $t \in \{0,1\}$. In the country there exist two types of industries, each of them constituted by a continuum of mass one of perfectly competitive firms owned by domestic households: a brown or carbon-intensive industry (indexed with the subscript b) and a green industry (indexed with g) that produce the same homogeneous tradable good but with different technologies. The two industries rely on both domestic (d) and foreign (f) lending in order to finance their investments and employ local labour force from a mass one of identical households. Investment decisions by foreign and domestic households are taken in period 0, while production and the remuneration of capital and labour take place in period 1. Consumption choices are undertaken in both periods.

Domestic households supply capital and labour to the two industries maximising their lifetime utility that combines an increasing and concave function of current and future consumption levels minus a penalty function that captures, in line with Baker *et al.* (2018) and Pastor *et al.* (2020),[5] the disutility of holding non-green assets. In this framework, we are thus able to include environmental concerns in the utility maximisation. More precisely, at time 0 domestic households receive an exogenous wealth A and choose the consumption expenditures in the two periods C_0 and C_1 and the share of investment in the carbon-intensive industry q_d, maximising:

$$U(C_0, C_1, q_d) = \frac{{C_0}^{1-\theta}}{1-\theta} + \beta \frac{{C_1}^{1-\theta}}{1-\theta} - \lambda_d \frac{{q_d}^{\varphi+1}}{\varphi+1} \quad (1)$$

[4] For a recent review of the capital controls literature, see Erten *et al.* (2019). For an empirical assessment of the effectiveness of capital controls, see Nispi Landi and Schiavone (2020).
[5] In these works, the authors introduce an extra-utility for green asset holding in a mean-variance utility maximisation framework.

subject to:

$$\begin{gathered} C_1 = (1 + \bar{r}_d)(A - C_0) + wL + \Pi_b + \Pi_g + T \\ \bar{r}_d \equiv q_d r_b + (1 - q_d) r_g \end{gathered} \qquad (2)$$

where β is the discount factor, $1/\theta$ is the elasticity of intertemporal substitution, λ_d is a positive weight associated to the disutility term, $1/\varphi$ represents the elasticity of the brown share with respect to the excess return of brown bonds. In stating the constraints listed in (2), it is assumed that in period 0 households consume a fraction of the initial wealth and the remaining part is invested in the brown and green industry with shares equal to q_d and $1 - q_d$, respectively.[6] The interest rate households earn ($\bar{r}_d$) is a weighted average of the returns (r_b, r_g) of corporate bonds issued by firms in the brown and green industry, respectively. L is the total supply of labour and w is the wage (assumed to be equal in both sectors). Π_j are the profits of firms in industry $j \in \{b, g\}$,[7] while T represents a government transfer equal to the revenues of the inflow capital tax (see below). From the constrained maximisation of expression (1), it is possible to derive the following optimality conditions:

$$\begin{gathered} \beta(C_1/C_0)^{-\theta}(1 + \bar{r}_d) = 1 \\ \beta\left(C_1^d\right)^{-\theta}\left(r_b - r_g\right)(A - C_0) = \lambda_d {q_d}^{\varphi} \end{gathered} \qquad (3)$$

The first condition in (3) is the Euler equation that relates the optimal level of consumptions in the two periods, while the other represents the equality between marginal benefits and marginal costs of investing in the carbon-intensive industry. In order to have a meaningful problem and avoid trivial solutions, as long as $\lambda_d > 0$, the carbon intensive-industry must pay in equilibrium higher returns $\left(r_b > r_g\right)$,[8] compensating for the environmental disutility it implies.

Foreign investors supply capital to the carbon-intensive and green industry too. Following Gabaix and Maggiori (2015) and Basu *et al.* (2020), they are risk-neutral financial intermediaries who borrow from the rest of the world P units in foreign currency (or take a position equal to $-P$ in foreign bonds) and lend to the two industries P/e_0 in domestic unit (or take a position P/e_0 in domestic currency bonds), where e_0 is the exchange rate in period 0.[9] Foreign investors chose P and the share invested in the brown sector q_f maximising the expected profits (expressed in foreign currency) from such financial transactions minus a disutility term related to brown bond holdings, which captures their environmental concerns or the size of the green finance compared to the traditional one:

[6] As in Basu *et al.* (2020), we assume that domestic households can only trade domestic bonds, while international financial intermediaries can trade both domestic and foreign assets (see below). This simplifying assumption is consistent with the empirical evidence on home bias in financial choices in emerging countries (see Coeurdacier and Rey, 2013, for a recent review).
[7] Given the perfectly competitive market hypothesis, profits are null in equilibrium.
[8] This inequality is consistent with the empirical evidence that finds an excess return for brown bonds in comparison to comparable green assets: e.g., Ehlers and Packer (2017), Baker *et al.* (2018), Gianfrate and Peri (2019) and Zerbib (2019) find that the yield of a green bond is lower than that of a conventional bond after conditioning on common characteristics (such as rating, sector, maturity). In particular, the authors of these papers explain the lower return of green bonds with the relevance of market pro-environmental preferences.
[9] The exchange rate is defined so that an increase of its value denotes an appreciation of the domestic currency.

$$V(P, q_f) = \beta \mathbb{E}_0 \left[(1 + \bar{r}_f) \frac{e_1}{e_0} - (1 + r^*) \right] P - H(P) - \lambda_f \frac{{q_f}^{\varphi+1}}{\varphi + 1} \quad (4)$$

In expression (4), r^* represents the foreign exogenous interest rate, while $H(P)$ is a convex cost function which limits the amounts borrowed by financial investors. This borrowing cost is in line with the credit constraint and the financial frictions introduced in Gabaix and Maggiori (2015) and Basu *et al.* (2020). Following these works, a quadratic cost function is specified:

$$H(P) = \delta + \frac{\omega}{2} P^2 \quad (5)$$

With the aim of reducing the negative externality of the carbon-intensive production and redirecting capital inflows to green activities, the government of the emerging economy imposes capital controls through a tax τ on foreign lending to the brown industry – more precisely a tax τ on the yield paid by brown bonds. Accordingly, the rate of return of foreign investor becomes:

$$\bar{r}_f \equiv q_f (1 - \tau) r_b + (1 - q_f) r_g \quad (6)$$

The revenues from the inflow tax are rebated to domestic households. The value of this transfer is equal to $T = \tau r_b q_f P / e_0$. The maximisation of (4) with respect to P and q_f yields the following optimality conditions:

$$\begin{aligned} P &= \frac{\beta}{\omega} \left[(1 + \bar{r}_f) \frac{\mathbb{E}_0 e_1}{e_0} - (1 + r^*) \right] \\ \beta P \left[(1 - \tau) r_b - r_g \right] &\frac{\mathbb{E}_0 e_1}{e_0} - \lambda_f {q_f}^{\varphi} = 0 \end{aligned} \quad (7)$$

In period 1, the goods produced by the small open economy that are not consumed by domestic households are traded to the rest of the world. Given that, by assumption, there is only one traded good and free international trade, the purchasing power parity (PPP) must hold in period 1, i.e. $e_1 = 1$.[10] Rational foreign investors anticipate this and set their expectations consequently ($\mathbb{E}_0 e_1 = 1$). The current exchange rate e_0 is endogenously determined in the model by assuming perfectly competitive markets for foreign intermediation. This assumption implies the following zero-profit condition:[11]

$$V(P(e_0), q_f(e_0)) = 0 \quad (8)$$

in which $P(e_0)$ and $q_f(e_0)$ are the solutions of equations (7). In facts, if profits were positive, new financial intermediaries would enter into the market selling foreign bonds and buying assets in domestic currency. This would appreciate the current exchange rate e_0 until to the point that such transactions were no more profitable. It is interesting to notice that in the absence of fixed and variable costs ($\delta = \omega = 0$) and environmental concerns ($\lambda_f = 0$), the no-arbitrage condition (8) implies the standard uncovered interest parity (UIP) condition: $1 + r^* = (1 + \bar{r}_f) \mathbb{E}_0 \, e_1 / e_0$.

[10] As in standard RBC models (e.g., Blankenau *et al.*, 2001), it is implicitly assumed that the domestic and foreign price of the traded good are equal to one. Therefore, the nominal exchange rate coincides with the real one.

[11] The determination of current and future exchange rates discussed here is in line with the portfolio model of Blanchard *et al.* (2016, 2017).

With regards to production, industry $j \in \{b, g\}$ combines capital and labour according to a constant returns to scale technology $F_j(K_j, L_j) = \phi_j K_j{}^{\alpha} L_j{}^{1-\alpha}$. It is assumed that, inputs being equal, the carbon-intensive technology is more productive in comparison to the green one, i.e., $\phi_b > \phi_g$, since it is subject to a less stringent regulatory framework[12] or because it exhibits more efficient production processes compared to the younger green industry. However, it exerts a negative environmental externality leading to a reduction of output equal to D in both sectors: the output produced by industry j is therefore $Y_j = (1 - D)F_j(K_j, L_j)$. Since the two industries produce the same homogeneous good, the green and brown technologies are perfect substitutes, as in Acemoglu *et al.* (2012). These assumptions imply a trade-off between a clean but less productive technology and a more productive one that has the inconvenient of generating a damage on the overall economy. Consequently, domestic households and foreign financial intermediaries will choose the optimal capital allocation in the two industries balancing their appetite for higher returns and their pro-environmental preferences. Given these assumptions, the profits of a representative firm in industry j are:

$$\Pi_j(K_j, L_j) = \phi_j(1 - D)K_j{}^{\alpha} L_j{}^{1-\alpha} - r_j K_j - wL_j \quad (9)$$

in which r_j is the rental cost of capital j (or, equivalently, the return of corporate bonds[13] issued by firms in the j-th industry) and w is the wage of workers which is equal in both sectors. The maximisation of (9) with respect to capital K_j and domestic labour L_j yields the following optimality conditions:

$$\begin{gathered} \alpha\phi_j(1 - D)K_j{}^{\alpha-1} L_j{}^{1-\alpha} = r_j \\ (1 - \alpha)\phi_j(1 - D)K_j{}^{\alpha} L_j{}^{-\alpha} = w \end{gathered} \quad (10)$$

with $L_b + L_g = L$, where L is the total labour force. It is important to stress that firms maximise profits choosing the optimal levels of capital and labour and taking as given the prices of productive inputs. Moreover, brown firms neglect their impact on the climate-related damage D, thus generating the environmental externality. In fact, it is reasonable to assume that climate-related damages depend on the aggregate behaviour of the carbon-intensive industry and the mass of each single firm belonging to the brown sector can be considered small enough that its impact on climate is negligible. In equilibrium, the value of the damage is proportional to the absolute size of the carbon-intensive sector in the whole economy in terms of inputs used during the production activity:

$$D = G(\gamma_0 + \gamma_1 K_b{}^{\alpha} L_b{}^{1-\alpha}) \quad (11)$$

where $G(.) = \exp(.)/[1 + \exp(.)]$ is the logistic transformation that constraints the damage to be between zero and one. Regarding the parameters of the function, γ_0 can be interpreted as the damage that depends on past CO2 emissions and pollution, which is unavoidable even allocating all inputs to the

12 In fact, according to the traditional economic view, environmental compliance generally forces firms to devote some part of inputs to pollution prevention and abatement, which are not considered as value added, or to curb production (Jaffe *et al.*, 1995; Ambec *et al.*, 2013). See also Kozluk and Zipperer (2015), for a review of the evidence on the relationship between environmental policy and productivity.

13 The analysis can be easily extended to equity in the form of portfolio investments. More caution should be paid to extend the results of the analysis to foreign direct investments because such capital flows could follow different strategies (e.g. the setting up of a foreign controlled entity for tax elusion purposes) and tend to be more stable over time.

green industry, while γ_1 measures the sensitivity of the damage to the absolute size of the brown sector. The idea behind specification (11) is that a higher equilibrium value of inputs supplied to the carbon-intensive production should lead to a greater concentration of CO2 emissions and pollution in the country. The increase of CO2 emissions and pollution implies a higher likelihood of climate-related damages and a reduction of the TFP, as in standard theoretical studies on the impacts of climate change (Nordhaus 1991, 1994; Frankhauser and Tol, 2005; Dietz and Stern, 2015).[14] It is important to stress that D captures only the environmental externality that is directly due to the production in the small-open economy (e.g., water pollution in the country attributable to the industrial discharges of resident firms) and that allows greater room for policy intervention.

Markets clear when the demand of capital from domestic firms equates the supplies of funds from domestic households and foreign investors:

$$\begin{aligned} K_b &= q_d(A - C_0) + q_f \frac{P}{e_0} \\ K_g &= (1 - q_d)(A - C_0) + (1 - q_f)\frac{P}{e_0} \end{aligned} \tag{12}$$

The equilibrium of the model can be found by solving numerically the system of nonlinear equations represented by the first order conditions of domestic (3) and foreign (7) investors, those of firms in the carbon-intensive and green industry (10), together with the market clearing conditions (12) and the equilibrium values of the climate-related damage (11) and the exchange rate (8). These conditions mechanically guarantee that the goods exported to the rest of the world (X) in period 1 are exactly equal to the returns paid by domestic firms to foreign lenders: $X \equiv A + Y_b + Y_g - C_0 - C_1 = \bar{r}_f P/e_0$. It is important to stress that the solution of the model can be interpreted as a long-run stationary equilibrium rather than the adjustment path toward such equilibrium, in which capital controls might have heterogeneous effects on the different generations involved in the transition.

From the first order conditions of domestic and foreign investors – in particular, the second equation in (3) and (7) - it is possible to observe that the parameters λ_d and λ_f determine the trade-off between the investment in the brown sector, which pays a higher return, and the moral cost of this investment, captured by the penalty term in the objective function. The presence of the disutility term associated to brown asset holdings, borrowed from Baker *et al.* (2018) and Pastor *et al.* (2020), allows to incorporate environmental concerns in the utility maximisation of domestic households and foreign intermediaries. This explains why, as long as λ_d and λ_f are both greater than zero, domestic and foreign investors decide to hold a positive share in green assets even though green bonds pay lower returns. This is consistent with the recent findings of the empirical financial literature showing that financial investors have pro-environmental preferences and these non-pecuniary motives explain the lower returns of green bonds compared to those of conventional assets (Ehlers and Packer, 2017; Baker *et al.*, 2018; Gianfrate and Peri, 2019; Zerbib, 2019). The specification of the disutility term associated to brown investments in the objective function is also the reason why no technology is strictly preferred in equilibrium even if the brown industry produces the same homogeneous good with a higher productivity. On the other hand, if

[14] Most of the studies on the economic impact of climate change assumes a damage function that affects the TFP or the accumulation of capital in the economy. One of the few exceptions is represented by the paper of Agemoglu *et al.* (2012), who incorporate the environmental externality directly into the utility function assuming that households derive utility from both consumption and the quality of the environment.

λ_d is equal to zero, domestic households have no incentive to invest capital in the green industry and q_d is equal to one. The same happens to foreign financial intermediaries ($q_f = 1$), provided that the inflows tax is sufficiently low, i.e., such that $(1-\tau)r_b > r_g$. Conversely, for values of the inflow tax higher enough to reverse the sign of the inequality, i.e., such that $(1-\tau)r_b < r_g$, the foreign investment in the brown sector is no more profitable ($q_f = 0$). To sum up, an interior solution exists for the share invested in the brown and green sector by domestic households ($0 < q_d < 1$) if and only if (a) $r_b > r_g$[15] and (b) $\lambda_d > 0$. Considering foreign intermediaries, an interior solution exists ($0 < q_f < 1$) if and only if (a') $(1-\tau)r_b > r_g$ and (b') $\lambda_f > 0$. Only a corner solution, in which domestic and foreign investors allocate capital uniquely to one sector, is possible, otherwise.[16]

In the calibration of the model, it is assumed that domestic households have stronger pro-environmental preferences than financial intermediaries, since it is reasonable that they care more about the environment in which they live than foreign investors. This is captured in the model by a higher weight given to environmental concerns ($\lambda_d > \lambda_f$) and by the specification of concave preferences in consumption for domestic households, while risk-neutral financial intermediaries exhibit a linear dependence on asset returns.[17] The lower environmental concerns of foreign intermediaries justify the adoption of capital controls, instead of a simple carbon tax, irrespective of the origin of the investor (more on this in Section 6.1).

3. Calibration

In the present paper the impact of capital controls is assessed by analysing the behaviour of the main variables of the model when the value of τ changes from zero (*laissez faire* with no capital control) to an increasingly larger positive value. The other parameters of the model are kept fixed at the values listed in Table 1.

The parameters related to domestic households and foreign investors' intertemporal preferences assume the values chosen in standard macroeconomic models. More precisely, in the macroeconomic literature the discount factor β is inside the (0.97, 0.99) interval, while the value for the inverse of the intertemporal substitution coefficient θ varies between 1 (log-utility) and 2. In our specification, an intermediate value is chosen for both parameters as in Mendoza (1991), Blankenau *et al.* (2001) and Meenagh *et al.* (2010): in particular, β assumes a value equal to 0.98 and θ is equal to 1.8. Following these works, a value of 0.33 is assigned to the remuneration of capital α and an annualised return of 1% to the foreign interest rate

[15] This condition is superfluous in reasonable model calibrations because it is likely to be satisfied given the assumption of a higher productivity in the carbon-intensive sector ($\phi_b > \phi_g$).

[16] Here, for the sake of the argument, it is assumed that short-selling is not allowed. However, in the model simulations described in the next sections, we allow for negative values of the invested shares, even though negative realisations can happen only for q_f and they occur in correspondence to extreme inflow tax rates such that $(1-\tau)r_b < r_g$.

[17] The assumption that domestic households have stronger pro-environmental preferences than foreign intermediaries is not obvious. In fact, against this hypothesis, it could be argue that residents in emerging markets and developing countries are poorer than residents in advanced economies and, consequently, the former could care more about investment returns (or could discount future earnings more heavily) than the latter. However, the recent but rapid development in EMEs of green assets that pay lower returns should confirm the growing importance of environmental motives in those countries.

r^*. The productivity parameters ϕ_c and ϕ_g are calibrated in order to obtain an average rate of return for domestic households ($\bar{r}_d$) and foreign investors ($\bar{r}_f$) between 3 and 8 percentage points, as in standard macroeconomic models. The initial endowment of domestic households and the total labour force in the domestic economy are both normalised to 1. The fixed and variable costs of foreign intermediaries (δ, ω) are selected in order to simulate capital inflows (P) with a size 20-30 per cent higher than the amount of savings ($A - C_0$) of the small open economy.

Table 1: Calibrated values of model parameters.

Parameter	Value	Parameter	Value
Domestic households		*Foreign investors*	
θ	1.80	β	0.98
β	0.98	λ_f	0.03
φ	1.00	ω	0.50
λ_d	0.08	δ	0.05
A	1.00		
L	1.00	*Climate-related Damage*	
		γ_0	-4.00
Firms		γ_1	3.00
α	0.33		
ϕ_b	0.20	*Foreign interest rate*	
ϕ_g	0.15	r^*	0.01

Regarding the parameters of the damage function, γ_0 is calibrated in order to have an unavoidable income loss of 2 percentage points that is consistent with the current estimates of the climate change literature (Tol, 2018). Since developing countries are particularly vulnerable to the extremes of climatic variability, climate change is likely to increase the frequency and magnitude of some extreme weather events and disasters (Mirza, 2003). Accordingly, the value for γ_1 is selected in order to have, without any policy intervention ($\tau = 0$), an extreme and largely disruptive weather event D close to 14 percent. This size is comparable to the estimated changes in welfare-equivalent income in developing countries for a likely 2.5°C (relative to preindustrial times) global warming scenario, as shown in Tol (2018). Such a significant level of the climate-related damage is also useful to better highlight the trade-off implied by the model in terms of the choice between the higher productivity of the carbon-intensive technology and the larger negative externality this technology implies.

Finally, echoing the specification of labour disutility in standard macroeconomic models, a quadratic penalty function ($\varphi = 1$) is specified for non-green asset holdings: this assumption implies that the elasticity of the brown share with respect to the excess return of brown bonds is equal to one. The weights associated to the disutility of the brown investment (λ_d, λ_f) determine the share of assets allocated to the green industry by domestic and foreign investors, respectively: this means that, if investors display stronger pro-environmental concerns, then the share of green asset holdings is higher in equilibrium. The two parameters are chosen in order to make the marginal disutility comparable to the marginal benefits, in terms of higher returns ($r_b - r_g$), of the brown industry: this implies that the range of variation for the environmental preferences (λ_d, λ_f) is roughly 0 - 0.15 to be compatible with the size of the other variables of the model involved in equations (3) and (7). Moreover, it is assumed that domestic households have stronger pro-environmental preferences than foreign investors ($\lambda_d > \lambda_f$) since it is reasonable that they care more about the environment of the country in which they live than foreign investors and because emerging markets and developing countries are more exposed to the risks of climate change. Accordingly, in the main calibration, the value of λ_f ($\lambda_f = 0.03$) is selected such that the equilibrium share (q_f) invested in the brown industry by foreign intermediaries, in the absence of any inflow tax, is close to 80 per cent. Analogously, the value of λ_d ($\lambda_d = 0.08$) is chosen in order to have a lower domestic asset share (q_d) allocated to the carbon-intensive production - i.e., close to 60 per cent - than the foreign one, but still higher than the domestic share in green activities. These calibrated values for (λ_d, λ_f) guarantee that the production of the green sector is much smaller than the one of brown firms in the absence of any policy intervention.

These parameter values represent our preferred calibration of the model. However, the sensitivity of the analysis with respect to the more original parameters of our model ($\lambda_d, \lambda_f, \gamma_0, \gamma_1$) is analysed in Section 5.

4. Results

The assessment of the effect of capital controls on the main variables of the model is performed through a comparative statics analysis, whereby we compare the equilibrium reached by the economy at different values of the tax rate τ. Fig. 1-2 illustrate the behaviour of the model when τ ranges from 0, the case in which capital controls are not in place, to an increasingly positive value.

Capital controls affect negatively the marginal benefits of the foreign investment in the small open economy, reducing the returns from the capital supplied to the carbon-intensive industry. This produces two effects. On the one hand, the reduction of profitability lowers the whole amount invested in the small open economy by foreign investors (P), with the consequence of a depreciation of the exchange rate e_0. On the other, foreign intermediaries alter their portfolio composition towards the green assets, reducing the equilibrium share invested in the brown industry (q_f). This results in a higher rental cost of capital r_b for the carbon-intensive industry. The increase of r_b represents an incentive for domestic households to invest in the brown asset, given that they are not subject to the inflow tax. However, the rise of q_d is not sufficient to offset the reduction of capital flows from foreign investors, who are heavily affected by the inflow tax, and the capital supplied to the brown sector (K_b) is overall reduced. With regard to the labour market, the higher funding costs of the brown industry, due to the increase of inflow tax, induce firms in the carbon-intensive sector to lower their demand of labour (L_b).[18]

Thus, capital controls are effective in re-directing capital flows and labour force from carbon-intensive to green activities, lowering the production of brown firms Y_b and increasing the output of the green industry Y_g (see Fig. 2). The rebalancing of productive inputs in favour of more environmentally sustainable projects induces a lower value of the climate-related damage D and, consequently, a higher total factor productivity in both sectors and an increase in the overall output produced $Y \equiv Y_b + Y_g$.

[18] A tax on domestic lending to the brown sector will imply the opposite result: domestic households, directly affected by this policy, will reduce the share invested in carbon-intensive firms. The higher rate of return paid by brown firms will induce foreign intermediaries to increase both the overall amount invested in the small open economy and their share in brown activities. The increase in capital inflows will lead to an appreciation of the exchange rate.

This can be considered the expansionary effect of such differentiated capital controls. As a result of the reduction of the negative externality, green firms tend to hire a greater number of workers and demand more capital, with the consequence of increasing both the wage w and the rate of return of the green assets r_g.

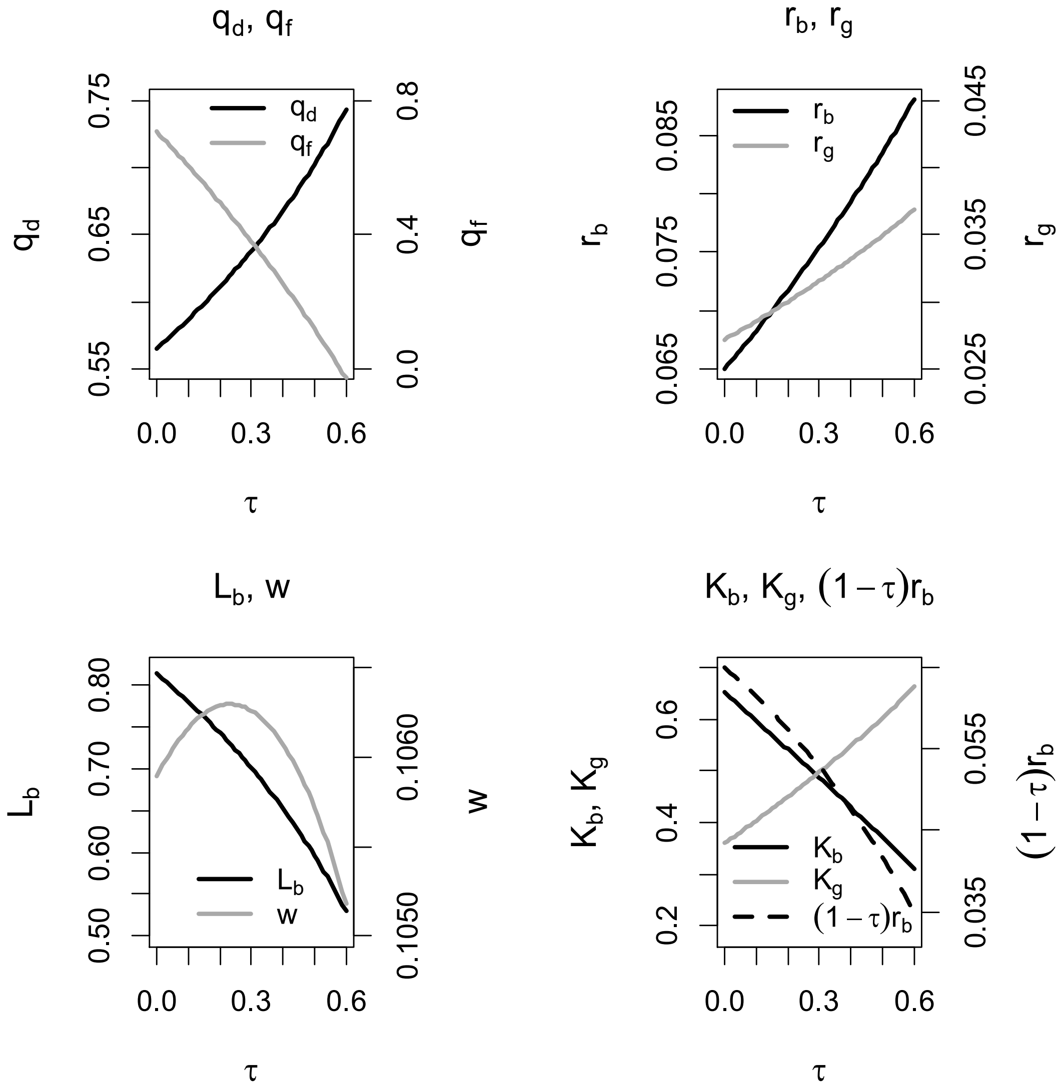

Fig. 1: Effects of capital controls on investment and working choices of domestic households and foreign investors. Resulting equilibrium rates of return and wages.

However, there is also a contractionary effect: whenever τ increases, the share of capital allocated to the more productive industry, the carbon-intensive one, is reduced and the overall production declines if τ exceeds a certain threshold. Therefore, the total output Y is maximised at an intermediate value of the inflow tax ($\tau \approx 20$ percent in our calibration). As we will see in the next section, given the presence of both expansionary and contractionary effects, policymakers face a trade-off in setting the optimal tax rate that maximises production and welfare.

Similarly, domestic households experience higher levels of wealth when the inflow tax increases up to a certain level, since they benefit from a greater transfer T rebated to them by the government and by higher wages in the two sectors. As long as the rise of τ does not exceed that threshold ($\tau \approx 30$ percent in our calibration), domestic households feel richer and this induce them to increase consumption in both periods (C_0 and C_1). On the contrary, for higher values of the tax rate, the reduction of foreign capital supplied to the brown industry more than compensates the increase of the inflow tax (T is reduced). Moreover, the productivity gains obtained through the reduction of the climate-related damage are overcome by the lower production in the more productive carbon-intensive sector. As a result, both the government transfers and wages are reduced. Therefore, when τ assumes an excessively high value, households' wealth decreases and savings start to increase. This explains the reason why the future consumption levels C_1 increase while the current expenditures C_0 are reduced.

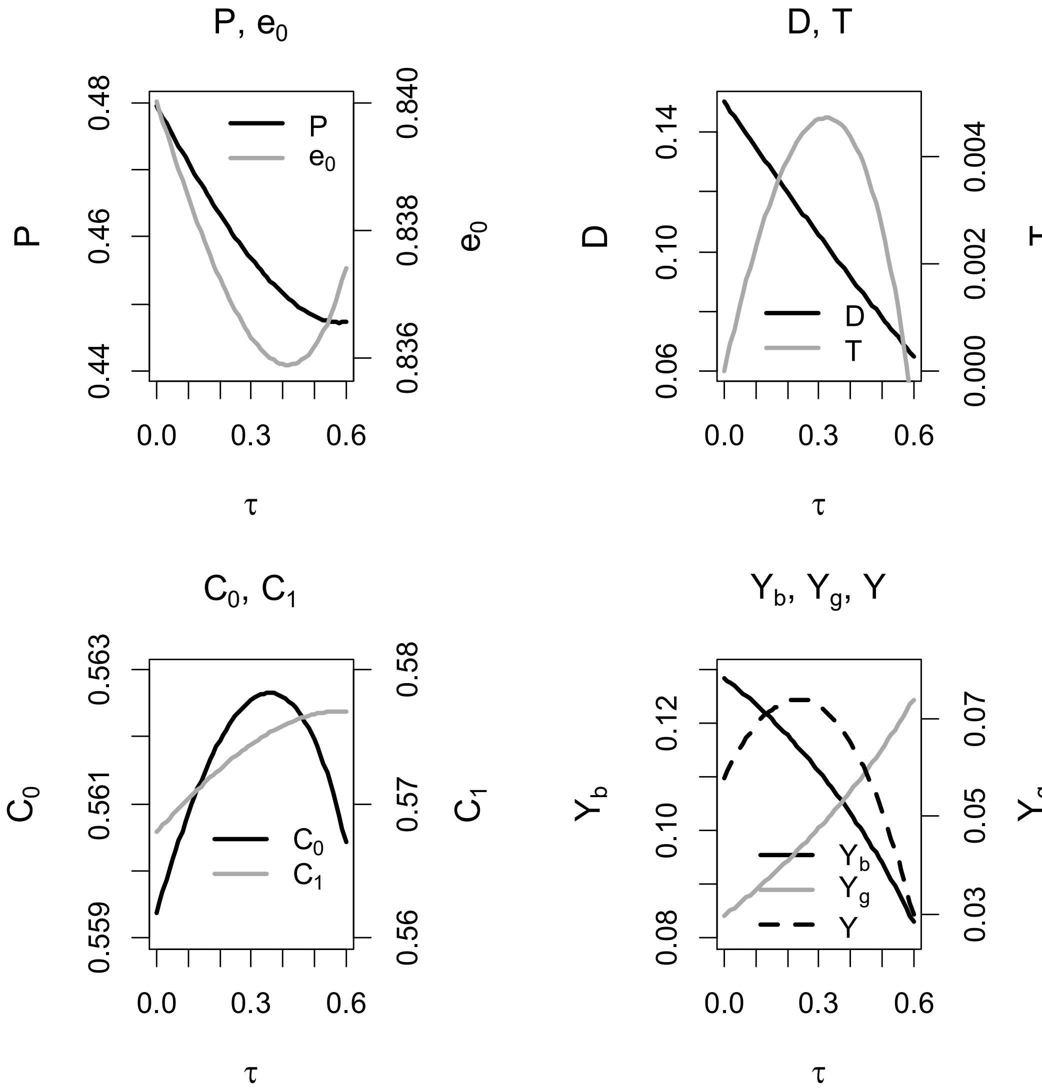

Fig. 2: Effects of capital controls on climate-related damage, production, consumption, foreign capital inflows and exchange rate. *Notes:* variable Y is rescaled in the bottom-right figure for comparability purposes with the Y_b and Y_c curves. The actual values of Y are reported in Fig. 3.

Regarding foreign investors, the reduction of their income expressed in domestic currency, due to the lower rate of return $\bar{r}_f$ (the weighted average of r_b and r_g with weights q_f and $1 - q_f$, respectively), is largely compensated by the depreciation of the exchange rate e_0, which diminishes in order to guarantee that the zero-profit condition (8) holds in equilibrium.

5. Welfare analysis and optimal controls

The literature on capital controls has focused its attention on the benefits of countercyclical capital controls as a stabilisation measure with respect to the boom and bust cycles of international capital flows (Jeanne and Korinek, 2010; Korinek, 2011; Erten *et al.*, 2019). The welfare-improving properties of capital controls rely on the fact that inflow taxes induce domestic agents to internalise the cost associated to excessive borrowing.

In the framework proposed in this paper, the sub-optimality of the *laissez faire* equilibrium is due to the negative externality caused by the carbon-intensive industry, which does not internalise the environmental consequences of its production, captured by the damage function, on the rest of the economy. Since the small open economy relies on foreign lending, an inflow tax on the capital supplied to the brown sector has the effect of increasing in equilibrium the marginal costs of carbon-intensive firms, discouraging their production. As noted in the previous section, the domestic economy benefits from the lower production in the carbon-intensive sector because the climate-related damage is reduced. However, excessively restrictive capital controls have a contractionary effect since they strongly inhibit production in the traditional brown industry, which is the most productive one, thus reducing consumption and welfare. The optimal capital controls should balance the two opposite effects. More formally, the government chooses the inflow tax that maximises the equilibrium level of well-being of domestic households:

$$\tau_U = \underset{\tau}{\operatorname{argmax}}(U) \qquad (13)$$

Fig. 3 illustrates the optimal choice of the inflow tax for our calibrated parameter values. Under our reasonable calibration exercise, the optimal inflow tax is equal to about 40 per cent. Since current and future domestic consumption have a hump-shaped profile (see Fig. 2), the utility of domestic households has an analogous curvature. The presence of environmental preferences, captured by the disutility term, slightly shifts the maximum level of well-being on the left with respect to the peak of the utility derived from consumption. It is interesting to notice that the welfare-maximising inflow tax τ_U is higher than the tax rate that maximises the total output, defined as:

$$\tau_Y = \underset{\tau}{\operatorname{argmax}}(Y) \qquad (14)$$

In fact, when $\tau = \tau_U$ the utility from consumption is higher because domestic households have both direct and indirect benefits from more stringent capital controls. Firstly, they are positively affected though the direct subsidy T. Secondly, they benefit indirectly from the increase of returns in the brown sector induced by the reduction of the foreign capital supplied to the carbon-intensive sector when the inflow tax is increased. Both motives explain why the small open economy has the incentive to increase the tax rate above the output-maximising level in order to optimise the welfare of domestic households.

In order to analyse how these policy implications are affected by different choices of the more original parameters introduced in this paper, Fig. 4 shows the dependence of the welfare-maximising (τ_U) and output-maximising (τ_Y) inflow tax on the environmental preferences of domestic and foreign investors (λ_d, λ_f) and on the damage parameters (γ_0, γ_1). Moreover, the results presented in the figure are useful to understand the effectiveness of capital controls in different scenarios.

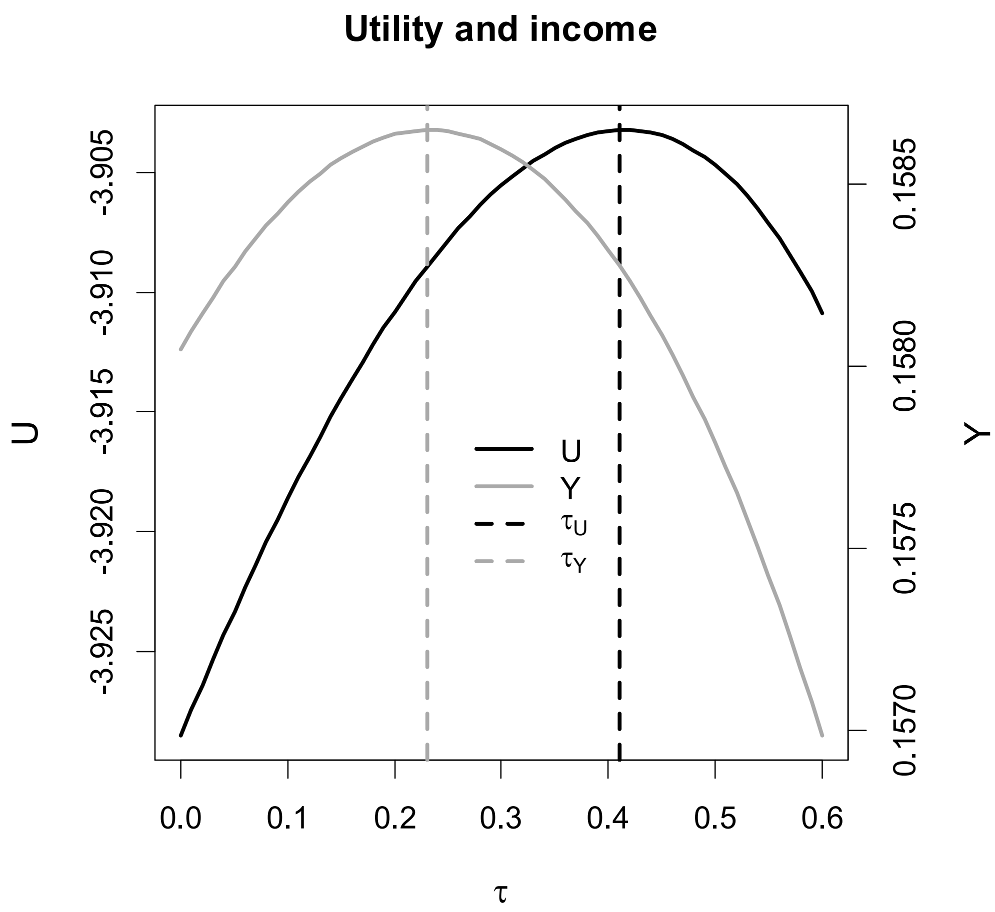

Fig. 3: Effects of capital controls on the welfare of domestic households. Comparison between the welfare-maximising value of τ and the value of τ that maximises production.

It is possible to observe that the output and welfare-maximising inflow taxes are a decreasing function of the environmental preferences of domestic households, as well as of foreign intermediaries. This means that, when λ_d and λ_f assume a higher value, the expansionary effect of the inflow tax is weaker because domestic and foreign investors with strong pro-environmental preferences already supply a considerable amount of capital to the green sector, lowering the damage function, even in the absence of any policy intervention. On the other hand, both the output and welfare-maximising inflow taxes are an increasing function of the severity of the climate-related damage, captured by a higher value of $\gamma_0$or γ_1. In fact, the expansionary effect of capital controls on production and, consequently, on utility are particularly strong if the economy faces potentially larger climate-related damages because in those scenarios discouraging investments in the brown sector is particularly valuable.

Moreover, the sensitivity analysis discussed in this section shows that the optimal inflow tax seems to be much more sensible to variations in the climate-related damage than to changes in environmental preferences. In fact, as environmental preferences vary, the optimal taxation lies in the range 39 - 44 per cent, while it is more sensitive to variations in the environmental externality, assuming values from 30 to 60 per cent. Therefore, looking at implementation concerns, the determination of the optimal inflow tax rate is intrinsically linked to the uncertainty of the forecasts on future environmental damages.

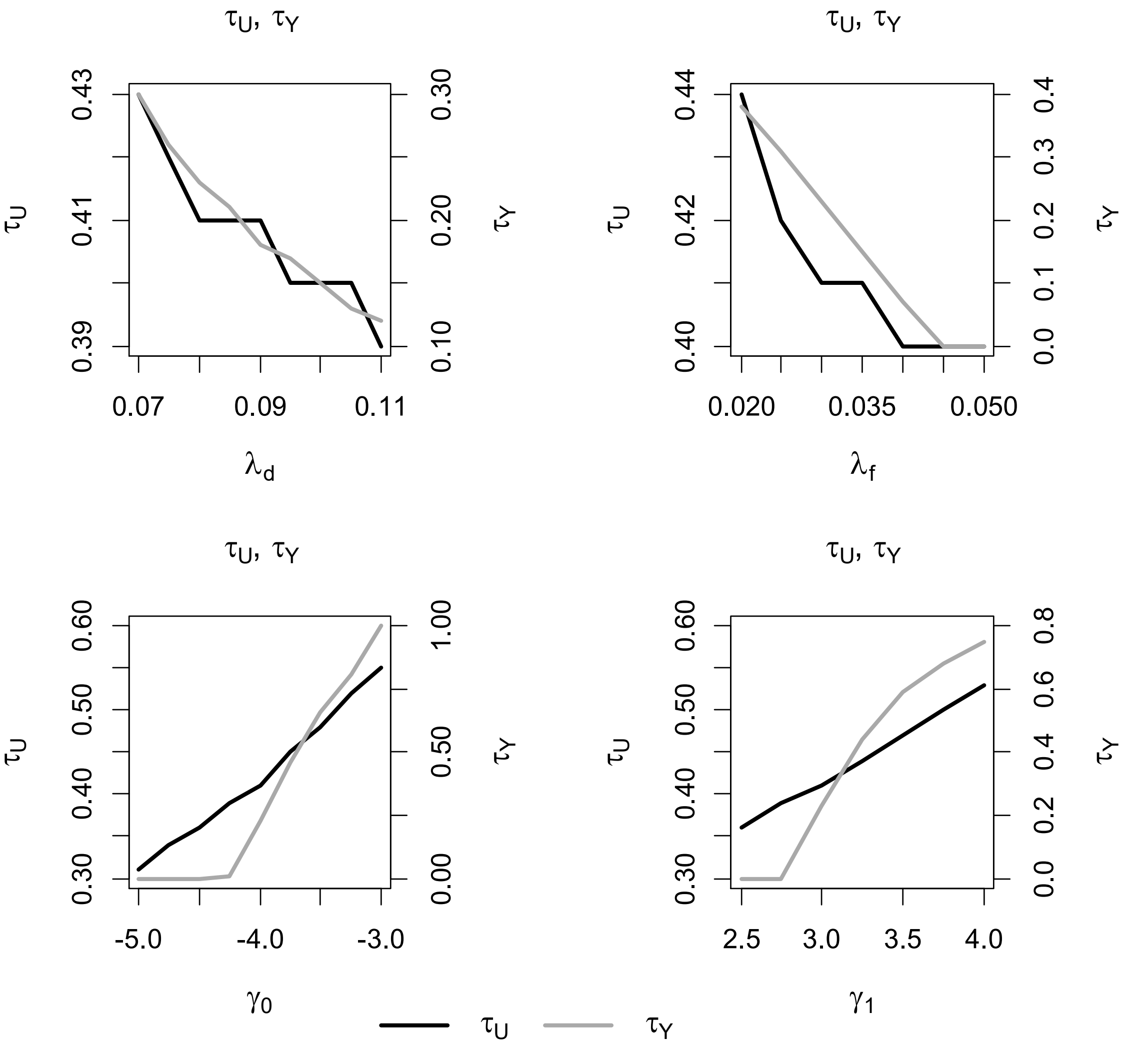

Fig. 4: Effects of environmental preferences of domestic households and foreign investors and climate-related damage severity on the optimal choice of the inflow tax. Comparison between the welfare-maximising value of τ and the value of τ that maximises production.

6. Model extensions

6.1 Taxation on domestic and foreign investments

In order to understand the advantages of capital controls on foreign investments in brown activities, instead of an equal carbon tax for domestic and foreign investors, it is interesting to discuss a more general case in which the small open economy imposes a tax on foreign (τ_f) as well as on domestic (τ_d) lending to the carbon-intensive sector. The returns from the two investments and revenues from the tax become:

$$\begin{aligned}\bar{r}_f &\equiv q_f(1-\tau_f)r_b + (1-q_f)r_g \\ \bar{r}_d &\equiv q_d(1-\tau_d)r_b + (1-q_d)r_g \\ T &= \tau_f r_b q_f P/e_0 + \tau_d r_b q_d (A - C_0)\end{aligned} \quad (15)$$

This more general setting includes a simple carbon tax applied to investments in the brown industry, irrespective of the origin of investors ($\tau_f = \tau_d$), as well as the differentiated capital controls applied to foreign investments (without a domestic carbon tax) discussed in the previous sections of the paper ($\tau_f > 0, \tau_d = 0$).

In order to identify the values of the two tax rates that maximise the welfare of the small open economy, Fig. 5 plots the utility of domestic households as a function of the two taxes. From the figure, it is possible to observe that the welfare-maximising pair (τ_f, τ_d) is such that τ_d is close to 20 per cent, while τ_f is much greater, around 40 per cent. Conversely, the best carbon tax, obtained when $\tau_f = \tau_d = 34\%$, is suboptimal because it allows to reach a lower level of utility.

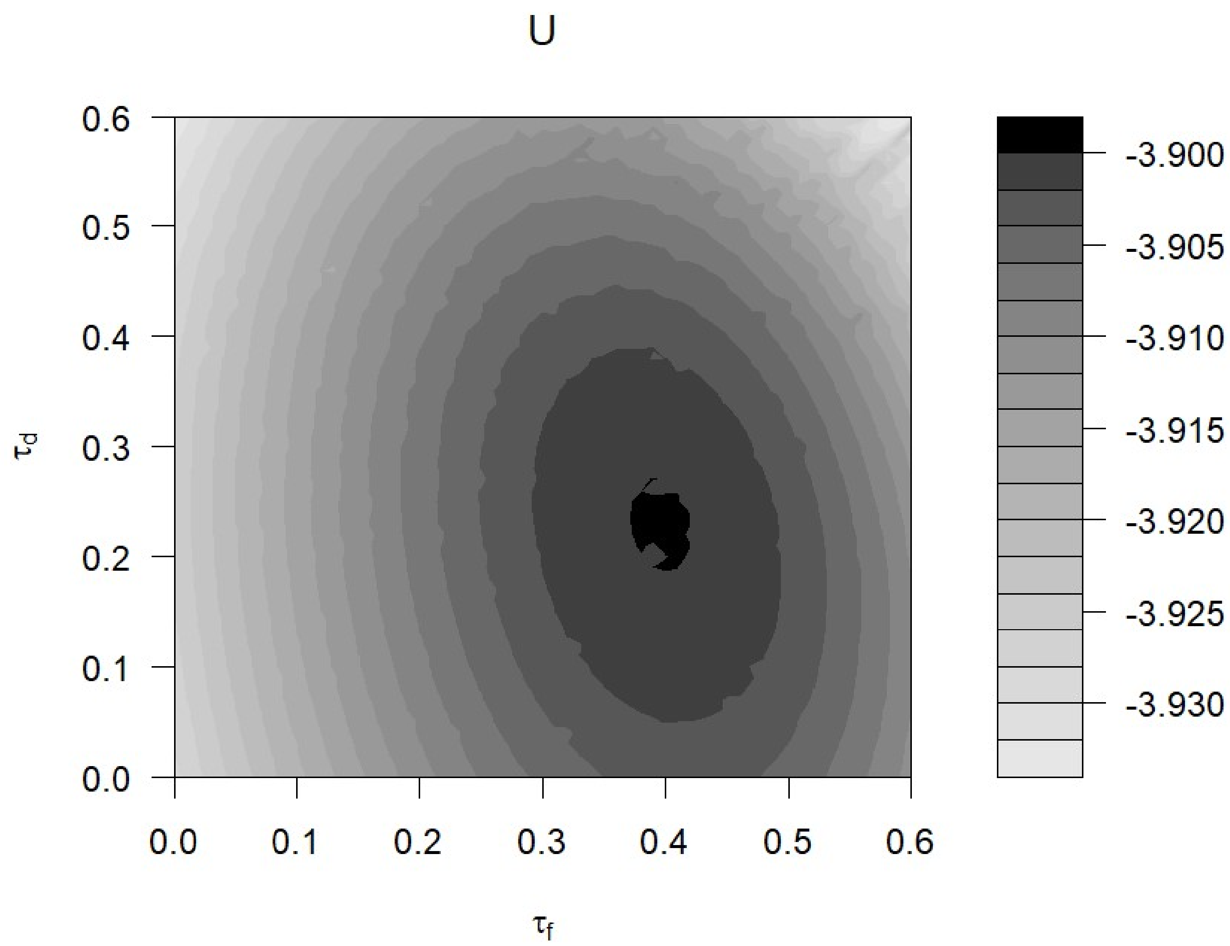

Fig. 5: Welfare implications of a differentiated tax on foreign (τ_f) and domestic (τ_d) investments in the carbon-intensive sector.

The sub-optimality of a non-discriminatory carbon tax with respect to a higher taxation on foreign investors is due to two model assumptions. (a) Domestic investors have stronger pro-environmental preferences than foreign intermediaries ($\lambda_d > \lambda_f$) and their preferences are concave in investment returns (while those of foreign intermediaries are linear in investment returns). (b) Foreign inflows (P) are assumed to be higher than the amount of savings ($A - C_0$) from domestic households. According to these assumptions, the tax on foreign investments should be set in order to counterbalance the attitude of foreign intermediaries to invest in the industry that pays higher returns, i.e., the brown sector. Moreover, since foreign investments overcome quantitatively domestic savings, capital controls are particularly effective to redirect significant amount of funds to green activities. These considerations explain the reason why the optimal tax rate on domestic households should be much lower than that on international investors. The main specification discussed throughout the paper, in which taxation is applied only to foreign investments, can be interpreted instead as a useful simplification capable of capturing, at least qualitatively, some more general features and implications.

However, it is important to stress that there are also disadvantages related to the implementation of a tax uniquely on foreign investors (or a higher tax rate for them), which are not incorporated in the model. In fact, taxing foreign movements of capital - or with a higher rate than that applied to similar investments by residents - might have undesirable side effects because it could be seen as a signal of an arbitrary and discriminatory taxation, discouraging foreign intermediaries from the investment in the country. This seems to be particularly true when capital controls are introduced by a single country in a unilateral way, provoking a flight of international capital flows to countries without capital controls. Moreover, there might be difficulties of implementation for this kind of differentiated taxation: e.g., the incentive for foreign investors to set up subsidiaries in the country just for elusive purposes. From this point of view, a systematic and non-discriminatory carbon tax might be better justifiable, especially from the perspective of an emerging economy.

6.2 *Risks for financial stability*

A tax on foreign investments in carbon-intensive firms implies that financial intermediaries channel a significant share of their funds away from brown firms and into green firms, causing potentially severe financial stability concerns. In order to address this issue, the basic model described in Section 2 is enriched incorporating default risks in the two sectors.

In particular, it is assumed that only a share π_j of firms in industry $j \in \{b, g\}$ survives in period 1 and uses capital and labour to produce the final output. Hence, only the fraction π_j of firms in each of the two sectors remunerates households and foreign intermediaries for the supplied productive inputs. The complementary share $1 - \pi_j$ exits the market and simply gives back the borrowed capital. The shares π_j can be interpreted as the probability of being solvent in the two industries and they are assumed to depend on the capital supplied by households and foreign intermediaries, according to the following expression:

$$\pi_j = G(\delta_0 + \delta_1 K_j) \quad (16)$$

where $G(.)$ is the logistic function and (δ_0, δ_1) are two parameters measuring the dependence of firms' solvency on the inflow of capital from domestic and foreign investors. Firm in both industries demand capital and labour in order to maximise the expected profits $\pi_j \Pi_j(K_j, L_j)$, taking as given the probability of being solvent π_j. In fact, solvency depends on the aggregate demand and supply of capital that each single firm is unlikely to alter.

Domestic households and foreign investors formulate in period 0 an expectation on the two probabilities of being solvent π_j^e in the next period. Given these expected shares, the budget constraint of domestic households becomes:

$$C_1 = (1+\tilde{r}_d)(A - C_0) + w\left(\pi_b^e L_b + \pi_g^e L_g\right) + \pi_b^e \Pi_b + \pi_g^e \Pi_g + \widetilde{T}$$
$$\tilde{r}_d \equiv q_d r_b \pi_b^e + (1-q_d) r_g \pi_g^e \qquad (17)$$
$$\widetilde{T} = \tau r_b \pi_b^e q_f P/e_0$$

It is important to stress that in this formulation of the problem domestic households weigh returns (as well as wages and profits) from the two industries with the respective probabilities of being solvent. Similarly, the rate of return earned by foreign intermediaries is:

$$\tilde{r}_f \equiv q_f(1-\tau) r_b \pi_b^e + (1-q_f) r_g \pi_g^e \quad (18)$$

The higher the expected firms' solvency in industry j is, the higher the expected returns from investment and the supply of capital to the corresponding firms by foreign and domestic investors are. In order to have expectations that are consistent with the model, the equilibrium inflows of capital to the two industries K_j^* must be such that:

$$\pi_j\left(K_j^*\right) = \pi_j^e \quad (19)$$

in which K_j^* is given by equations (12). It is important to stress that, by assumption, each single firm faces the risk of default while there is no uncertainty for households and financial intermediaries because, given equation (19), in equilibrium they know exactly the share of firms that default in the two sectors. This is a standard perfect foresight assumption.

The upper panel in Fig. 6 shows the equilibrium firms' solvency for the two industries in correspondence to different values of the inflow tax. Capital controls have the effect of reducing the amount of capital supplied by foreign intermediaries to brown firms. This reduction of inflows from abroad is not compensated by the increase of funds supplied by domestic households. Therefore, the inflow tax leads to a decline in solvency and to an increase of the likelihood of financial stability risks in the brown sector. Conversely, this policy instrument increases inflows to the green industry, with the result of improving its solvency. Looking at production and utility (lower panel of Fig. 6), it is possible to observe that output and utility are reduced compared to the baseline model (Fig. 3) because the default risk in the brown sector, increasingly financed by domestic investors, reduces the expected income of resident households. Moreover, both the output-maximising tax rate and the welfare-maximising one are significantly lower than those in the baseline model.[19] In fact, in this version of the model, capital controls affect the more productive carbon-intensive sector through two channels, i.e. discouraging foreign inflows and, as a side effect, reducing the solvency of the industry. Consequently, the tax rate that was optimal in the baseline specification of the model (without financial stability concerns) would depress excessively the production in the brown industry in this version of the model that considers default risks.

[19] The values chosen for the δ_0, δ_1 parameters ($\delta_0 = 1, \delta_1 = 5$) in (16) are such that firms' solvency in the two sectors are relatively high (above 90 per cent) in equilibrium. By reducing the equilibrium solvency, the optimal inflow tax would be even smaller.

There are other financial stability concerns related to the introduction of differentiated capital controls that are not explicitly considered in the model. One of these is the increasing exposure of the green sector to foreign funds, which might make it more prone to the flightiness of international capital flows as well as more vulnerable to the risk of sudden stops and capital reversals.

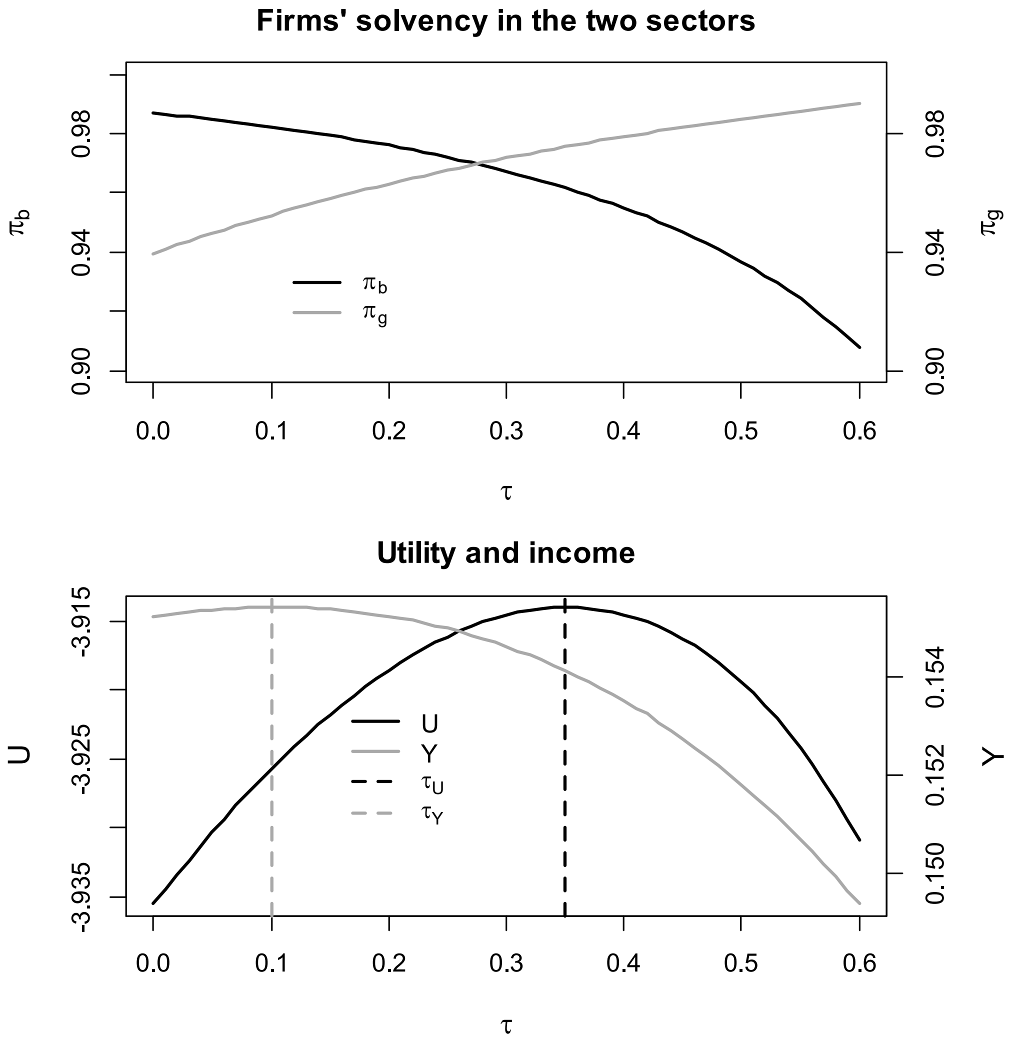

Fig. 6: Effects of capital controls in the model with firms' solvency ($\delta_0 = 1, \delta_1 = 5$). Solvency as a function of the inflow tax τ (upper panel). Comparison between the welfare-maximising value of τ and the value of τ that maximises production (bottom panel).

7. Concluding remarks

Despite its simplicity, the model described in the present paper is useful to derive some important implications on the effectiveness of differentiated capital controls aimed at reducing inflows to the brown, carbon-intensive industry and attracting foreign investments in green activities.

The analysis shows that such measures can be a useful tool for developing and emerging countries to finance the green reconversion of their industries. In fact, according to the model, an increase of the inflow tax leads to a higher equilibrium value of capital supplied to the green industry. This result is followed by productivity gains obtained through the reduction of the negative climate-related externality of the carbon-intensive industry induced by the lower size of brown production in the economy.

However, this result holds up to a certain threshold of the tax rate. If the government raises excessively the inflow tax, only a small share of capital is supplied to the more productive brown industry with the result of lowering production and consumption. Policymakers therefore face a trade-off in deciding the optimal rate of the inflow tax, balancing the expansionary and contractionary effects described above.

The effectiveness of capital controls in stimulating production depends on the environmental attitude of domestic and foreign investors and on the potential damage that affects the economy: in fact, the lower the environmental concerns of capital lenders are (or the higher the climate-related damage is), the more useful capital controls are in reducing the negative externality of carbon-intensive production.

Another interesting point highlighted in the analysis is the discrepancy between the value of the inflow tax that maximises the overall production and the higher tax rate that optimises the total welfare. The difference between the two values is due to the incentives for the small open economy to increase the inflow tax in order to extract part of the revenues of foreign financial intermediaries and rebate them to domestic households with a direct subsidy. Moreover, domestic households also benefit from the higher rental costs of capital in the brown sector when foreign capital inflows in the carbon-intensive industry are discouraged through capital controls.

The introduction of capital controls on foreign inflows in the carbon-intensive industry is justified when foreign investors exhibit lower pro-environmental preferences than domestic households. In fact, the first model extension demonstrates that, even considering a tax on domestic investments in the brown sector in addition to the inflow tax, the former should be significantly smaller than the latter. However, the analysis shows that such differentiated capital controls might have some limitations. One of the most important is related to financial stability concerns: in fact, the lower inflows in the carbon-intensive industry are likely to increase its default risk. There are also other caveats not explicitly considered in the analysis: for instance, the unilateral introduction of capital controls by a single country could lead to a flight of international capital flows to countries with a more open financial account.

Finally, as a last remark, the framework developed in this paper supports the view, discussed recently in Ehlers *et al.* (2020), that an environmental rating system designed at the firm-level could provide a useful signal to investors, favouring the allocation of capital to green activities.

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