Beware the Side Effects: Capital Controls, Misallocation and Welfare *

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Abstract

We study the effects of capital controls using a dynamic model with heterogeneous firms, monopolistic competition, endogenous trade participation and financial frictions. Taxing foreign borrowing increases misallocation via static effects that reduce capital-labor ratios and increase firm prices, reduces it via dynamic effects that strengthen saving incentives, and may increase or reduce it via general equilibrium effects. Quantitative analysis calibrated to the 1990s Chilean *encaje* predicts higher misallocation with larger effects on more financially-dependent firms (exporters, younger or less productive firms). Social welfare falls and welfare costs are much larger for exporters. LTV regulation that reduces aggregate credit by the same amount yields much smaller welfare costs, even tough misallocation still rises, because it spreads the burden of credit tightening more evenly and real wages and output fall less. Empirical evidence from Chilean firm-level data shows that misallocation did increase relatively more for more productive firms, for exporters and for firms that were further away from their steady state.

Keywords: Capital controls, welfare, misallocation, financial frictions, international trade.

JEL codes: F12, F41, O47

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1 Introduction

Capital controls (CCs), unpopular since the collapse of the Bretton Woods system in 1971, began to gain favor in the aftermath of the 1990s emerging markets Sudden Stops as a policy instrument to counteract credit booms and other financial vulnerabilities arising from surging capital inflows. The 2008 Global Financial Crisis widened their appeal to the point that they are now a well-accepted macroprudential policy tool to reduce systemic financial risk and contagion. This about-face was also supported by new research that provided theoretical arguments favoring the macroprudential use of CCs to address pecuniary externalities that cause overborrowing and sudden stops through credit constraints linked to collateral prices (see Bianchi and Mendoza (2020) for a review of this literature). As with previous research on the subject, however, these studies focus on how capital controls affect financial intermediaries, aggregate balance-of-payments adjustment and macroeconomic dynamics and typically in representative-agent settings.

This paper takes a new direction by examining the "side effects" of capital controls. In particular, we study CCs from a perspective that emphasizes their heterogeneous impact across the cross-section of nonfinancial firms and the aggregate effects of firm heterogeneity. Some of the existing research and policy debates on macroprudential policy have noted that CCs may entail costly tradeoffs because the higher borrowing costs they imply distort investment in a manner akin to a capital income tax, but still in the context of representative-agent models.[1]. Empirical evidence from firm-level data shows, however, that CCs affect firms differently depending on characteristics such as size, financial dependence or capital intensity (Alfaro et al. (2017), Forbes (2007), Andreasen et al. (2020)). Thus, the data indicate that there is an important transmission mechanism linking CCs to firm dynamics and firm heterogeneity, but to date little is known about the nature of this mechanism and its positive and normative implications at the aggregate level.

Two key questions remain unanswered: What are the side effects of CCs in terms of inducing misallocation of productive factors across firms? And, what are the aggregate and social welfare implications of these side effects? This paper provides theoretical, quantitative

[1]For istance, some studies show that, unless CCs are sufficiently state-contingent, they remain in place in states in which taxing investment is inefficient (see Bianchi and Mendoza (2020) and Darracq-Paries et al. (2019))

and empirical answers to these questions by studying the effects of CCs on misallocation, aggregate outcomes and welfare in a dynamic model with monopolistically-competitive heterogeneous firms that face credit constraints and choose whether to enter export markets.[2] A continuum of risk-averse, heterogeneous entrepreneurs produce differentiated domestic varieties of intermediate goods and sell them to final-good producers domestically and, if they so choose, abroad. Entrepreneurs differ in their exogenous idiosyncratic productivity draw, the size of their capital stock, their debt, and whether they sell abroad or not. They can save and borrow internationally but they face a collateral constraint when they borrow. CCs are modeled as a tax on foreign borrowing (i.e., an asymmetric tax) that increases the effective interest rate for all firms that borrow and adds to the financial frictions already present because of the collateral constraint.

We show that a social planner without credit constraints sets allocations such that the marginal revenue products of capital (MRPK) and labor (MRPL) are equalized across firms, and the MRPKs are also equal to the world opportunity cost of capital, irrespective of the firms' idiosyncratic productivity or exporting status.

In the model, if there are no financial frictions (i.e., removing collateral constraints and CCs), there is no misallocation in the decentralized equilibrium: the marginal revenue products of capital (MRPK) and labor (MRPL) are equalized across firms, and MRPKs are efficient in that they are also equal to the world opportunity cost of capital, irrespective of the firms' idiosyncratic productivity or exporting status. The collateral constraint alters this outcome by raising MRPKs of at least some firms above the efficient one, thereby causing dispersion in MRPKs across firms. Hence, misallocation arises. This occurs because credit-constrained firms are forced to operate below their efficient capital scale (i.e., they display a negative "optimal scale gap" or OSG) with an effect that is larger for more financially-dependent firms. Firms are more financially-dependent the larger their OSG, which varies with their productivity, age, capital size, and exporting status.

The focus of our analysis is on how introducing CCs alters the equilibrium of an economy where the collateral constraint was already in place. The model predicts that misallocation responds to three effects: First, "static" effects, namely responses of firms' capital,

[2] We focus on the case of capital controls, but the model is also applicable to analyze two other important questions, namely the misallocation effects of financial repression and financial integration.

labor, production and pricing choices to the introduction of CCs taking as given aggregate variables and firm-specific net worth and saving plans. We show that these effects worsen misallocation when CCs are introduced by tightening the firms' financial constraints (i.e., making the adverse effects of financial dependence more severe), which reduces their capital and capital-labor ratios and increases their prices, and consequently increases their MRPKs. Second, dynamic effects driven by an "oversaving" distortion due to stronger saving incentives as tighter financial constraints increase the marginal return on saving and incentivize entrepreneurs to growth their net worth faster. Hence, firms with a given net worth have higher MRPK because of the static effects when CCs are introduced, but in the stationary distribution of firms there may be more firms at higher levels of net worth where MRPKs are lower (i.e., relative to the economy with just collateral constraints, CCs increase MRPK for some firms but lower it for others). Third, general equilibrium effects that result from changes in aggregate variables (wages and the price and output of final goods), which change as CCs affect the distribution of firms and the misallocation of capital across them and therefore aggregate demand for final goods and labor and supply of intermediate goods. As a result, the net effects of CCs on misallocation, aggregate outcomes, and social welfare are theoretically ambiguous.[3]

The adverse effect of collateral constraints on misallocation are well-known in the literature. Intuitively, CCs are similar inasmuch as they also limit access to credit. They differ, however, in one key respect: The effects of a collateral constraint shrink monotonically as firm assets grow while the effects of CCs are non-monotonic. The reason is that the collateral constraint weakens monotonically as the firms' collateral rises, while the effect on financial-dependence of a firm in the economy with CCs is most severe for firms with assets such that they have reached the pseudo-optimal scale consistent with the effective opportunity cost of capital *inclusive* of the tax on foreign borrowing. Firms with fewer assets have similar MRPK as with the collateral constraint alone and firms with more assets shrink their debt until they no longer borrow. Thus, misallocation is much smaller for firms with very little net worth or net worth just short of their optimal scale than for firms with net worth in between.

We derive the model's quantitative predictions by comparing stationary equilibria

[3]Since the collateral constraint alone causes misallocation, CCs introduce an additional source of misallocation into an economy that was already inefficient. As inefficient equilibria cannot be ranked in general, the social welfare effect of CCs is theoretically ambiguous.

before and after the imposition of capital controls for a calibration based on a well-defined natural experiment: the case of the Chilean *encaje*, a 30% unremunerated reserve requirement on foreign inflows introduced in 1991 and fully removed in 1998. We calibrate the model to pre-*encaje* data and then introduce a tax on foreign debt that is calculated to be equivalent to the *encaje* in terms of its impact on borrowing costs. Misallocation is measured as the mean deviation of of MRPKs relative to their efficient level in the stationary distribution of firms. In addition, the model is calibrated to capture the well-documented empirical fact that exporting firms have better access to international credit markets (see, for example, Muuls (2015)). Hence, exporters are allowed to collateralize into debt a larger fraction of their capital than non-exporters.

The model predicts that capital controls produced an increase in misallocation of 0.39% for the economy as a whole that was unevenly distributed across firms. Misallocation worsened more for exporters (0.68%) and slightly more for averages of low-tfp firms v. high (0.45% v. 0.33%) and young firms v. old (0.4% v. 0.32%). Across non-exporters, misallocation rose 0.33% but mainly on account of a 0.45% increase for those with low productivity, while it changed little for those with high productivity (0.14%). The firm groups for which misallocation rose spend more time in asset positions with higher financial dependence, and hence rely more on credit to accumulate capital as they move toward their optimal scales and (for exporters) to pay the fixed cost of entering export markets. CCs reduce social welfare by an amount equivalent to a permanent cut of 0.37% in consumption of all entrepreneurs (using a utilitarian social welfare function that aggregates lifetime utility of entrepreneurs with the model's stationary distribution). The burden of CCs is also distributed unevenly, with the welfare costs incurred by low-productivity and exporting entrepreneurs roughly twice and nearly six times as large as those incurred by high-productivity and non-exporting entrepreneurs, respectively. These results are due in part to non-trivial declines of -0.44% in the aggregate real wage in units of final goods and of -0.11% and -0.57% in the aggregate price and output of final goods, respectively. These effects result in decline in aggregate consumption of roughly 0.5%. Entrepreneurs that collect a larger share of their income from wages (i.e., those with capital further away from their optimal scale), suffer more from the fall in real wages. On the side of capital income (real profits in units of final goods), the fall in real wages offsets the effect of the higher MRPKs caused by CCs on firm relative prices. Firms with MRPKs at or close to the efficient level reduce prices as wages fall and increase profits, while firms for which MRPKs rise sufficiently, relative prices rise and profits fall. Exporters benefit slightly from the small real depreciation induced by the fall in the domestic price level.

These results are qualitatively robust to whether we assume that the revenue generated by the debt tax is a resource loss to entrepreneurs (the baseline case and the one more in line with how CCs operated in Chile) or rebated to them as a lump-sum transfer that matches the tax bill paid by each, although the model with rebates generates smaller welfare costs. The social welfare loss falls slightly to -0.13%

Our findings indicate that capital controls have non-trivial adverse effects on misallocation, aggregate outcomes and welfare is a non-trivial misallocation tradeoff. This led us to examine the implications of an alternative policy analogous to loan-to-value (LTV) credit regulation: a tighter LTV requirement that effectively reduces the fraction of capital that firms can pledge as collateral. This LTV policy is calibrated to reduce the ratio of aggregate credit to value added in the same magnitude as with the CCs. LTV regulation entails significantly lower welfare costs than CCs, both in the aggregate and across firms grouped by age, productivity or exporting status. Misallocation, however, also increases in the aggregate and for all firm groups (except only marginally for young firms). The same force explains both results: LTV regulation spreads the burden of the credit reduction more evenly across all firms, and by reducing credit to all firms operating below their optimal scale (instead of only to those who do not borrow at the higher interest rate with CCs), it increases the MRPKs of all of these firms. The general equilibrium effects on real wages and output of final goods are much weaker, at -0.27% and -0.17%, respectively, and the price of final goods rises slightly (0.07%) instead of falling. Moreover, contrary to the CC, the substitution effect between capital and consumption stimulates production and domestic sales.

The model's quantitative predictions at the firm level show an adverse effect of capital controls on misallocation that is significantly larger for firms with higher productivity, for exporters and for firms that are further away from their optimal scale. If these effects are empirically relevant, they should be observable in the data. Hence, we conducted an empirical analysis to determine whether this is the case. We constructed a panel of Chilean manufacturing firm data from 1990 to 2007 using the *Encuesta Nacional Industrial Anual* (ENIA). In line with the model's results, CCs increase misallocation relatively more for more productive firms, for exporters and for firms that are further away from their optimal scale.

The rest of the paper is organized as follows: Section 2 places the contributions of our work in the context of the related literature. Section 3 presents the theoretical model and derives its key implications. Section 4 discusses the quantitative results. Section 5 conducts the panel-data analysis and discusses its findings. Section 6 concludes.

2 Related Literature

This paper is related to three strands of the literature. First, studies that explore the link between misallocation and financial frictions. Second, research on the trade effects of misallocation. Third, studies on the firm-level implications of capital controls.

Studies of misallocation and financial frictions use heterogeneous-firms models to study and quantify how policies and firm characteristics generate misallocation (e.g., Restuccia and Rogerson (2008), Hsieh and Klenow (2009)). Several of these studies focus on closed-economy models under perfect competition. Buera et al. (2011) proposed a model with sectors that differ in their degree of financial dependence and show that financial frictions can significantly distort the allocation of productive factors. Midrigan and Xu (2014) propose a model with traditional and modern productive sectors in which debt constraints distort technology adoption decisions and create misallocation. Both models predict that financial liberalization reduces misallocation. Buera and Moll (2015) examine how shocks to a collateral constraint under three forms of heterogeneity affect aggregate wedges used to account for aggregate fluctuations. Our work differs from these studies in that we examine an open-economy model, which links efficient levels of MRPK to world opportunity costs, and assume monopolistic competition, which amplifies MRPK effects.

Gopinath et al. (2017) propose an open-economy model with monopolistic competition and a collateral constraint that is an increasing, convex function of a firm's capital. They show that a decline in interest rates can lead to a sharp decline in sectoral total factor productivity as capital inflows are misallocated towards firms that have higher net worth but are not necessarily more productive. They document capital misallocation and productivity losses in Spain, Portugal and Italy during a period of declining real interest rates but not in Germany, France, and Norway. They focus on partial-equilibrium analysis. Our work is similar in that we also study an open-economy model with monopolistic competition, but differs in that we use a standard collateral constraint linear in capital, introduce endogenous trade participation, and examine general equilibrium outcomes (with the finding that general equilibrium effects play a key role in determining the misallocation and welfare effects of capital controls). Our work also contrasts with these closed- and open-economy studies in that we study the social welfare implications of misallocation.

Our paper is also closely related to Andreasen et al. (2020) that study the effect of capital controls in an economy with financial constraints. Using manufacturing data from Chile, they find that capital controls reduce aggregate production while increasing exports and TFP. The present works differs as it takes a more normative approach as we focus on misallocation and welfare.

There are also several empirical papers that focus on the relation between capital controls and TFP across firms. citetbekaertetal2011 demonstrate that the easing of CCs positively affects capital stock growth and TFP. Larraín and Stumpner (2017), focusing on Eastern European countries, find that capital account liberalization increases aggregate productivity through a more efficient allocation of capital across firms. Related to this, Varela (2018) studies the financial liberalization episode of Hungary in 2001 and shows that a reduction in CCs can lead firms to invest in technology adoption and, through this channel, aggregate TFP increases. Some papers study the Chilean case. Oberfield (2013) examines allocative efficiency and TFP during the 1982 financial crisis. He finds that within-industry TFP either remained constant or improved in 1982, while a decline in between-industry allocative efficiency accounts for about one-third of the reduction in TFP. Chen and Irarrázabal (2015) provide suggestive evidence that financial development might be an important factor explaining growth in output and productivity in Chile between 1983 and 1996. Pavcnik (2002) investigates the effects of trade liberalization on plant productivity in Chile in the early 1980s. Using plant-level manufacturing data she finds that trade liberalization improved within plant productivity in the import-competing sector. Our paper contributes to this empirical literature by examining the effects of the Chilean *encaje* on misallocation using a large panel dataset for manufacturing establishments and showing that it increased misallocation and significantly more for high-productivity exporting and young firms.

Our paper also relates to the literature that addresses the impact of trade on productivity, welfare and misallocation. Berthou et al. (2020) and Bai et al. (2019) studies the impact of trade in a two-country Melitz model with previous firm-level distortions. Bai et al. (2019) finds that trade can potentially reduce welfare by exacerbating missallocation. Using Chinese manufacturing data, they show that trade integration can lead to a 18% welfare loss. Berthou et al. (2020) shows that trade reforms have ambiguous effects on welfare and productivity. Using data for 14 European countries and 20 manufacturing industries during 1998-2011 they document that export expansion and import penetration increases aggregate productivity. However, the productivity gains work through different channels. Export growth induces higher average productivity and a reallocation towards more productive firms. Imports, on the other hand, improve competition and raise average firm productivity. Brooks and Dovis (2020) studies how credit frictions affects trade liberalization. Using a Melitz model with credit frictions, they show that exporters expand efficiently when debt limits are endogenous and respond to profit opportunities. On the contrary, the gains from trade are lower when debt limits are modeled as a fraction of assets. Using data from Colombia they find evidence consistent with the first model. Our paper differs in that we study a small open economy with financial constraints and focus on the trade effects induced by capital controls.

Finally, our paper relates to the literature that studies the firm-level implications of capital controls. Alfaro et al. (2017) find a decline in cumulative abnormal returns for Brazilian firms following the imposition of CCs in 2008-2009, they also find that this effect is stronger for smaller, non-exporting and more financially dependent firms. For the specific case of the Chilean encaje, Forbes (2007) finds that smaller firms experienced significant financial constraints, which decreased with firm size. We add to this literature by considering the effects of capital controls on resource allocation.

3 Model

The model we study is in the spirit of those proposed by Midrigan and Xu (2014), Buera and Moll (2015) and Gopinath et al. (2017). In the model, entrepreneurs sell differentiated varieties of intermediate goods to domestic and foreign final-goods producers in monopolistically-competitive markets. They can make an irreversible choice to become exporters by paying an entry cost in units of labor. Their access to foreign financing is limited by a collateral constraint and capital controls. The collateral constraint causes misallocation by inducing dispersion in MRPKs via the financial-dependence mechanism familiar from the literature (i.e., constrained firms grow their net worth gradually and display higher MRPKs the further away they are from their optimal scale). CCs operate also through a financial-dependence mechanism, but one that introduces new non-linear features we explain later in this Section. These financial frictions also interact with the entry cost to become an exporter, because it implies that firms must accumulate enough assets for them to be optimal to become exporters.

3.1 Final-goods sector

A representative producer of final goods purchases differentiated varieties of intermediate goods from domestic and foreign firms and uses them as inputs to operate a constant-elasticity-of-substitution (CES) production technology. The elasticity of substitution across inputs is denoted by $\sigma > 1$. Let the set $[0, 1]$ index the measure of domestic entrepreneurs and define $\{p_{h,t}(i)\}_{i\in[0,1]}$ and p_m as the prices charged by domestic and foreign entrepreneurs, respectively. The producer of final goods chooses the optimum bundle of domestic, $\{y_{h,t}(i)\}_{i\in[0,1]}$, and imported, $y_{m,t}$, inputs so as to maximize profits from final-goods production, y_t, taking all input prices as given and subject to the CES technology:

$$\max_{y_{h,t}(i), y_{m,t}} p_t y_t - \int_0^1 p_{h,t}(i) y_{h,t}(i) di - p_m y_{m,t},$$

$$\text{s.t.} \qquad y_t = \left[\int_0^1 y_{h,t}(i)^{\frac{\sigma-1}{\sigma}} di + y_{m,t}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where eq. (1) is the CES production function and p_t is the CES price index of final goods, $p_t = [\int_0^1 p_{h,t}(i)^{1-\sigma} di + p_m^{1-\sigma}]^{1/(1-\sigma)}$. This problem yields standard results by which the final goods producer demands each input up to the point where its marginal product equals its corresponding market price, which is its marginal cost.

3.2 Intermediate-goods sector

Domestic entrepreneurs are risk-averse and supply one unit of labor inelastically. They sell their inputs in monopolistically-competitive markets at home and, if they are exporters, abroad. Preferences of an entrepreneur $i \in [0,1]$ are:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\gamma}}{1-\gamma},$$

where c_t is consumption, γ is the coefficient of relative risk aversion, and β is the subjective discount factor. The expectation $\mathbb{E}_0$ is taken over the possibility of death (the only stochastic variable in the model), which happens with probability ρ. At the end of the period, deceased entrepreneurs are replaced by a measure ρ of newborn entrepreneurs. In order to insure against the risk of death, entrepreneurs engage in an annuity contract by which, if they die, all savings and capital are transferred to existing entrepreneurs. This annuity pays surviving entrepreneurs an amount that expands their accumulated net worth by a proportion $\frac{\rho}{1-\rho}$.[4]

Entrepreneurs make a choice to remain non-exporters ($e = 0$) or become exporters ($e = 1$) at the beginning of each period. The latter choice is irreversible while an entrepreneur who chooses to remain a non-exporter retains the option to become an exporter in the future. If the entrepreneur chooses $e = 1$, it pays a one-time entry cost F in units of labor at t and starts exporting at $t + 1$. Exporting goods also incurs an "iceberg" trade cost that requires shipping τ units of intermediate goods for every unit that is sold abroad, with $\tau > 1$.

Because of monopolistic competition, an entrepreneur faces the following domestic demand function for its particular input variety:

$$y_{h,t}(i) = \left(\frac{p_{h,t}(i)}{p_t}\right)^{-\sigma} y_t, \tag{2}$$

Entrepreneurs who export also face this foreign demand function:

$$y_{f,t}(i) = \left(\frac{p_{f,t}(i)}{p^*}\right)^{-\sigma} y^*, \tag{3}$$

where $p_{f,t}(i)$ is the price the entrepreneur charges for its input variety abroad, and p^* and y^* are the exogenous price index and output of foreign final goods, respectively.

Newborn entrepreneurs arrive with zero debt, receive a transfer of capital from the government $\underline{k}$ and draw idiosyncratic productivity z that remains constant throughout their

[4]This annuity contract is standard in the Blanchard-Yaari overlapping generations models so that uncertainty and risk can be removed from the agents' optimization problem. We acknowledge that it implies assuming the existence of a well-developed annuity market that is a bit at odds with assuming collateral constraints.

lifetime. z has a log-normal probability distribution function $f(z)$ with mean μ_z and standard deviation ω_z. Entrepreneurs operate a Cobb-Douglas technology with capital intensity $\alpha \in (0,1)$. Their output is a function of their productivity z, their capital stock k_t, and the labor they hire n_t. Market-clearing in the market of each input variety requires:

$$y_{h,t} + e(\tau y_{f,t}) = z k_t^{\alpha} n_t^{1-\alpha}. \tag{4}$$

Capital depreciates at rate δ and investment is denoted x_t. Taking into account the annuity payments, the law of motion of capital is given by:[5]

$$k_{t+1} = \frac{1}{1-\rho}[(1-\delta)k_t + x_t]. \tag{5}$$

Entrepreneurs participate in a global market of one-period, risk-free discount bonds. d_{t+1} denotes debt issued (bonds sold) at date t to be repaid at t+1.[6] They also face a collateral constraint by which they cannot borrow more than a fraction $0 \leq \theta \leq 1$ of the value of the capital stock they have available when the debt is due for repayment:

$$d_{t+1} \leq \theta k_{t+1}. \tag{6}$$

Without capital controls, the gross interest rate on these bonds is the world real interest rate $R^* \equiv 1 + r^*$ and their price is $q^* = 1/R^*$. To match the Chilean *encaje* episode, we model capital controls as an asymmetric tax on external borrowing: for $d_{t+1} > 0$, the interest rate is $\hat{r} = r^* + \nu$ with a corresponding bond price $\hat{q} \equiv 1/(1+\hat{r})$, where ν is the tax-equivalent capital control on inflows, and for $d_{t+1} \leq 0$ the interest rate is $r = r^*$ with bond price q^*.[7] Hence, bond prices are given by $q = \mathbb{1}_{d' \leq 0} q^* + \mathbb{1}_{d'>0} \hat{q}$.

We follow an approach similar to Buera and Moll (2015) to characterize the en-

[5] The entrepreneur accumulates capital by the amount $(1-\delta)k_t + x_t$ and receives an extra $\frac{\rho}{1-\rho}[(1-\delta)k_t + x_t]$ from the annuity, which yields $k_{t+1} = \frac{1}{1-\rho}[(1-\delta)k_t + x_t]$.

[6] The debt is assumed to be denominated in units of domestic final goods for simplicity. We could assume that risk-neutral banks intermediate foreign debt that pays a real rate of r^* in units of p^* and that $p^* = 1$. Since our analysis focuses on the stationary equilibrium where p_t is constant, the no arbitrage condition of banks would imply $r = r^*$.

[7] We will calibrate ν to match the tax-equivalent of the Chilean *encaje* on capital inflows with a 12-month maturity. See Appendix A for a description of the Chilean *encaje* episode and Appendix B for details on how the tax-equivalent measure was constructed.

trepreneurs' optimization problem in recursive form.[8] In particular, we define the relevant state variable as the entrepreneur's cash on hand $m \equiv [w + \frac{p_h^{1-\sigma}}{p^{-\sigma}} y + e \frac{p_f^{1-\sigma}}{p^{*-\sigma}} y^* - wn + p(1 - \delta)k - pd - T]/p$ and define a' as its net worth $a' \equiv k' - qd'$. Hence, the budget constraint of the entrepreneur can be expressed as $c = m - (1-\rho)a'$.[9] The entrepreneur's optimal plans can then be formulated as a solution to a two-stage budgeting problem: An optimal choice of a' to maximize lifetime utility and a "static" choice to maximize m' by allocating allocating a' into a portfolio of k' and d' and setting p'_h, p'_f and n'.

At the beginning of the period, an entrepreneur who is not an exporter and drew productivity z at birth chooses whether or not to switch to become an exporter by selecting the option with the highest payoff:

$$v(m,z) = \max_{e \in \{0,1\}} \left\{ (1-e) v^{NE}(m,z) + e v^{S}(m,z) \right\} \tag{7}$$

where $v^{NE}(m,z)$ is the value of continuing as a non-exporter and $v^{S}(m,z)$ is the value of switching to be an exporter. Note that z does not vary over time. The dependence of these payoff on z reflects only differences across firms in the one-time productivity draw "at birth."

$v^{NE}(m,z)$ solves the following two-stage optimization problem:

$$v^{NE}(m,z) = \max_{a'} \left[u\left(m - (1-\rho)a'\right) + \tilde{\beta} v\left(\tilde{m}'(a',z), z\right) \right] \tag{8}$$

$$\tilde{m}'(a',z) = \max_{k',d',p'_h,n'} \left[\frac{w' + \frac{{p'_h}^{1-\sigma}}{{p'}^{-\sigma}} y' - w'n' + p'(1-\delta)k' - p'd' - T}{p'} \right] \tag{9}$$

$$\text{s.t.} \quad \left(\frac{p'_h}{p'}\right)^{-\sigma} y' = z {k'}^{\alpha} {n'}^{1-\alpha} \tag{10}$$

$$a' = k' - qd' \tag{11}$$

$$d' \leq \theta k' \tag{12}$$

[8] Because of the monopolistic competition, however, in our setting the firms' profits and their debt and capital choices are not linear in net worth, and hence the net worth decision rule is not linear in cash on hand.

[9] The entrepreneur's budget constraint is $pc + p[(1-\rho)k' - (1-\delta)k] + pd + wn = w + p_h y_h + e(p_f y_f) + p(1-\rho)qd' - T$. Using the definition of a' and rearranging terms yields $pc + p(1-\rho)a' - p(1-\delta)k + pd + wn = w + p_h y_h + e(p_f y_f) - T$. Then using the demand functions (2)-(3) and rearranging terms yields $pc = w + \frac{p_h^{1-\sigma}}{p^{-\sigma}} y + e \frac{p_f^{1-\sigma}}{p^{*-\sigma}} y^* - wn + p(1-\delta)k + pd - T - p(1-\rho)a'$. Finally, applying the definition of m and dividing through by p yields $c = m - (1-\rho)a'$. Notice that a' is multiplied by $1-\rho$ because the annuity contract transfers all savings and capital to existing entrepreneurs, so $1-\rho$ multiplies both k' and a'.

where $\tilde{\beta} \equiv \beta(1-\rho)$ to account for the probability of death. The function $v(\cdot)$ appears in the right-hand-side of (8) because the non-exporter retains the option to become an exporter in the future. The two-stage-budgeting structure of the solution is evident in that this dynamic programming problem yields the decision rule $a'(m,z)$ that drives the evolution of net worth as a function of cash on hand, while the solution to the maximization problem defined by (9)-(12) determines $\tilde{m}'$, the optimal portfolio allocation of a' into k' and d' and the optimal ${p'}_h$ and n', all as recursive functions of (a',z). Hence, evaluating a' at the optimal value given by $a'(m,z)$, we can express these decision rules as $\tilde{m}'(m,z)$, $k'(m,z)$, $d'(m,z)$, ${p'}_h(m,z)$ and $n'(m,z)$. These decision rules depend also on the aggregate variables (y',p',w'), but we do not carry them as state variables to keep the notation simple, since we will solve for stationary equilibria in which they are time-invariant.

The value of a firm that is already exporting is:

$$v^E(m,z) = \max_{a'} \left[u\left(m-(1-\rho)a'\right) + \tilde{\beta} v^E\left(\tilde{m}'(a',z),z\right) \right] \tag{13}$$

$$\tilde{m}'(a',z) = \max_{k',d',{p'}_h,{p'}_f,n'} \left[\frac{w' + \frac{{p'}_h^{1-\sigma}}{p'^{-\sigma}} y' + \frac{{p'}_f^{1-\sigma}}{p^{*-\sigma}} y^* - w'n' + p'(1-\delta)k' - p'd' - T}{p'} \right] \tag{14}$$

$$\text{s.t.} \quad \left(\frac{p'_h}{p'}\right)^{-\sigma} y' + \tau \left(\frac{p'_f}{p^*}\right)^{-\sigma} y^* = z {k'}^{\alpha} {n'}^{1-\alpha} \tag{15}$$

$$a' = k' - qd' \tag{16}$$

$$d' \leq \theta k' \tag{17}$$

This optimization includes sales abroad as part of cash on hand, adds foreign demand inclusive of the iceberg cost of exporting in condition (15), and takes into account that an exporter chooses ${p'}_f$ in addition to k', d', ${p'}_h$ and n'. Since the decision to become an exporter is irreversible, $v^E(\cdot)$ is the same function in both sides of (13).

The value of switching to become an exporter, $v^S(m,z)$, solves the following problem:

$$v^S(m,z) = \max_{a'} \left[u\left(m-(1-\rho)a' - wF\right) + \tilde{\beta} v^E\left(\tilde{m}'(a',z),z\right) \right] \tag{18}$$

$$\tilde{m}'(a',z) = \max_{k',d',p'_h,p'_f,n'} \left[\frac{w' + \frac{{p'}_h^{1-\sigma}}{p'^{-\sigma}} y' + \frac{{p'}_f^{1-\sigma}}{p^{*-\sigma}} y^* - w'n' + p'(1-\delta)k' - p'd' - T}{p'} \right] \tag{19}$$

$$\text{s.t.} \qquad \left(\frac{p'_h}{p'}\right)^{-\sigma} y' + \tau \left(\frac{p'_f}{p^*}\right)^{-\sigma} y^* = z{k'}^{\alpha}{n'}^{1-\alpha} \tag{20}$$

$$a' = k' - qd' \tag{21}$$

$$d' \leq \theta k' \tag{22}$$

The value function in the right-hand-side of (18) is that pertaining to an entrepreneur who is already an exporter, $v^E(\cdot)$, which differs from $v^s(\cdot)$ because of the entry cost of becoming an exporter that is incurred only when the choice to switch is made. Notice that m includes prices, factor demands, and production of date t chosen while still not being able to export, while $\tilde{m}'(\cdot)$ includes optimal choices to start exporting as of $t+1$. This captures the assumption that it takes one period after making the decision to switch for a firm to start exporting.

We verified quantitatively that these value functions are increasing and concave in m for all z, and cross once with $v^S(\cdot)$ crossing $v^{NE}(\cdot)$ from below. Hence, for a given z, there is a threshold value of cash on hand $\hat{m}(z)$ at which the firm switches to become an exporter defined by $v^{NE}(\hat{m},z) = v^S(\hat{m},z)$. Hence, the payoff function for an entrepreneur at state (m,z) is given by:

$$V(m,z) = \begin{cases} v(m,z) & \text{for } m \leq \hat{m}(z) \\ v^E(m,z) & \text{for } m > \hat{m}(z) \end{cases} \tag{23}$$

3.3 Recursive stationary equilibrium

We study the effects of capital controls on the recursive stationary equilibrium. Since the model has no risk, we assume $\beta R^* = 1$, so that the steady-state capital of a firm prevented from borrowing at R^* by capital controls is the same as in the economy without capital controls. The distribution of firms across age (τ) and productivity is exogenous (given by $\phi(\tau,z) = \rho(1-\rho)^{\tau-1}f(z)$), but the stationary distribution across m and z , $\phi(m,z)$, or its alternative representation in terms of net worth or capital and debt (and z), varies in response to the effects of CCs on the optimal plans of entrepreneurs.

For given q (i.e., given r^* and $\hat{r}$), p^* and y^*, the model's recursive stationary equilibrium consists of aggregate prices $\{w, p\}$, final goods output $\{y\}$, entrepreneurs' decision rules $\{c(\cdot), a'(\cdot), n'(\cdot), \tilde{m}'(\cdot), p'_h(\cdot), p'_f(\cdot), y'_h(\cdot), y'_f(\cdot), d'(\cdot), k'(\cdot), e(\cdot)\}$, lump-sum taxes T, value functions $v(\cdot), v^{NE}(\cdot), v^S(\cdot), v^E(\cdot)$ and a stationary distribution of firms, $\phi(m, z)$, such that:

1. Entrepreneurs' value functions and decision rules solve their optimization problems.

2. Decision rules for demand of intermediate goods and output of final goods solve the final-goods producer's problem.

3. The government budget constraint is satisfied: $p\rho\underline{k} = T$.

4. The labor market clears: $\int[n'(m, z) + F\mathbb{1}_{\tilde{m}'(m,z)=\hat{m}(z)}]d\phi(m, z) = 1$, where $\hat{m}(z)$ is the threshold that defines entrepreneurs switching from non-exporters to exporters.

5. The market of final goods clears: $\int[c'(m, z) + x'(m, z)]d\phi(m, z) + \rho\underline{k} = y$, where $c'(m, z) = \tilde{m}'(m, z) - (1 - \rho)a'(\tilde{m}'(m, z), z)$ and $x'(m, z) = (1 - \rho)k'(\tilde{m}'(m, z), z) - (1 - \delta)k'(m, z)$.

6. $\phi(m, z)$ satisfies the following stationarity condition (i.e., it is a fixed point of the law of motion of conditional distributions of (m, z)):

$$\phi(m', z') = \int\int[(1 - \rho)I^S(m', m, z) + \rho I^D(m', m, z)]\phi(m, z)dmdz, \tag{24}$$

   where $I^S(m', m, z)$ and $I^D(m', m, z)$ are indicator variables for surviving and deceased firms, respectively, such that $I^S(m', m, z) = 1$ if $m' = \tilde{m}'(m, z)$ and $I^D(m', m, z) = 1$ if $m' = \underline{m}(z)$ and zero otherwise.[10] $\underline{m}(z)$ is the cash on hand of a newborn firm, which is given by $\underline{m}(z) = [w + \underline{p}_h(z)z\underline{k}^\alpha n(z)^{1-\alpha} - w\underline{n}(z) + p(1 - \delta)\underline{k} - T]/p$, where $\underline{p}_h(z), \underline{n}(z)$ are the solutions that maximize m taking as given $k = \underline{k}$ and $d = 0$ and subject to the market-clearing constraint for production of y_h.[11] The distribution of $\underline{m}(z)$ is induced by $f(z)$. Moreover, applying the envelope theorem to this maximization problem yields $d\underline{m}(z)/dz = \underline{p}_h(z)\underline{k}^\alpha\underline{n}(z)^{1-\alpha} > 0$. Hence, $\underline{m}(z)$ rises with z and only via its first-order effect on production. Note also that newborn entrepreneurs who draw high enough z

[10] $\tilde{m}'(m, z)$ is set to the corresponding decision rule for non-exporters if $v^{NE}(m, z) > v^S(m, z)$, exporters if $v^S(m, z) > v^{NE}(m, z)$, and switchers if $v^{NE}(m, z) = v^S(m, z)$ (i.e., those at the threshold $\hat{m}(z)$).

[11] At equilibrium, total revenue $p_h y_h + p_f y_f$ can be expressed as $p_h z k^\alpha n^{1-\alpha}$. To derive this result, substitute the demand functions for y_h, y_f, apply the equilibrium condition $p_f = \tau p_h$ and simplify.

such that $v^S(\underline{m}(z), z) \geq v^{NE}(\underline{m}(z), z)$, become exporters from the start (i.e., $\underline{e}(z) = 1$), otherwise $\underline{e}(z) = 0$.

3.4 Capital Controls and Misallocation

To characterize the effects of capital controls on misallocation, we start by examining the optimality conditions of an exporter's second-stage problem of maximizing $\tilde{m}'$ by choosing d', k', p'_h, p'_f, n' for a given a' (eqs. (14)-(17)). The second-stage problems of non-exporters and switchers are very similar, except there are no foreign sales and no price associated with them. The first-order conditions simplify to:

$$MRPN = \frac{p'_h}{\varsigma}(1-\alpha)z(k')^{\alpha}(n')^{-\alpha} = w' \tag{25}$$

$$MRPK = equiv\frac{p'_h}{\varsigma}\alpha z(k')^{\alpha-1}(n')^{1-\alpha} = \mathbb{1}_{d' \leq 0}\left[p'(r^* + \delta) + \mu R^*\right] + \mathbb{1}_{d'>0}\left[p'(\hat{r} + \delta) + \eta(\hat{R} - \theta)\right] \tag{26}$$

$$\left(\frac{p'_h}{p'}\right)^{-\sigma} y + \tau\left(\frac{p'_f}{p^*}\right)^{-\sigma} y^* = zk'^{\alpha}n'^{1-\alpha} \tag{27}$$

$$p'_f = \tau p'_h \tag{28}$$

$$d' = R[k' - a'] \tag{29}$$

where $\varsigma = \sigma/(\sigma - 1)$ is the markup of price over marginal cost, η is the multiplier on the collateral constraint ($\eta > 0$ only if $d' > 0$ *and* the collateral constraint binds, otherwise $\eta = 0$), and μ is the multiplier on the constraint that prevents borrowing at R^* because of the capital controls ($\mu > 0$ only if $d' \leq 0$ *and* the no-borrowing constraint binds, otherwise $\mu = 0$).[12] The left-hand-sides of (25) and (26) are the marginal revenue products of labor ($\frac{\partial(p_h y_h + p_f y_f)}{\partial n}$) and capital ($\frac{\partial(p_h y_h + p_f y_f)}{\partial k}$), respectively.[13] When $\eta > 0$, k' is set by the collateral constraint at $k'(a') = [\hat{R}/(\hat{R} - \theta)]a'$, and when $\mu > 0$, $k'(a') = a'$.

Three important properties of the above conditions: First, the collateral constraint and the constraint that rules out borrowing at R^* because of CCs cannot bind at the same time. A firm that is borrowing with the collateral constraint binding borrows at $\hat{R}$, hence

[12]The budget constraint with CCs is akin to the textbook problem with a kinked budget constraint. The non-differentiability of the problem due to the kink is circumvented by solving an equivalent problem with the constraint $d' \leq 0$ for $R = R^*$. The multipliers η and μ for maximizing $\tilde{m}'$ are related to those for maximizing lifetime utility in the standard optimization problem, $\tilde{\eta}$ and $\tilde{\mu}$, by the conditions $\eta = \tilde{\eta}\frac{p'}{\beta u'(c')}$ and $\mu = \tilde{\mu}\frac{p'}{\beta u'(c')}$.

[13]See Appendix D for the corresponding derivations.

$\eta > 0$ and $\mu = 0$. A firm that is not borrowing because it would like to borrow at R^* but not at $\hat{R}$ has $\eta = 0$ and $\mu > 0$. Second, the optimal choices of k' and n' (as well as p'_h and p'_f) only depend on a' if either $\eta > 0$ or $\mu > 0$. Otherwise Fisherian separation holds, because the optimal k' is independent of a' and d'. Third, by construction, there is no labor misallocation, even when the financial distortions are present: the MRPN of all firms is the same and it equals the wage rate they all pay. Comparing regimes with and without CCs, however, wages differ and thus MRPNs differ, but within each regime MRPN is the same across firms.

Condition (26) is the engine driving the effects of CCs on misallocation. To understand the transmission mechanism and contrast it with the one at work in the literature on financial frictions and misallocation, we study its implications first without any financial frictions, then introducing the collateral constraint and the CCs separately, and finally adding CCs to the economy with the collateral constraint.

3.4.1 No financial distortions

To remove all financial frictions, assume $\theta \to \infty$, so that the collateral constraint never binds for any firm, and $\nu = 0$.[14] In this case, MRPK and MRPN are equalized across firms in the decentralized equilibrium. Moreover, a utilitarian planner without financial frictions sets allocations in the same manner. These results are contained in the following propositions:

Proposition 1. *If $\theta \to \infty$ and $\nu = 0$ (no collateral constraint and no CCs), all firms equate factor prices to their corresponding marginal revenue products.*

Proof. If $\theta \to \infty$ and $\nu = 0$, the first-order conditions (25) and (26) reduce to:

$$MRPN_i = w \quad \text{and} \quad MRPK_i = p(r^* + \delta).$$

□

Proposition 2. *The efficient allocations of a utilitarian planner free of financial frictions imply constant marginal revenue products of capital and labor across firms.*

[14] $\theta \to \infty$ is sufficient but not necessary for the collateral constraint to be irrelevant. The necessary condition for a firm of productivity z at birth is $\theta(z) > R^*[1 - (\underline{k}/\bar{k}(z))]$, where $\bar{k}(z)$ is the firm's steady-state capital . Intuitively, with this θ even a newborn entrepreneur who draws z and receives $\underline{k}$ can borrow enough to attain $\bar{k}(z)$ in the first period.

Proof. See Appendix F. □

The marginal revenue products of capital and labor are equal between firms both in the decentralized and the socially optimal equilibria, and there is no misallocation, in the sense that no factor reallocation across firms would be optimal.[15] If $\underline{k} < \bar{k}_i$, where $\bar{k}_i$ is the steady state of capital for firm i, a newborn firm jumps to its optimal scale immediately by borrowing as much as needed.

In light of these results, we will denote $\overline{MRPK} \equiv p(r^* + \delta)$ as the efficient MRPK and the associated steady-state of capital for firm i, $\bar{k}_i$, as the firm's optimal scale. Whenever $k_i < \bar{k}_i$, we will refer to the excess of $\bar{k}_i$ over k_i as the optimal scale gap (OSG).

3.4.2 Collateral constraints & capital controls separately

Consider first the NCC regime, representing an economy with collateral constraints ($\theta > 0$) but no CCs ($\nu = 0$), as is the case in the pre-CCs calibration of the quantitative analysis.

Proposition 3. *For θ sufficiently low so that constraint* (6) *binds for entrepreneur i and* $\nu = 0$ *(collateral constraint without CCs), $MRPK_i > \overline{MRPK}$ and $k_i < \bar{k}_i$.*

Proof. For θ small enough so that constraint (6) binds, the first-order conditions of the second-stage problem imply:

$$MRPN_i = w, \text{and}$$

$$MRPK_i = p(r^* + \delta) + \eta_i(R^* - \theta),$$

Firms with $k_i < \bar{k}_i$ need to borrow to invest. If the required debt exceeds $\theta\bar{k}_i$, jumping to the optimal scale at birth is unfeasible and instead they must set investment as high as the constraint allows: $k_i'(a_i') = [R^*/(R^* - \theta)]a_i'$. Capital accumulation occurs gradually as the firm grows its net worth and the constraint binds as long as $k_i < \bar{k}_i$, so $\eta_i > 0$ and thus $MRPK_i > \overline{MRPK}$.[16] □

[15] As it is standard in monopolistic competition settings, the first-best allocations yield higher production than the decentralized equilibrium ones because imperfect substitutability between varieties implies that firms have market power to set prices in the latter case. Hence, we can constrain the planner to use the same aggregate capital and labor as in the decentralized equilibrium to obtain the same allocations in both problems.

[16] At equilibrium, $u'(c_i)/\beta u'(c_i') = [R^*/(R^* - \theta)][(MRPK_i/p') + 1 - \delta - \theta]$ for these firms (see section 3.4.3).

These firms behave as those in standard models of misallocation caused by credit constraints: MRPK equals $p(r^*+\delta)$ plus the marginal cost of capital associated with the tightness of the credit constraint. This cost is given by the shadow value of the constraint η_i, which is in terms of marginal utility, multiplied by $(R^* - \theta)$ (i.e., the opportunity cost of capital net of the benefit that an additional unit of capital provides as pledgeable collateral). Misallocation thus results from dispersion in the MRPKs of credit-constrained firms that operate below their optimal scale. The MRPKs of these firms differs across themselves too, with higher MRPKs for those that are more constrained. Importantly, for a firm of productivity z, the excess of MRPK over its efficient level and the OSG in k' decrease monotonically as a' rises.

Consider next a case in which CCs are present but there are no collateral constraints.

Proposition 4. *When $\theta \to \infty$ and $\nu > 0$ (no collateral constraint with CCs), if firm i would need to borrow at R^* to reach its optimal scale, $MRPK_i > \overline{MRPK} = p(r^* + \delta)$ and $k_i < \bar{k}_i$.*

Proof. If $\theta \to \infty$, $\nu > 0$, and firm i would need to borrow at R^* to reach $\bar{k}_i$, the CCs bind and the first-order conditions of the second-state problem imply

$$MRPN_i = w, \text{and}$$

$$MRPK_i = \mathbb{1}_{d_i>0}[p(\hat{r} + \delta)] + \mathbb{1}_{d_i\leq 0}\left[p(r^* + \delta) + R^*\mu_i\right],$$

Firms with capital below $\bar{k}_i$ face the CCs and hence can only borrow at $\hat{r}$. When they are born, they optimally choose a debt amount so that $MRPK_i = p(\hat{r}+\delta) > \overline{MRPK}$. This is akin to the optimality condition without financial frictions but at a higher interest rate. Hence, all firms in this category jump to a pseudo-steady state with a capital stock $\bar{k}_i^{CC}$ (which differs across them only because of their z_i). Fisherian separation holds and they share a common MRPK equal to $p(\hat{r} + \delta)$. Since $\beta(1 + \hat{r}) > 1$, however, these firms find it optimal to gradually reduce their debt and increase their net worth until they pay down their debt completely ($d_i = 0$). At this point, they are free from the CCs and can save at interest r^*. But they would like to borrow to jump to $\bar{k}_i$. Since they cannot, the constraint that there is no borrowing at R^* binds ($\mu_i > 0$), and thus they start accumulating capital gradually, effectively as if they were under financial autarky.[17] As long as $k_i < \bar{k}_i$, $MRPK_i = [p(r^* + \delta) + R^*\mu_i] > \overline{MRPK}$

[17] At equilibrium, $u'(c_i)/\beta u'(c_i') = (MRPK_i/p') + 1 - \delta$ for these firms (see section 3.4.3).

because $\mu_i > 0$. Moreover, in this case, the MRPK's differ also across firms in this category, with those more distant from $\bar{k}_i$ having higher MRPK. □

CCs distort the allocation of capital in two ways. First, all firms pay the same tax rate when borrowing from abroad, which increases the opportunity cost of funds by the same amount to all firms in a way akin to the efficiency wedge of debt taxes in representative agent models. Second, there is also variation due to heterogeneity in the financial conditions of firms that representative agent models miss: μ_i is larger for firms that are more debt constrained (i.e., firms with lower a' that would have liked to borrow at R^* but not at $\hat{R}$).

3.4.3 Static effects of capital controls

Our main goal is to compare the *NCC* regime with one in which both credit constraints and capital controls are present, the *CC* regime. We study first how the two regimes compare in terms of the entrepreneurs' second-stage optimization problem of maximizing cash on hand for given a' and given aggregate prices, wages and output. We refer to these results as the "static" effects of capital controls. Conditions (25)-(29) and Propositions 3 and 4 provide the main tools for this analysis.

Figure 1 plots an entrepreneur's choice of k' for given a' in both regimes in the interval $a' \in [\underline{k}, \bar{k}]$ (for a given value of z and keeping (y, p, w) constant). The two horizontal lines correspond to $\bar{k}$ and $\bar{k}^{cc}$. The 45° ray corresponds to $k' = a'$, which is the capital choice when the capital controls prevent borrowing at R^*. The rays with slopes of $R^*/(R^* - \theta) > \hat{R}/(\hat{R} - \theta) > 1$ indicate the choices of k' consistent with the collateral constraint when the interest rate is R^* and $\hat{R}$, respectively. The red and yellow piece-wise linear functions show the optimal second-stage choice of k' as a function of a' in the *CC* and *NCC* regimes, respectively.

Conditions (25)-(29) imply that the choice of k' in the *CC* regime can be broken down into the four regions labeled in the Figure:[18]

1. *Binding collateral constraints at higher borrowing costs:* For $a' \in [\underline{k}, ((\hat{R} - \theta)/\hat{R})\bar{k}^{CC}]$, the outcome is analogous to Proposition 3, but substituting R^* for $\hat{R}$ and $\bar{k}^{CC}$ for $\bar{k}$. The firm would like to borrow at $\hat{R}$ to jump to $\bar{k}^{CC}$ but is credit constrained, so it

[18]For the numerical solution, it is important that in each region the system (25)-(29) has closed-form solutions for (k', d', p'_h, p'_f, n') given $(a', z; y', p', w')$ that do not depend on consumption. Hence, $\tilde{m}'(\cdot)$ is well defined.

can only attain $k'(a') = [\hat{R}/(\hat{R}-\theta)]a'$. As Proposition 3 showed, firms in this category have higher MRPK the further away they are from $\bar{k}^{CC}$. MRPKs differ across these firms and they all differ from $\overline{MRPK}$. As we show later, these firms have stronger incentives to save because they face a higher endogenous effective interest rate given by $\hat{R}\,[1+(\eta/p')]$. Thus, they increase a' and k' gradually until they reach $\bar{k}^{CC}$.

2. *CCs increasing borrowing costs for firms unaffected by the collateral constraint:* For $a' \in (((\hat{R}-\theta)/\hat{R})\bar{k}^{CC}, \bar{k}^{CC}]$, the outcome is related to Proposition 4. These firms have attained the pseudo-steady state consistent with $\hat{R}$, and since $\beta\hat{R} > 1$, they also have incentives to save and thus gradually pay down their debt to zero. MRPK is the same for all firms in this category, but since $\hat{R} > R^*$, it exceeds $\overline{MRPK}$.

3. *CCs preventing firms to borrow at the rate R^*:* For $a' \in [\bar{k}^{CC}, \bar{k})$, the outcome is also related to Proposition 4. The firm has no debt, so it faces the interest rate R^*. It would like to borrow to jump to $\bar{k}$ but it cannot at this rate because of CCs. Hence it chooses $k' = a'$. MRPKs differ across firms in this category and they are higher for the more debt-constrained, and they all exceed $\overline{MRPK}$. Similar to region 1, these firms have stronger incentives to save because of a higher endogenous effective interest rate given by $R^*\,[1+(\mu/p')]$. Thus, a' and k' rise gradually until reaching $\bar{k}$ while maintaining $d' = 0$.

4. *Firms at their optimal scale:* For $a' \geq \bar{k}$, the firm has attained its optimal scale. It does not need to borrow, and hence neither the collateral constraint nor the capital controls affect it. Any firm with $a' > \bar{k}$ would have a positive position in foreign bonds, instead of debt, given by $d' = R^*[\bar{k}-a'] < 0$. As Proposition 1 shows, these firms have the same MRPK and it is equal to $\overline{MRPK}$.

Figure 1 shows that, for a given (a', z) and keeping (y, p, w) the same, k' is (weakly) smaller in the CC case than in the NCC case (i.e., OSGs are larger), except for firms that have attained their optimal scale (region 4). In region 1, the collateral constraint supports a higher capital stock with R^* than with $\hat{R}$.[19] In region 2, firms in the CC regime are at

[19]The contribution of this region to overall misallocation is small. Quantitatively, unless ν is large, $[R^*/R^*-\theta)]$ and $[\hat{R}/(\hat{R}-\theta)]$ are very similar and thus the yellow and red rays are very similar. Theoretically, the two differ because the collateral constraint is in terms of the debt repayment at $t+1$. Defining it instead in terms of the debt sold at t, $qd_{t+1} \leq \theta k_{t+1}$,the two rays are identical with a slope of $1/(1-\theta)$.

the pseudo-steady state $\bar{k}^{cc}$, and $R^* > \hat{R}$ implies that $\bar{k} > \bar{k}^{cc}$. In region 3, firms in the CC regime hit the no-borrowing constraint and set $k' = a'$, which is less than their optimal scale $\bar{k}$, while firms in the NCC regime are already at $\bar{k}$.

The lower k' under CCs translates into higher $MRPKs$. To show this, note that equations (25)-(29) yield these three conditions:

$$p_h'(a') = \left[\frac{[(p')^\sigma y' + (p^*)^\sigma \tau^{1-\sigma} y^*]^\alpha}{z\,(k'(a',z))^\alpha \left[\frac{1-\alpha}{w'\varsigma}\right]^{1-\alpha}} \right]^{\frac{1}{1+\alpha(\sigma-1)}} \tag{30}$$

$$\frac{k'}{n'}\,(a') = \left[\frac{w'\varsigma}{(1-\alpha) z p_h'(a',z)} \right]^{1/\alpha} \tag{31}$$

$$MRPK(a') = \frac{\alpha z}{\varsigma} \frac{p_h'(a',z)}{\left[\frac{k'}{n'}\,(a',z)\right]^{1-\alpha}} \tag{32}$$

For given $(a', z; y', p', w')$, the lower $k'(a')$ in the CC regime implies that the firm charges a higher $p_h'(a')$ (condition (30)) and this implies that it has lower $\frac{k'}{n'}\,(a')$ (condition (31)). These two effects increase its $MRPK(a')$ (condition (32)).

Figure 1 yields another important result: While with the standard collateral constraint the excess of MRPK over the efficient level and the OSGs are strictly decreasing in a', with CCs there is a region in which both are invariant in a' (region 2). As a' increases, a firm's misallocation falls monotonically in the NCC regime until it vanishes when it reaches its optimal scale. In contrast, in the CC regime, MRPK falls with a' in region 1 (always higher than in the NCC regime, since $k(a')$ is smaller), then is constant as a' rises in region 2 (since in this region $k(a')$ is independent of a'), and then decreases again in region 3 until it vanishes (since this region is akin to region 1 but with $\theta = 0$). As a result, the differences in OSG and MRPKs between the NCC and CC regimes are non-mononotinc in a'. The OSG and MPRKs differ little for firms with either a' high enough to be close to $\underline{a}$ or high enough to be close to the optimal scale, and they are at their largest when net worth is in region 2. This non-monotonicity will play an important role in explaining non-linear effects of CCs on misallocation, differences between CCs and LTV regulation as alternative policies to reduce credit, and non-linearities identified in the results of the empirical analysis of the effects of CCs based on Chilean firm-level data.

Using condition (32), the difference in MRPKs ($\Delta MRPK(a') \equiv MRPK_{CC}(a') - MRPK_{NCC}(a')$) across regimes for a common a' is:

$$\Delta MRPK(a') = \frac{\alpha z}{\varsigma}\left[\frac{p'_{h,CC}(a')}{\left[\frac{k'}{n'}_{CC}(a')\right]^{1-\alpha}} - \frac{p'_{h,NCC}(a')}{\left[\frac{k'}{n'}_{NCC}(a')\right]^{1-\alpha}}\right] \geq 0, \tag{33}$$

which equals zero only in region 4. As explained earlier, $\Delta MRPK(a')$ is non-monotonic in a'. It is zero or close to zero for firms with net worth close to $\underline{a}$ or $\overline{k}$, and is at its maximum where $k' = \overline{k}^{CC}$ at each level of z.

The above is a characterization of MRPKs in physical terms. We can use the right-hand-side of condition (26) to express $\Delta MRPK$ in financial terms. In regions 1 and 2, where firms are borrowing and the collateral constraint may bind in one or both regimes:

$$\Delta MRPK|_{d'_{CC}>0} = \left(p'_{CC} - p'_{NCC}\right)(r^* + \delta) + \nu p'_{CC}\left(1 + \frac{\tilde{\eta}_{CC}}{\tilde{\beta}u'(c'_{CC})}\right) + \left(\frac{p'_{CC}\tilde{\eta}_{CC}}{\tilde{\beta}u'(c'_{CC})} - \frac{p'_{NCC}\tilde{\eta}_{NCC}}{\tilde{\beta}u'(c'_{NCC})}\right)(R^* - \theta), \tag{34}$$

where we used the condition $\eta = p'\frac{\tilde{\eta}}{\tilde{\beta}u'(c')}$ to replace η, the multiplier of the collateral constraint when maximizing m, with its equivalent in terms of the multiplier of the constraint when maximizing lifetime utility ($\tilde{\eta}$). When the constraint tighthens, $\frac{\tilde{\eta}}{\tilde{\beta}u'(c')}$ rises because $\tilde{\eta}$ increases and, since the credit constraint forces consumption into the future, $u'(c')$ falls.

Evaluating the above expression keeping aggregate variables constant, yields $\Delta MRPK|_{d'_{CC}>0} = \nu(p' + \frac{\tilde{\eta}_{CC}}{\tilde{\beta}u'(c'_{CC})}) + (p'/\tilde{\beta})\left(\frac{\tilde{\eta}_{CC}}{u'(c'_{CC})} - \frac{\tilde{\eta}_{NCC}}{u'(c'_{NCC})}\right)(R^* - \theta) > 0$, which must be positive as implied by (33). Hence, the differences in p_h and k/n that explain higher MRPKS for a given a' in the CC regime in regions 1 and 2 are due to (a) the higher borrowing cost ν affecting all firms equally (the term $\nu p'$) and more those that are more constrained (the term $\nu\frac{\tilde{\beta}\tilde{\eta}_{CC}}{u'(c'_{CC})}$) and (b) if the collateral constraint is binding, firm-specific differences in the tightness of this constraint across regimes $\left(\frac{\tilde{\eta}_{CC}}{u'(c'_{CC})} - \frac{\tilde{\eta}_{NCC}}{u'(c'_{NCC})}\right) > 0$, which is positive because, for a given a', the constraint always binds more in the CC regime.[20]

In region 3, where firms hit the no-borrowing constraint in the CC regime and the

[20] For a common (a', z), the constraint allows for more debt in the NCC regime since $R^*/(R^*-\theta) > \hat{R}/(\hat{R}-\theta)$.

collateral constraint may or may not bind in the NCC regime:

$$\Delta MRPK|_{d'_{CC}\leq 0} = \left(p'_{CC} - p'_{NCC}\right)(r^* + \delta) + R^* \left(\frac{p'_{CC}\tilde{\mu}_{CC}}{\tilde{\beta}u'(c'_{CC})} - \frac{p'_{NCC}\tilde{\eta}_{NCC}}{\tilde{\beta}u'(c'_{NCC})}\right) + \theta \frac{p'_{NCC}\tilde{\eta}_{NCC}}{\tilde{\beta}u'(c'_{NCC})}, \tag{35}$$

where we made the same substitution for η as above and we also used the condition $\mu = p'\frac{\tilde{\mu}}{\tilde{\beta}u'(c')}$ to replace μ, the multiplier of the no-borrowing constraint when maximizing m, with its equivalent in terms of the multiplier of the same constraint when maximizing lifetime utility ($\tilde{\mu}$). When this constraint tightens, $\frac{\tilde{\mu}}{\tilde{\beta}u'(c')}$ rises for the same reason as $\frac{\tilde{\eta}}{\tilde{\beta}u'(c')}$.

For firms in region 3 in the CC regime that would be already at their optimal scale in the NCC regime, the above expression reduces to $\Delta MRPK|_{d'_{CC}\leq 0} = R^* \frac{p'\tilde{\mu}_{CC}}{\tilde{\beta}u'(c'_{CC})} > 0$, with more constrained firms showing larger MRPK differences across regimes. If the collateral constraint binds in the NCC regime, the difference in MRPKs depends also on how much tighter is the no-borrowing constraint in the CC regime than the collateral constraint in the NCC regime.[21]

The trade status of firms also matters for these results. Exporters have larger optimal scales than non-exporters for a given z. The effects of CCs for firms that are below their optimal scale depend on the their net worth. If a' is small enough so that an exporter and a nonexporter are in region 1, they both choose the same k', but the exporter charges a higher price, because of the effect of foreign demand on p'_h (see condition (30)), and thus it also has a lower capital-output ratio and these two effects result in a higher MRPK. Since all firms face the same $\overline{MRPK}$, misallocation is higher for the exporter. If the non-exporter is in region 2 or 3, however, the exporter (or a firm that switches to become an exporter) chooses a larger k' than the non-exporter. As condition (30) shows, this tends to offset the effect pushing for a higher price because of the foreign sales. The price may rise less or even fall and thus the capital-output ratio may fall less or even rise. Hence, MRPK of the exporter may be larger or smaller than for the nonexporter. If a' is large enough for the non-exporter to be in region 4, it has reached its optimal scale and remains there since it has no incentive to grow is net worth further (as we show below). Hence, it remains a nonexporter until it dies and it has no misallocation. In contrast, an exporter with the same (a', z) but still below its optimal

[21] $\mu_{CC} > \eta_{NCC}$ because, for a common (a', z) in region 3, if firms in the NCC regime are constrained, the collateral constraint with R^* allows for more debt than the no-borrowing constraint in the CC regime.

scale has higher k' than the nonexporter but less than its own optimal scale, so it has positive misallocation and thus more misallocation than the nonexporter.

Figure 1 is also helpful for interpreting the implications of using LTV regulation (i.e., lowering θ) instead of CCs for misallocation. Intuitively, think first of lowering the collateral coefficient to a value $\tilde{\theta}$ so that the ray where the constraint binds in the CC regime in Figure 1 matches a regime without CCs but with a collateral constraint set at $\tilde{\theta}$ (i.e., $\tilde{\theta}$ such that $\hat{R}/(\hat{R}-\theta) = R^*/(R^*-\tilde{\theta})$. Relative to the CC regime, misallocation would be the same in region 1 but lower in regions 2 and 3. Overall misallocation would therefore fall relative to the CC regime. For $0 < \theta < \tilde{\theta}$, however, misallocation would be larger than with CCs in region 1 and smaller in regions 2 and 3. What happens with overall misallocation depends on the relative fractions of firms for which misallocation rose and fell in the stationary distribution. Moreover, it also becomes evident that the LTV regulation distributes more evenly the burden of reducing credit than the CCs.

3.4.4 Dynamic & general equilibrium effects

The previous analysis is incomplete because taking a' as given implies that *dynamic effects* resulting from differences in the net-worth decision rule that solves the entrepreneurs' first-stage optimization problem, $a'(m,z)$, across the CC and NCC regimes are ignored. These differences imply different locations along the horizontal axis of Figure 1 and therefore different $k'(a'(m,z))$ decisions. Moreover, keeping (w',p',y') constant implies that *general equilibrium (GE) effects* are also ignored. The two regimes yield different stationary distributions which affect aggregate demand and supply allocations that determine (y',p',w'). Even for firms in region 4, MRPKs in the CC regime differ from the value of $p(r^*+\delta)$ in the NCC regime, because p differs. MRPNs also differ, since w also differs. Hence, GE effects alter both the optimal scale of firms and the stringency of the credit constraints.

We shed some light on the dynamic effects by examining the entrepreneurs' optimal consumption and saving plans. Applying the envelope theorem to the first-stage optimization problem of exporters (problem (18)) yields this Euler equation:

$$u'(c) = \beta u'(c') \frac{\delta \tilde{m}'(a',z;y',p',w')}{\delta a'} \tag{36}$$

Differentiating condition (19) and simplifying using conditions (25)-(26), we find that:

$$\frac{d\tilde{m}'(a', z; y', p', w')}{da'} = \mathbb{1}_{d'>0}\left[\hat{R}\left(1+\frac{\eta}{p'}\right)\right] + \mathbb{1}_{d'\leq 0}\left[R^*\left(1+\frac{\mu}{p'}\right)\right], \tag{37}$$

with the caveat that this derivative is not defined at the kinks where the $k'(a')$ function changes regions, since $k'(a')$ is piece-wise linear and changes slope at the kinks.

It follows from the above two results that in regions 2 and 4, $u'(c)/\beta u'(c') = R$ where R equals $\hat{R}$ and R^*, respectively. Thus, region 4 yields the familiar result from small open economy models without financial frictions: Entrepreneurs that have reached their optimal scale are unaffected by CCs and collateral constraints and make optimal saving plans so as to equate their intertemporal marginal rate of substitution (IMRS) in consumption with the world's real interest rate R^*. Since $\beta R^* = 1$, these entrepreneurs desire consumption to be stationary. Something similar occurs in region 2, for firms that borrow at the rate $\hat{R}$ unaffected by the collateral constraint, except that the real interest rate is higher because of the capital controls. Since $\beta\hat{R} > 1$, these entrepreneurs are at the pseudo-steady state of capital but still desire to reallocate consumption into the future by saving.

In region 1, for entrepreneurs that borrow at $\hat{R}$ but are credit constrained, we obtain:

$$\frac{u'(c)}{\beta u'(c')} = \hat{R}\left[1+\frac{\eta}{p'}\right] = \frac{\hat{R}}{\hat{R}-\theta}\left[\frac{MRPK'}{p'} + 1 - \delta - \theta\right] \tag{38}$$

and in region 3, for entrepreneurs that hit the no-borrowing constraint at R^*, we obtain:

$$\frac{u'(c)}{\beta u'(c')} = R^*\left[1+\frac{\mu}{p'}\right] = \left[\frac{MRPK'}{p'} + 1 - \delta\right]. \tag{39}$$

These two cases are analogous in that (a) the financial distortions increase the effective real interest rate faced by the entrepreneurs and (b) the IMRS and the net marginal return on capital accumulation are equalized as if entrepreneurs were in financial autarky, so that there is no Fisherian separation between the consumption/saving choice and the investment choice.

These findings imply that CCs have differential effects across entrepreneurs in the CC regime relative to the NCC regime. For entrepreneurs in region 1, CCs tighten the collateral constraint, increasing both the contractual borrowing rate from R^* to $\hat{R}$ and the effective interest rate inclusive of the shadow value of the constraint. In this region, the higher interest rate reduces the ability to leverage net-worth to invest in physical capital and at the same time it reduces the incentive to borrow overall, because $\hat{R}$ represents a higher intertemporal relative price of consumption. For those in region 2, only the latter effect is present. For those in region 3, the CCs imply they have yet to reach their optimal scale and they hit the no-borrowing constraint that increases the borrowing rate from R^* to a higher effective rate inclusive of the shadow value of the constraint. Hence, firms in this region are affected by the inability to leverage investment on net-worth but the intertemporal relative price of consumption is R^*. Finally, entrepreneurs in region 4 are unaffected.

The saving distortions have important dynamic implications that also differ across regimes. Because $\beta R^* = 1$, region 4 yields $IMRS = R^*$ and $u'(c) = u'(c')$, so that there is no incentive to save or disave. In contrast, in all other regions $IMRS > R^*$ so entrepreneurs have the incentive to reallocate consumption into the future by saving (increasing a'). As eqs. (38)-(39) show, this effect is stronger for entrepreneurs borrowing at $\hat{R}$ but affected by the collateral constraint and more for those who are more constrained (for these entrepreneurs, $IMRS_i = \hat{R}\left(1 + \frac{\eta_i}{p'}\right) > \hat{R}$), followed by those who borrow at $\hat{R}$ but are unconstrained (with $IMRS_i = \hat{R} > R^*$) and then those prevented from borrowing at R^* by the CCs (with $IMRS_i = R^*\left(1 + \frac{\mu_i}{p'}\right) > R^*$). Thus, even tough the "static" effects of misallocation summarized in Figure 1 predict lower $k'(a')$ and higher $MRPK(a')$ in the CC than the NCC regime for a common a', this pattern of saving distortions incentivizes higher saving and faster adjustment to the optimal scale (higher decision rules $a'(m, z)$) for firms facing tighter financial constraints and higher interest rates, and this pattern differs across regimes. Hence, in principle, it is possible that an entrepreneur with some (m, z) would save sufficiently more under capital controls (i.e., $a'^{CC}(m, z) > a'^{NCC}(m, z)$) so that eqs. (30)-(32) would predict that MRPK is higher *without* CCs.

It is worth noting that even tough the model lacks a domestic credit market and the interest rates $\hat{R}$ and R^* are exogenous, the effective interest rates faced by credit-constrained entrepreneurs in regions 1 and 3 are endogenous (they depend on η and μ, see eqs. (38)-(39)) and they vary with their corresponding MRPKs. This is akin to a model in which each firm faces an endogenous interest rate determined by its MRPK, and the resulting set of interest rates decentralizes an outcome where lenders do not impose credit constraints but instead tailor the interest rate at which each firm borrows so as to satisfy the credit constraints.

The GE effects of CCs operating via changes in y, p, w and the dynamic effects are difficult to characterize in analytic form. Intuitively, they interact with the static effects to determine the differences across the stationary equilibria of the CC and NCC regimes. Regarding GE effects, the interaction with the static effects works via the effect shown earlier that firms in the CC regime set higher prices for the input they sell, which exerts pressure for p to be higher simply as an implication of the CES price index. On the other hand, higher input prices reduce demand for these inputs by the producer of final goods, putting downward pressure on w, p and y. The share of firms that are exporting also matters, since foreign sales exert pressure for them to post higher prices and they face a weaker demand response to their price increases (y^* is assumed to be independent of the variation in the price of inputs domestic firms sell abroad).

The GE effects on misallocation will be reflected in $\Delta MRPK$. Conditions (34)-(35) show that there is a first-order effect of changes in p that induces differences in the efficient level of MRPK in each regime. If $p_{NCC} > p_{CC}$, as will be the case in our calibrated model, this GE effect will push for *lower* misallocation in the CC regime. There are also second-order effects, because differences in (y, p, w) matter for the tightness of the credit constraints that determine $\Delta MRPK$.

The interaction with the dynamic effects works through differences in net-worth decision rules across CC and NCC regimes and in the stationary distributions of firms that they induce ($\phi^{CC}(m, z)$ and $\phi^{NCC}(m, z)$, respectively). The latter are key for determining aggregate demand in the labor and final-goods markets and aggregate prices and wages. Moreover, although the combined effect of the static and GE effects of CCs for a given a' is fully determined by evaluating conditions (30)-(32) using equilibrium prices and allocations, the overall changes on prices, allocations, MRPKs and social welfare across the CC and NCC regimes depend on differences in decision rules and in the distributions $\phi^{CC}(\cdot)$ and $\phi^{NCC}(\cdot)$. In particular, these distributions provide the welfare weights for the utilitarian social welfare function we assume. A particular pattern of differences in MRPKs at equilibrium, determined by evaluating $\Delta MRPK(a')$ using the equilibrium decision rules $a'^{CC}(m, z)$ and $a'^{NCC}(m, z)$, for the CC and NCC regimes respectively, yields a particular welfare effect depending on how firms with higher vs. lower MRPK are weighted.

3.4.5 Social welfare measures

We study welfare effects using a standard welfare measure based on *individual* (percent) compensating variations in consumption ($g(m, z)$) that make each entrepreneur as well off in the stationary equilibrium under the NCC regime as in the CC regime:[22]

$$g(m,z) = \left(\frac{V^{CC}(m,z;\bar{y}^{CC},\bar{p}^{CC},\bar{w}^{CC})}{V^{NCC}(m,z;\bar{y}^{NCC},\bar{p}^{NCC},\bar{w}^{NCC})} \right)^{\frac{1}{1-\gamma}} - 1, \tag{40}$$

where $\bar{y}^i, \bar{p}^i$ and $\bar{w}^i$, for $i = CC, NCC$, denote the steady-state values of the aggregate variables in each regime. We then measure an *aggregate utility* effect by averaging using $\phi(m, z)$:

$$\bar{g}^i = \int g(m,z) d\phi^i(m,z) \tag{41}$$

where $i = CC, NCC$. Hence, $\bar{g}^{CC}$ ($\bar{g}^{NCC}$) uses $\phi^{CC}(m, z)$ ($\phi^{NCC}(m, z)$) as weights and thus aggregates the individual welfare gains according to the stationary distribution of the CC (NCC) regime. We also compute the *social welfare* effect by adopting a utilitarian social welfare function (SWF), which uses $\phi(m, z)$ as weights, and calculating a compensating consumption variation that equalizes social welfare across the two regimes:

$$G^i = \left[\frac{\int V^{CC}(m,z) d\phi^i(m,z)}{\int V^{NCC}(m,z) d\phi^i(m,z)} \right]^{\frac{1}{1-\gamma}} - 1, \tag{42}$$

where $i = CC, NCC$. These measures use the same weights to evaluate social welfare in the NCC and CC regimes. We also construct a third social welfare measure that uses the stationary distribution of each regime to evaluate the corresponding social welfare:

$$G = \left[\frac{\int V^{CC}(m,z) d\phi^{CC}(m,z)}{\int V^{NCC}(m,z) d\phi^{NCC}(m,z)} \right]^{\frac{1}{1-\gamma}} - 1. \tag{43}$$

[22]Given the definition of m, we can define $m(a, z; \bar{y}, \bar{p}, \bar{w}) = [\bar{w} + \frac{p_h(a)^{1-\sigma}}{\bar{p}^{-\sigma}} \bar{y} + e \frac{p_f(a)^{1-\sigma}}{p^{*-\sigma}} y^* - \bar{w}n + \bar{p}(1 - \delta)k(a) - \bar{p}d(a) - T]/\bar{p}$ as the cash on hand in the stationary equilibrium for an entrepreneur with the values of k, d, p_h, p_f, n set by the corresponding decision rules that are functions of the individual variables (a, z) and of the aggregate variables set at their steady-state values $(\bar{y}, \bar{p}, \bar{w})$. The exception are newborn entrepreneurs, who have $k = a = \underline{k}$ and $d = 0$ set by initial conditions but still choose p_h, p_f, n optimally by using conditions (25), (27) and (28) taking as given $k = \underline{k}$.

Note that $\bar{g}^i$ and G^i isolate the welfare measures from the first-order effect of changes in the stationary distribution of firms across regimes, while G includes this effect.[23] Also, all of these measures compare only stationary equilibria, they do not include the transitional dynamics from the NCC regime to the CC regime.

These social welfare assessments are determined by the effect of CCs on the entrepreneurs' consumption plans and lifetime utility, jointly with the stationary wealth distribution. Since we focus on stationary equilibria, we can analyze how consumption plans are affected by analyzing how income from labor and capital varies across entrepreneurs. The budget constraint implies that all of them are affected uniformly by changes in the real wage, w/p. How much this matters for their individual consumption depends, however, on their relative reliance on capital income. To analyze this, we use the optimality conditions of the entrepreneurs' second-stage problem to yield these expressions:

$$\frac{p^h(a',z)}{p} = \frac{\varsigma(r+\delta)^\alpha}{(1-\alpha)^{1-\alpha}\alpha^\alpha z}\left(\frac{w}{p}\right)^{1-\alpha}\left(\frac{MRPK(a',z)}{p(r+\delta)}\right)^\alpha \tag{44}$$

$$\frac{\pi(a',z)}{p} = \frac{y + \frac{1}{\tau^{\sigma-1}}\left(\frac{p^*}{p}\right)^\sigma y^*}{\left(\frac{p^h(a',z)}{p}\right)^{\sigma-1}}\left[1 - \frac{(1-\alpha)}{\varsigma}\right], \tag{45}$$

where $\pi/p \equiv [p^h y^h + p f^y f - wn]/p$ are the real profits of an entrepreneur. Condition (44) shows that a firm's relative price is a geometric weighted average of the real wage and the ratio of the firm's MRPK relative to the efficient one. Since the latter changes non-monotonically with a' under CCs, the effect on relative prices is also non-monotonic. Real wages are the dominant determinant for firms with a' low (large) enough to be in region 1 (4), but for firms in regions 2 and 3 the MRPK term can dominate. If, as will be the case in our baseline quantitative results, w/p falls with CCs, the former group of firms cuts prices and from (45) this implies that their profits rise. For firms in the second group with sufficiently large MRPKs, the opposite holds: they raise prices and their profits fall. Hence, CCs redistribute consumption so that firms in regions 2 and 3 (1 and 4) consume relatively less (more). Notice that profits are also affected by the GE changes in y and p. For the latter, a real appreciation (higher p) reduces profits because the real value of exports falls as p^*/p falls.

[23] Second-order effects of changes in $\phi(\cdot)$ are still present because aggregate demand for labor and final goods, and therefore y, p and w, respond as $\phi(\cdot)$ changes.

4 Quantitative Analysis

We calibrate the *NCC* regime using Chilean data for 1990-1991, before the introduction of the capital controls. A subset of the parameter values are set to widely-used values or taken from estimates found in the related literature and the rest are set so that the *NCC* stationary equilibrium matches a set of target data moments. Table 1 lists the calibrated parameter values. We then construct the *CC* regime by setting the value of ν (the tax-equivalent measure of Chile's unremunerated reserve requirement on capital inflows), solve for the stationary equilibrium, and compute the effects of CCs on misallocation and welfare.

4.1 Calibration

The parameters assigned commonly-used values or values taken from the misallocation literature are $\{\gamma, \beta, \sigma, \delta, \rho, r^*\}$. The coefficient of relative risk aversion and the subjective discount factor are set to standard values of $\gamma = 2$ and $\beta = 0.96$. Hence, $R^* = 1/\beta = 1.04167$. The rate of depreciation $\delta = 0.06$ is taken from Midrigan and Xu (2014). The elasticity of substitution across varieties $\sigma = 4$ is from Leibovici (2021), who also calibrates a model to Chilean data and uses this value of σ based on estimates from Simonovska and Waugh (2014). The exit rate of firms is $\rho = 0.08$ which is the average exit rate in the Chilean dataset described below over the 1990-2007 period.

For the quantitative analysis, we introduce two additional features left out from the model analyzed in the previous section for tractability. First, we allow $\underline{k}$ to vary with z. The capital injection given to a newborn entrepreneur with productivity draw z is a fraction κ of its steady state-capital $\underline{k}(z) = \kappa\bar{k}(z)$, taking into account that $\kappa\bar{k}(z)$ is higher for exporters than for non-exporters. This rules out the possibility that, with a common $\underline{k}$ for all entrepreneurs, those with sufficiently low z could start with $\underline{k} > \bar{k}(z)$. Second, we capture the well-established empirical fact that exporters have better access to credit markets (e.g., Muuls (2015))) by setting the fraction of capital pledgeable as collateral higher for exporters than for non-exporters (i.e., $\theta^E > \theta^{NE}$).

The parameter values determined by targeting data moments are $\{\tau, \omega_z, F, \theta_f, \theta^{NE}, \kappa, \alpha\}$, where we define $\theta^E = (\theta_f + 1)\ \theta^{NE}$. The data targets are: (1) the share of firms that export (0.18); (2) the average sales of exporters divided by average sales of non-exporters (8.55); (3)

the ratio of average sales of five- to one-year-old firms, among new firms that survive for at least five years (1.26); (4) aggregate exports as a fraction of total sales (0.21); (5) aggregate credit as a fraction of value added (0.20); (6) the aggregate capital stock divided by the wage bill (6.6); and (7) the ratio of the investment shares in value added of exporters to non-exporters (1.84). These targets are averages computed using Chile's *Encuesta Nacional Industrial Anual* (ENIA) for the 1990-1991 period, except for aggregate credit that corresponds to the mean of outstanding credit in manufacturing as share of value added from 2000 to 2007, using credit data from the Superintendencia de Bancos e Instituciones Financieras de Chile.[24] We choose the 1990-1991 period because capital controls were implemented only in mid-1991 and, arguably, did not affect the data reported for these years. The calibration is executed using an SMM algorithm with equal weight on each parameter (i.e., minimizing the squared differences of moments in the model from their data targets). The resulting parameter values are $\{\tau = 3.64, \omega_z = 0.437, F = 1.505, \theta^{NE} = 0.046, \theta^{E} = 0.1011, \kappa = 0.2994, \alpha = 0.471\}$.

Table 2 shows the data targets and their model counterparts in the stationary equilibrium of the calibrated NCC economy. The NCC calibration delivers moments quite close to the data moments.

For the CC regime, the value of ν is determined following the methodology proposed by De Gregorio et al. (2000) applied to a loan maturity of 12 months (see Appendix B) using the calibrated value of r^* (0.0416). The average for the period 1991-1998 yields $\nu = 0.0175$, which is sizable relative to the value of r^*.

4.2 Positive effects of capital controls

As explained in Section 3.4, misallocation arises in the model only when financial distortions are present. The collateral constraint causes misallocation by itself and by a magnitude that is monotonically larger for firms with smaller net worth. When CCs are added, misallocation is the result of the static, dynamic and GE effects we described. The static effects worsen misallocation unambiguously (with effects that are no longer monotonic in net worth) but the dynamic and GE effects trigger mechanisms that can work in the opposite direction. Hence, quantitative exploration is necessary for assessing how capital controls affect misallocation and social welfare.

[24] ENIA is available since 1980 but exports data are available starting in 1990. See Section 5 for details.

Column (1) of Table 3 shows statistics summarizing the aggregate effects of introducing capital controls in the calibrated benchmark economy. These aggregate effects are significant and, as explained below, play an important role on the overall effects of CCs on misallocation and welfare. The three key aggregate variables driving the GE effects fall, with y, p, and w falling 0.57%, 0.11% and 0.56%, respectively. Hence, real wages in units of final goods (w/p) fall 0.46%, a similar order of magnitude as the 0.49% fall in aggregate consumption. Aggregate investment declines 1%, aggregate domestic sales of intermediate goods 0.60% and the share of firms that are exporters 1.62%. Interestingly, aggregate exports themselves actually decrease only 0.22%, as the decline in prices embodies lower firm prices for both domestic and foreign sales, so the larger exporter firms are able to sell more abroad as they lower their prices. Note also that there is a large reduction of nearly 14% in the ratio of credit to value added. Hence, CCs yield a sizable fall in credit and are thus a powerful policy for reducing credit.

Consider next the effects of CCs on misallocation. We measure misallocation for an individual firm i in either the CC or the NCC regime as the absolute value of the deviation of the log of the firm's MRPK relative to the log of efficient level:

$$mis_i^j = abs[log(MRPK_i^j) - log(\overline{MRPK})],$$

where $j = \{NCC; CC\}$. Figure 2 shows a surface plot of the percent change in misallocation across the two regimes for firms of a given age and productivity, including firms with the 10 values of z in the discrete approximation to $f(z)$ and with τ from 0 to 200 years of age.[25] Since the misallocation measure uses the equilibrium outcomes for MRPKs that combine the static, dynamic and general equilibrium effects, the effects of CCs shown in the Figure also combine them. Still, the four regions identified in Figure 1 to characterize only the static effects are clearly visible. Right after they are born, firms generally find themselves in region 1 (for z values larger than the second lowest), acquiring debt to finance investment subject to the collateral constraint as they growth their net worth. Misallocation worsens by a relatively small percentage that raises with τ for each z. Firms with the two lowest values of z, on the other hand, start very close to or at region 2, so region 1 is not visible.[26] As a firm

[25] Recall that the stationary distribution in terms of τ and z is exogenous and the same across regimes, but firms of the same τ and z have different m, a, k and d and also make different price and production decisions.

[26] Firms with low z still receive payment w for their labor services which can be large compared to their

reaches its pseudo steady state in the economy with capital controls (region 2), misallocation worsens at sharply faster rate (recall the OSGs and MRPKs of firms are nonmonotonic in net worth as we move from region 1 into regions 2, 3 and 4) and this is again evident in the figure. Misallocation peaks at the vertex between regions 2 and 3 and then starts declining until it vanishes at the vertex of regions 3 and 4, as the firm first repays its debt and then self-finances capital accumulation until it reaches its optimal scale in region 4, where there is no misallocation.

The same pattern repeats for all levels of z as firms age, with the noted caveat that region 1 is not visible for the lowest two levels of z, but there are some noteworthy differences among productivity levels. As mentioned before, firms with low z start out at region 2, so the jump in misallocation comes sooner in their life-cycle, where the mass of firms is larger. Firms with higher z, on the other hand, have larger, more persistent jumps when transiting from region 2 to region 3, but such jumps come when they are older. Finally, there is a large negative change in misallocation (i.e., higher MRPK in the NCC than in the CC regime) for the firm with $z = 6$ and $\tau = 28$. This is because this firm postpones the decision to become exporter in the CC regime to the next period. Therefore, misallocation for this firm when it does not become exporter is lower than when it does (at the same age).

Table 4 shows the change in overall misallocation across the NCC and CC regimes (column 1). Overall misallocation is computed by aggregating the firm-specific values of mis_i^j using the stationary distribution of each regime. The percent change in misallocation due to CCs is then defined as the difference across the two (since we took logs of firm-level and efficient MRPKs). To construct aggregates for groups of firms with a given characteristic (e.g., exporters), we use the distribution of firms in the CC regime to classify firms accordingly, and then compute the misallocation effect for each subgroup in the same way as for overall misallocation.[27] Misallocation increases by 0.39% overall. As is evident from Figure 2, though, there is substantial heterogeneity depending on whether the firm is exporting or not, its

optimal investment decisions. These firms may not find it optimal to borrow to accumulate capital when the capital control is in place, even in their initial periods of life.

[27] An alternative way to compute changes in misallocation for groups of firms is to first classify firms of economy j with $j = \{NCC, CC\}$ with the distribution for this economy, aggregate them and then compute the change in misallocation between the CC and the NCC economy. We prefer the computation described in the main text because it is closer in spirit to the empirical exercise of Section 5. The results using the latter specification are qualitatively similar.

level of z and the OSG that differs across regimes with their age. As a result, the change in misallocation for exporters is more than twice the change for non-exporters (0.68% v. 0.33%). Exporters have larger optimal scales and, since capital controls affect only firms that are transitioning to their optimal scales, such larger scale implies that these firms are more exposed to the policy (i.e., they are more financially dependent). Figure 2 shows that the change in misallocation is larger and more persistent for firms that are exporting (with productivity above $z = 6$).

Similarly, firms that are closest to their optimal scales, i.e. firms with a small OSG, see smaller changes in misallocation, while the converse is true for firms with large OSG, as it is clear from Figure 2.[28] Table 4 confirms this: the change in misallocation is 0.40% for the latter, while it is 0.32% for the former. The relation between OSG and the change in misallocation is not monotonic, though, because very young firms with the largest OSGs are typically in region 1, where the change in misallocation is minimal. Moreover, the higher the productivity level of the firm, the longer it takes to exit region 1 and the lower the mass of firms that do exit. This, along with the large drop in misallocation for the switcher with $z = 6$ described in detail before, translates into low productivity firms, defined as those with $z = 1$ to $z = 5$, to display larger increases in misallocation than high productivity ones (0.45% to 0.33%).

To better understand the non-monotonicities that may arise in the stationary equilibrium because of the heterogeneous effects of capital controls on misallocation, Table 5 divides firms in terms of exporters v. non-exporters and large v. small OSG. As discussed before, exporters are relatively more productive than non-exporters and have larger optimal scales, which translates into longer transitions to reach them. Indeed, non-exporters see a decrease in the % change in misallocation (from 0.33% to 0.31%) when they get relatively closer to their optimal scales, while for exporters the converse is true (from 0.68% to 1.20%). This last result is mainly due to the fact that large, productive firms spend a long time in region 3 because of dynamic effects slowing down capital accumulation in this region. Once here, their OSGs may be small but misallocation changes are relatively large. It is worth noting that, once again, changes in misallocation are larger for exporters than for non-exporters,

[28] We define a firm with small OSG as one that has a capital stock of 90% of its optimal scale or lower. Firms with large OSG are all the rest.

irrespective of their OSG.

Finally, Table 6 shows results breaking down firms by z. We can again observe the non-monotonic effect of capital controls on misallocation: while for relatively low z the % change in misallocation increases with z, this increase reaches a peak for $z = 5$ and then it decreases and stays almost flat for high levels of z. The intuition for this result can be once more grasped from Figure 2: Firms with very low z see tiny changes in misallocation because they reach their optimal scales almost immediately. As z increases, this transition takes longer and the regions where capital controls distort capital accumulation expand, with the consequent increase in misallocation. Firms with high z, however, spend many periods in region 1, where misallocation is barely changed, and reach regions 2 and 3 later in life, when many firms have already exited. The low mass of firms in these regions explains why, despite the large firm-to-firm effects shown in Figure 2, the overall change in misallocation is lower for these firms.

4.3 Welfare effects of capital controls

Figure 5 shows $g(m, z)$ at the ten levels of z considered, averaged across m. For all firms, $g(\cdot) < 0$, which is to be expected because ν is a debt tax that induces inefficiencies in saving and investment decisions, and the revenue generated by the tax is not rebated to entrepreneurs. Figure 5 shows also that the welfare losses are not-monotonic in z. They grow smaller as z rises up to $z = 5$, they increase sharply for $z = 6$ and continue to increase but a much lower pace at the three highest levels of z. The large increase in welfare costs for $z = 6$ occurs because of the firms that are at the switching phase and thus incur the one-time entry cost for exporting. This interacts with differences in the timing of switching decisions across regimes. Switchers with $z = 6$ take longer to make the switch under the CC regime, and since these entrepreneurs spend proportionally more periods remaining non-exporters, their welfare loss relative to the NCC regime is larger than for the next productivity level. Note also that firms that are already exporters benefit from the fall in wages and domestic prices (i.e., a real depreciation) associated with the CC. This allows them to increase exports and partially overturn the negative direct effect of the CC.

The large heterogeneity in welfare effects illustrated in Figure 5 reflects the differential impact of CCs on the capital and labor sources of income across firms. The 0.46% drop in real wages affects all entrepreneurs the same in terms of their labor income, but the same change in real wages combined with the firm-specific changes in misallocation induce changes in firm prices and profits that differ across entrepreneurs. In particular, condition (44) implies that a firm's relative price changes with CCs as a geometric weighted average of the real wage and the ratio of the firm's MRPK relative to the efficient one, with weights given by the labor and capital shares in production, respectively. Hence, while the fall in real wages has the same effect on all firms, pushing for lower firm relative prices, for firms that have little or no misallocation (at the start of region 1 or near the vertex of regions 3 and 4), this effect dominates so they cut prices and this raises their profits (see eq. (45)). But rising misallocation in region 2 starts to offset the relative price effect of lower real wages and for some firms it can dominate and result in them charging higher prices that reduce profits. Thus, capital income responds non-monotonically to CCs across firms and accounts for the shape of the welfare costs in Figure 5. The fall in y also reduces profits for all firms and the drop in p benefits exporters as the real exchange rate depreciates (see the numerator of eq. (45)).

The third column of Table 4 shows the social welfare losses (G) for all entrepreneurs and also for groups dividing by productivity, export status and age. Capital controls reduce social welfare by 0.37%, which is large considering that it is due to a 175-basis-points hike in the interest rate. Low-z entrepreneurs, which are all non-exporters, are less affected and suffer a welfare loss of 0.28%. Conversely, high-z firms, which include all exporters and some non-exporters, have losses of 0.54%. Welfare costs for exporters are significantly larger than for non-exporters, at 1.26% v. 0.22%. As discussed before, exporters need to borrow more to reach their optimal scales, so CCs heavily distorts their investment and consumption patterns.

4.4 Sensitivity and counterfactual experiments

We examine next the robustness of our findings and the implications of alternative policy strategies. First, we modify the model to rebate the revenue generated by debt-tax payments as a lump-sum transfer to each entrepreneur, matching what each one paid (to rule out introducing redistribution among entrepreneurs). The per-entrepreneur tax rebate is $(1 -$

$\rho)p\nu(k'(m,z) - a'(m,z))/R^*$.

Table 3 shows the effects on the model's aggregate variables and Figure 3 and Table 4 show the effects on misallocation and welfare. Figure 3 shows that the results are qualitatively very similar to the case without transfers, though the decision to start exporting is now taken earlier for firms with $z = 6$, so there is a positive peak instead of a negative one. Considering all firms, misallocation rises slightly more. This is because the tax rebates go to the more credit-constrained entrepreneurs and thus reduce the tightness of their collateral constraints. As $\eta(m,z)$ falls, the dynamic effect reducing their MRPKs that is driven by the higher effective return on saving weakens, and so the dispersion of MRPKs rises. The social welfare cost for all firms is significantly smaller: for low-z firms, that are almost not borrowing, welfare costs are smaller through the dampened effect of capital controls on wages. For high-z firms that see less severe credit constraints, welfare losses are cancelled out. In the case of exporters, welfare actually increases. This result is due to the extensive margin playing a role, as firms that enter the foreign markets benefit from an appreciated exchange rate. The quantitative effects are small because in fact debt tax payments are small. Firms in regions 3 and 4 do not pay debt taxes because $d = 0$ for all of them. Each firm in region 1 pays a debt tax for the amount $\nu[(1-\rho)p\hat{q}\theta k(m,z)/R^*]$, where $\theta k(m,z)$ is the debt allowed by the collateral constraint. They pay the largest tax when their debt is $\theta\bar{k}^{cc}$, at the kink connecting regions 1 and 2. Firms in region 2 pay a decreasing fraction of that maximum tax as they pay down their debt until they reach zero debt tax at the kink with region 3. The tax payment at the calibrated parameter values is equivalent to a tax of 0.216% on the value of a firm's capital ($\nu(1-\rho)\hat{q}\theta/R^* = 0.00216$), and since firms in region 1 have little capital and in region 2 are reducing debt, the payments are small.

We study next the implications of one alternative "macroprudential" policy designed to reduce the ratio of aggregate credit to GDP by the same magnitude as the CCs. This experiment implements a reduction in the fraction θ^{NE} of capital that is pledgeable, which represents tightening of a regulatory loan-to-value (LTV) ratio requirement. Hence, this case is denoted the LTV-policy case.

Attaining the same 13.65% decline in the debt-GDP ratio as in the CC case requires setting $\theta^{NE} = 0.0434$. Figure 4 and Table 4 show the effects on misallocation and welfare. In terms of static effects in Figure 1, this experiment is equivalent to rotating clock-wise the ray with slope $R^*/(R^* - \theta)$, making it flatter by reducing θ. For $\tilde{\theta}$ such that $\hat{R}/(\hat{R} - \theta) = R^*/(R^* - \tilde{\theta})$, we would have the same ray along which region 1 is located. Moreover, region 1 widens until reaching $\bar{k}$ and regions 2 and 3 vanish. Misallocation falls because the firms that were in regions 2 and some of 3 in the CC regime now can carry debt meeting the collateral constraint and grow their capital faster. Firms in region 1 have the same debt and the same misallocation. This combination implies, however, that $\theta^{\tilde{N}E}$ generates more debt than the CC regime, so attaining the same debt reduction as with CCs requires an LTV such that $\theta^{NE} < \theta^{\tilde{N}E}$. This would imply reduced debt for firms in region 1 and a smaller increase for those in 2 and 3, so that total debt can match the reduction under the CC regime. Misallocation rises for firms that were in region 1 and some of 2 but falls for those that were in region 3.

The dynamic and GE effects are also at work: Replacing the CCs with an LTV below $\theta^{\tilde{N}E}$ tightens credit for firms in regions 1 and some of 2 and relaxes it for those in region 3 and also some of 2. Hence, consumption and investment demand rise in the first group and fall in the second and the net GE effects depend on which change is stronger. Similarly, saving incentives strengthen for the firms that are more credit constrained but weaken for those that are less credit constrained. Quantitatively, the net result is higher p and lower y and x. The supply of inputs shrinks as firms in region 1 and some of 2 have less capital, hence input prices rise and their demand by the final goods producer falls, and this effect dominates the opposite effect coming from firms in the second group. Misallocation worsens by 0.23%, relative to the initial NCC regime, which is less than in the CC case. In terms of welfare, the LTV regime yields small social welfare costs, about a thrid of the cost of the CC regime without tax rebate, and similar to the CC with tax rebate. This policy, though, is much simpler to implement than the CC with tax rebate as the latter requires the government to know exactly how much the firm's level of debt is at every moment in time.

5 Empirical Evidence

This Section provides empirical evidence showing that the introduction of capital controls in Chile during the 1990s had effects consistent with the predictions of the model. In particular, when capital controls are introduced, more productive firms experience a relative increase in their misallocation with respect to less productive firms. The same happens for firms with a larger optimal scale gap and for exporters with respecto to non-exporters.

5.1 Data

The empirical analysis requires three data components: a proxy for the CCs policy (the main independent variable of interest), firm-level estimates of misallocation and firm- and aggregate-level data for a set of control variables.

The Chilean capital controls were in the form of an unremunerated reserve requirement on capital inflows known as the *encaje*, introduced in June, 1991 and fully removed in September, 1998. As noted earlier, our empirical proxy for this policy is an interest-rate-equivalent of the financing cost implied by the reserve requirement, based on the methodology proposed by De Gregorio et al. (2000) (see Appendix B for details).[29] Computing it requires data on the evolution of the terms of the policy, namely the fractional reserve requirement and the length of the holding period in which the reserves had to remain at the central bank, which are reported in Table 7. It also needs a proxy for the risk-free interest rate at which the borrowed funds could have been invested abroad, for which we chose the LIBOR rate (downloaded from the *FRED Economic Data* of the St. Louis Fed). Figure 6 shows the time-series of this tax-equivalent estimate of the Chilean capital controls. It hovered around a peak of roughly 2.5% between 1994 and 1997, and averaged 1.75% over the eight years the policy was in place. The sharp, sudden increase in 1991 and removal in 1998 is crucial to identify the effects of the CCs. These fluctuations came mainly from changes in the terms of the policy (the fractional reserve requirement and the holding period) and less so from changes in the risk-free rate.

For constructing measures of misallocation on income profits and firm-level control variables, we use the manufacturing plant-level panel from Chile's *Encuesta Nacional Industrial Anual* (ENIA) for the period 1990 to 2007. The ENIA has data on all establishments with more than ten employees.[30] It includes approximately 4,500 observations per year and provides detailed information on establishments' characteristics, such as total workers, payroll,

[29] See, also, Cárdenas and Barrera (1997) and Soto (1997).

[30] This restriction does not apply to firms that belong to companies that operate in more than one sector or that have more than one plant.

domestic sales, exports, inputs, physical assets, etc.

We construct an estimate of each firm's fixed capital stock by adding cars, machinery, land and buildings. Since ENIA does not have data on the depreciation rate before 1995, we use a standard annual depreciation rate of 6% for the 1990-1994 period. Moreover, before 1992 ENIA does not report the data needed to construct this estimate of fixed capital, so we impute it using investment and the depreciation rate of 6%. To measure productivity at the establishment level, we follow Wooldridge (2009).[31] To deflate the variables used to calculate this productivity measure, we use the 4-digit NAICS code deflator and the price of capital provided by ENIA. Additionally, we use the wholesale price index and fuel price index reported by the *Instituto Nacional de Estadística* (INE) to deflate the electricity and fuel use, respectively.

Misallocation is measured by first constructing MRPK estimates. We followed an approach similar to Gopinath et al. (2017) and Hsieh and Klenow (2009) by constructing MRPK as implied by our model. Rewriting condition (26), a firm's MRPK is:

$$MRPK = \frac{(\sigma - 1)}{\sigma}(p_h y_h + p_f y_f)\frac{\alpha}{k}. \tag{46}$$

We use the ENIA data on total sales for $(p_h y_h + p_f y_f)$ and tangible assets deflated by the price of capital to replace k. σ and α are taken from the calibrated model. We then measure misallocation for a firm i in industry j at date t (MIS_{ijt}) as presented in Section 4.2. However, since we do not know the empirical counterpart of the efficient MRPK we replace it with the yearly industry mean $\overline{MRPK_{jt}}$. We define industries at the 4-digit ISIC code. All other firm-level variables used in the regressions below are also expressed in logs.

5.2 Panel estimation results

We estimate a set of panel regressions aimed at studying how the CCs affected firm-level misallocation depending on the firms' TFP, their OSG and their exporter status. The main

[31] The results are robust to computing TFP as in Levinsohn and Petrin (2003).

regression model is the following:

$$MIS_{ijt} = \omega_0 + \omega_1 CC_{t-1} * Ln\_TFP_{ijt} + \omega_2 CC_{t-1} * OSG_{ijt} + \omega_3 CC_{t-1} * Exp_{ijt}$$
$$\omega_4 X_{ijt} + A_i + B_t + \epsilon_{ijt}, \quad (47)$$

CC_{t-1} denotes the tax-equivalent capital controls, lagged one period. OSG_{ijt} is the percentage gap between the firm's capital in period t with respect to the average capital of the firms in the industry that are older than 10 years old. Thus, if we interpret the denominator of the ratio as a proxy of the steady state size of firms in the industry, OSG_{ijt} gives us an indication of the firm's distance from its steady state size. For defining firms that are exporters (Exp_{ijt}) we consider a backward-looking classification that defines exporters as firms that exported at least once during the previous two years. From this perspective, exporters can be differently affected as they typically have a higher level of capital in the steady state and are more productive.[32]

X_{ijt} is a set of time-varying firm characteristics that includes the direct effect of the interacted variables–i.e., Ln_TFP_{ijt}, OSG_{ijt} and Exp_{ijt}– as well as other standard firm-level controls–i.e., fixed capital, total workers, payroll and the ratio of expenditures on interest to total capital, $Int.Exp/Fixed\_Capital_{ijt}$. (which we include as a proxy for a firm's debt). Table 8 presents the summary statistics of these variables. A_i is a vector of firm dummy variables that account for firm fixed effects to control for time-invariant firm characteristics and B_t is a vector of time dummy variables that account for unobservables at the aggregate level that could be correlated with CC_{t-1}, which could potentially bias the results. Including the time fixed effects absorbs the direct effect of the tax-equivalent capital control as well as the effect of any other aggregate time-varying change. Although this strategy has the disadvantage of only allowing us to identify the firm-level heterogeneous effects triggered by the CC, it also has the desirable feature of considerably reducing potential endogeneity problems due to omitted variables. Standard errors are clustered at the firm level.

Before moving to the results it is worth noting some differences between the nature

[32]In the robustness checks we also consider a forward-looking classification that defines exporters as firms that report exports at least once in the subsequent two years. This classification aims at capturing that firms that want to export in the future might have to undertake more extensive investments today, thus being more exposed to CCs. Results are robust to this alternative classification of exporters.

of the empirical and quantitative exercise. While the empirical exercise focuses on firm-level effects, the quantitative exercise allows us to compute both firm-level and aggregate effects with the latter also taking into account how the distribution of firms in terms of net worth changes as a result of the introduction of the CC. While the distribution of firms in terms of z and age is exogenous in the model, the speed of growth of firms is endogenous and this affects the overall stationary distribution.

Table 10 presents results of our panel regressions based on the above specification. Columns (1) shows the results for misallocation considering the full sample of firms. In line with the model's quantitative predictions at the firm level(see Figure 2), the main insight from Table 10 is that when capital controls are introduced, more productive firms experience a relative increase in their misallocation with respect to less productive firms. The same happens for firms that are relatively further away from their optimal scale–i.e., that have a larger OSG– and for exporters with respect to to non-exporters.

Column (2) of Table 10 presents results using a balanced panel of firms that existed between 1990 and 2003. Since the sample is now significantly restricted we recalculate the within sample relative size measure, $Rel\_Size\_BP_{ijt}$. The similarity of the qualitative results with those in Columns (1) show that the findings derived from the full sample are not driven by the possibility of endogenous firms' entry or exit decisions.Furthermore, quantitatively, our results in terms of the interaction of the CC with the firm characteristics are smaller in absolute terms than in the balanced panel sample, suggesting that our baseline regression is actually capturing a lower bound of the effect.

Ates and Saffie (2021) find that the sudden stop triggered by the Russian crisis of 1998 had significant effects on the characteristics of Chilean firms born around that time. In particular, they find that firm cohorts born during the crisis and in its aftermath are about 30 percent smaller; nevertheless, the average firm born during the crisis is 64 percent more productive than the average firm born in normal times. Then, in order to make sure that these cohort effects are not biasing our results, column (3) replicates our baseline regression restricting the cohorts of firms that were not born during the Russian crisis–i.e. following Ates and Saffie (2021) we only consider firms born before 1998 or after 2000– and we find that our results are robust to this restriction.

In additional regressions reported in Appendix F, we show that our results are also robust to: (i) introducing an alternative (forward-looking) classification of exporters; (ii) introducing the interaction of alternative macroeconomic controls with our firms' characteristics; and (iii) winsorizing the top and bottom 1% observations of our database with respect to alternative dimensions–i.e., dependent variable, controls, and sectors' productivity.

5.2.1 Exporters vs Non-exporters

In this section we modify our baseline regression in order to explore whether the data validates the non-linearities that arise in the model in terms of the effects of capital controls when firms become exporters. To this end Table 11 presents two complementary strategies. First, columns (1-3) of table 11 include the following triple interactions $CC_{t-1} * Ln\_TFP_{ijt} * Exp_{ijt}$ and $CC_{t-1} * OSG_{ijt} * Exp_{ijt}$ first one at a time in columns (1) and (2) and then together in column (3). Second, columns (4-5) of table 11 explore whether the heterogeneous effect of CC changes between the subsamples of exporters and non-exporters.

Results show that indeed becoming an exporter changes how TFP and OSG shape the effect that CCs have on misallocation. For the case of TFP, the quantitative analysis (see Table 6 shows that the increase on misallocation triggered by the CC increases with TFP until entrepreneurs become exporters while it decreases or becomes constant for exporting firms–i.e. firms with productivity higher or equal than 6. In line with this result, the triple interaction $CC_{t-1} * Ln\_TFP_{ijt} * Exp_{ijt}$ has a negative sign in columns (1) and (3) and the coefficient for the interaction $CC_{t-1} * Ln\_TFP_{ijt}$ becomes non-significant when considering the subsample of Exporters while it is significant and positive in the case of the subsample of non-exporters in columns (4-5).

For the case of OSG the mapping between the empirical and quantitative exercise is not so direct as in this case the quantitative exercise is also taking into account the endogenous changes in the distribution in terms of net worth, as previously explained. In this case, Table 6 also shows that the effect on misallocation of the CC changes between non-exporters and exporters, increasing with the OSG for non-exporters and not decreasing with the OSG in the case of exporters. In line with these results, Table 11 shows that the increase on misallocation when CCs are introduced increases with OSG until entrepreneurs become exporters while its effect decreases for exporting firms.

De las últimas 4 columnas me resulta informativo cómo se incrementa el efecto de

OSG para las columnas 3-4 y como se pierden significancias para aqullas firmas con OSG negativo.

5.2.2 Capital controls and income tax revenues

Finally, in Table **??** we explore the effect of CCs on firms' income taxes as a proxy of firms' profits, in an attempt to assess the ultimate consequences of CCs on firm performance. As we have shown that CCs increase misallocation relatively more for more productive firms, exporters and firms with a larger OSG, we expect that these firms will also see their overall performance more negatively affected and would therefore pay lower income taxes.

The results for the regressions on income profits are analogous to those on misallocation in terms of the effects of OSG and the exporting status in shaping the consequences of CCs: Exporting firms and firms with larger OSG are more negatively affected. However, we find no significant effect on the interaction with TFP. One potential explanation for this lack of significance is that the interaction with log of TFP in levels could be too noisy. Thus, as an alternative strategy, we use the interaction of the CC with the firms' ranking of TFP within each year. By doing this we manage to capture that more productive firms seem to be more negatively affected by the CC, in line with our previous results.

6 Conclusion

This paper examined the effects of CCs on misallocation and welfare through the lens of a dynamic general equilibrium model with heterogeneous firms, monopolistic competition, endogenous participation in external trade and financial frictions. The focus is on comparing stationary equilibria between an economy already distorted by collateral constraints and one in which CCs (an asymmetric tax on foreign debt) are added to those constraints. The episode of the Chilean *encaje* (a 30% unremunerated reserve requirement imposed between 1991 and 1998) is used as a natural experiment for exploring the model's quantitative predictions and for conducting empirical tests.

The model predicts that introducing CCs to an economy with collateral constraints affects misallocation in part via static effects (responses of firms' factor demands, production and pricing to capital controls taking as given aggregate variables and saving plans). These effects yield the result that CCs worsen misallocation by tightening the firms' financial constraints, which reduces their capital and capital-labor ratios and increases their prices. There are also, however, general equilibrium and dynamic effects induced by changes in aggregate variables (wages and the output and price of final goods) and an oversaving distortion due to stronger saving incentives as financial constraints tighthen, and some of these effects contribute to reduce misallocation. Social welfare responds to these effects on misallocation and saving, and because the effects are ambiguous in theory, quantitative analysis is necessary both to assess the potential significance of capital controls as a source of misallocation and to evaluate their social welfare implications.

The quantitative analysis is conducted by first calibrating the model so that the stationary equilibrium matches key features of Chilean data from before the introduction of the *encaje* and then solving for the new stationary equilibrium under the CCs policy. The model predicts that CCs increase misallocation slightly aggregating across all firms but at the same time misallocation increases sharply for high-productivity exporting and young firms, while it decreases for low-productivity firms. Low-productivity firms have smaller optimal scales and, consequently, need to borrow less to reach them. On the other hand, high-productivity exporting or young firms have larger optimal scales and, consequently, rely more on credit to accumulate capital and pay the fixed cost of becoming an exporter. The social welfare implications are significant. Overall, the model predicts that the adoption of the *encaje* had a sizable social welfare cost equivalent to a permanent cut of 2.39% in the consumption of all agents. The distribution of consumption across agents worsens slightly but aggregate consumption falls sharply as a result of the adverse aggregate implications of the heterogeneous increases in misallocation, which are reflected in sharp declines in GDP, wages, final goods output, aggregate investment and consumption, and higher prices of final goods (a higher real exchange rate).

The paper includes also a detailed panel empirical analysis based on firm-level data for the Chilean manufacturing sector and a tax-equivalent estimate of the value of the *encaje* as an increase in the effective interest rate on foreign borrowing. The results provide strong evidence indicating that, in line with the model's quantitative predictions, CCs increased misallocation and significantly more for exporting or young firms with high productivity.

The findings of this paper have implications beyond the analysis of capital controls.

The model's theoretical predictions apply to the broader question of the effects of financial repression (i.e., situations in which interest rates differ for borrowing and lending) and also to capital income taxation. The analysis also sheds light on the misallocation, trade and real-exchange-rate implications of altering the degree of financial openness in an economy, either to reduce it as is the case with capital controls or to increase it with financial integration.

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Figures and Tables

Figure 1: Optimal k' as a function of a'.

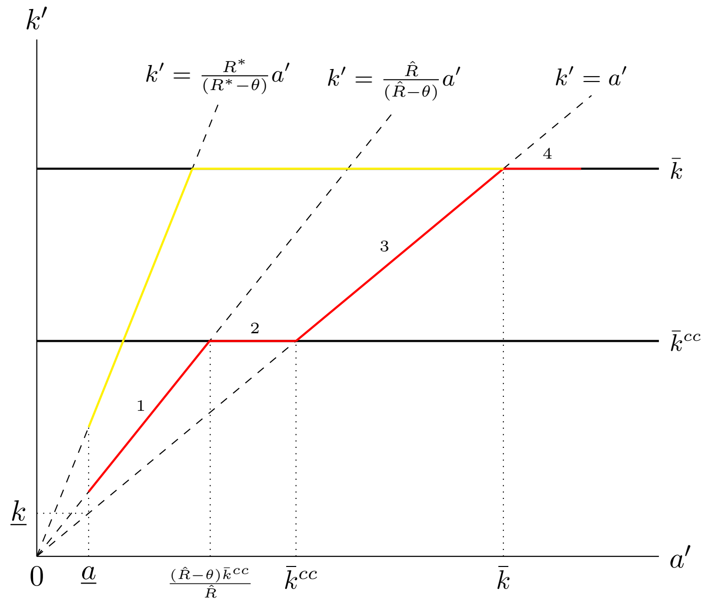
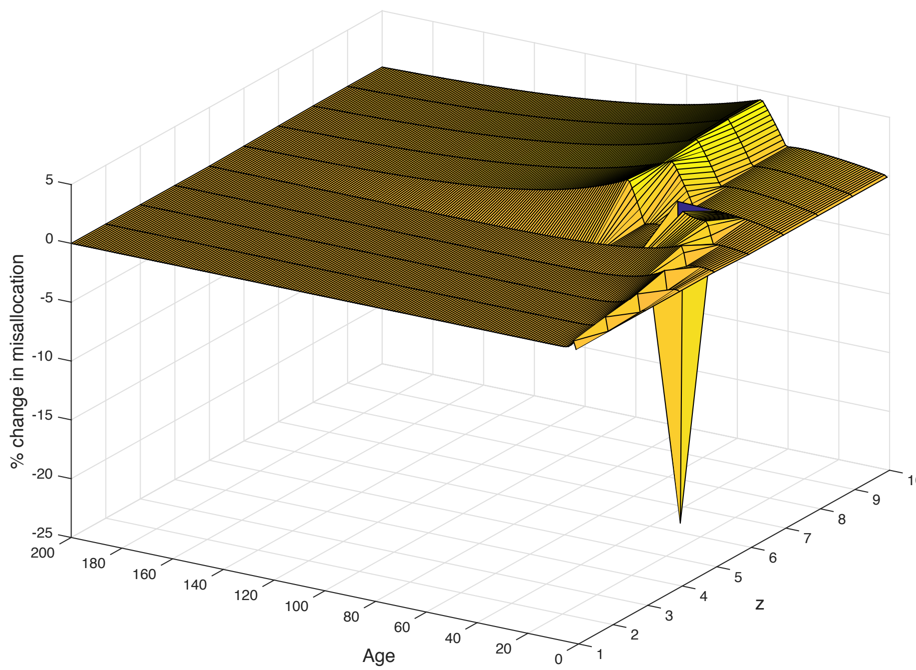
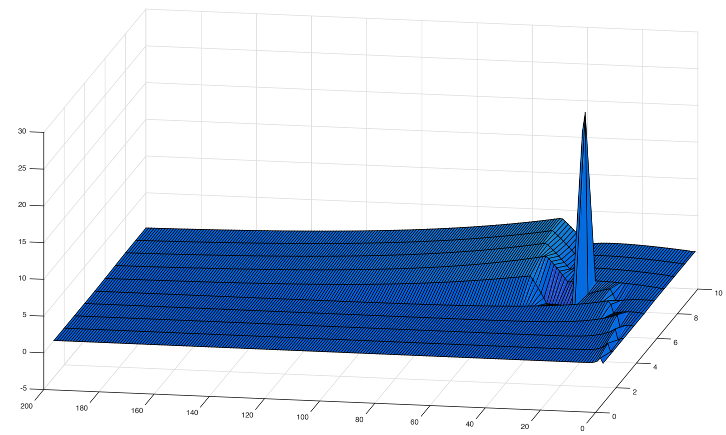


Figure 2: Change in misallocation - Benchmark



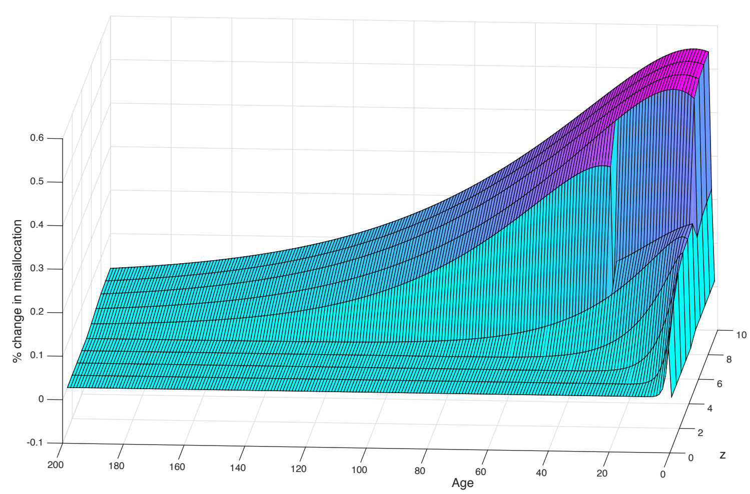
Note: Misallocation is computed as $abs(log(MRPK) - log(\overline{MRPK}))$ where $\overline{MRPK}$ is the efficient level of MRPK.

Figure 3: Change in misallocation - Lump-sum



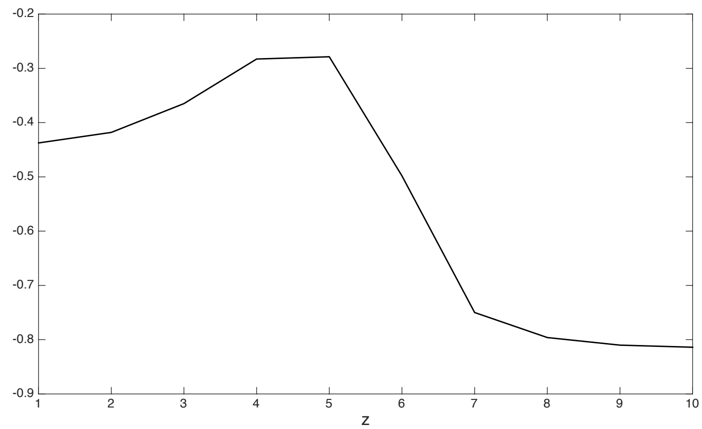
Note: Misallocation is computed as $abs(log(MRPK) - log(\overline{MRPK}))$ where $\overline{MRPK}$ is the efficient level of MRPK.

Figure 4: Change in misallocation - LTV



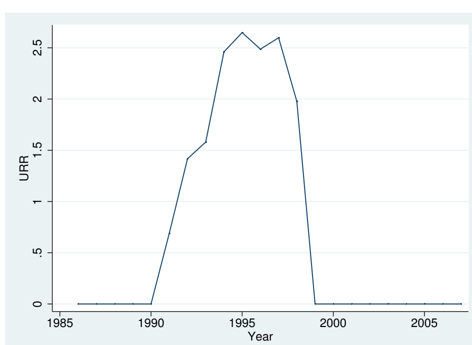
Note: Misallocation is computed as $abs(log(MRPK) - log(\overline{MRPK}))$ where $\overline{MRPK}$ is the efficient level of MRPK.

Figure 5: Welfare gains by z



Note: Welfare gains are computed as compensating variations in consumption for each z.

Figure 6: The tax equivalent of the *Chilean encaje*



Note: We calculate the tax equivalent following the methodology in De Gregorio et al. (2000) .

Table 1: Parameter Values

Predetermined parameters				Calibrated parameters		
β	Discount factor	0.96	Standard	τ	Iceberg trade cost	3.6412
γ	Risk aversion	2	Standard	ω_z	Productivity dispersion	0.437
σ	Substitution elasticity	4	Leibovici (2021)	F	Sunk export entry cost	1.505
δ	Depreciation rate	0.06	Midrigan and Xu (2014)	θ^{NE}	Nonexporters collateral coefficient	0.0464
ν	Death probability	0.08	Chilean data	θ_f	Exporters collateral factor	1.1893
				α	Capital intensity	0.471
				κ	Fraction of steady-state capital as initial capital	0.2994

Table 2: Moments

Target Moment	Data (1990-1991) (1)	Model (No C.controls) (2)
Share of exporters	0.18	0.18
Average sales (exporters/non-exporters)	8.55	8.57
Average sales (age 5 / age 1)	1.26	1.23
Aggregate exports / sales	0.21	0.21
Aggregate credit / Value added	0.20	0.20
Aggregate capital stock / wage bill	6.60	6.58
(Investment /VA)$_{exporters}$ / (Investment/VA)$_{non_exporters}$	1.84	1.83

Table 3: Aggregate effects of the CC and LTV policies

	Benchmark (Δ%) (1)	Lump-sum (Δ%) (2)	LTV (Δ%) (3)
Exports	−0.22%	0.06%	−0.43%
Share of exporters	−1.62%	3.67%	0.00%
Domestic Sales	−0.60%	−0.29%	−0.15%
Investment	−1.00%	−1.19%	−0.63%
Consumption	−0.49%	−0.20%	−0.08%
Final goods output	−0.57%	−0.35%	−0.17%
Real GDP	−0.40%	−0.49%	−0.28%
Wage	−0.56%	−0.13%	−0.21%
Price level (Real ex. rate)	−0.11%	0.27%	0.07%
Agg. credit/Value Added	−13.65%	−13.41%	−13.65%

Table 4: % change in misallocation

	Capital Controls		Lump-sum		LTV	
	% change (1)	G (%) (2)	% change (3)	G (%) (4)	% change (5)	G (%) (6)
All firms	0.39%	−0.37%	0.53%	−0.13%	0.23%	−0.12%
Low z	0.45%	−0.28%	0.45%	−0.20%	0.17%	−0.17%
High z	0.33%	−0.54%	0.62%	0.00%	0.29%	−0.02%
Exporters	0.68%	−1.26%	0.41%	1.35%	0.46%	−0.03%
Non-exporters	0.33%	−0.22%	0.56%	−0.32%	0.18%	−0.15%
Large OSG	0.40%	—	0.55%	—	0.05%	—
Small OSG	0.32%	—	0.31%	—	0.24%	—

Table 5: % change in misallocation, by type of firm

	% change Misallocation	
	Exporters	Non-Exporters
Large OSG	0.68%	0.33%
Small OSG	1.20%	0.31%

Table 6: % change in misallocation, by level of z

z	% change Misallocation	Switching period CC	Switching period No CC
1	0.08%	—	—
2	0.16%	—	—
3	0.31%	—	—
4	0.44%	—	—
5	0.46%	—	—
6	0.29%	29	28
7	0.42%	2	2
8	0.38%	2	2
9	0.37%	2	2
10	0.37%	2	2

Table 7: Main changes in the administration of the *Chilean encaje*

Jun-1991	20% URR introduced for all new credit Holding period (months)=min(max(credit maturity, 3),12) Holding currency=same as creditor Investors can waive the URR by paying a fix fee (Through a repo agreement at discount in favor of the central bank) Repo discount= US$ libor
Jan-1992	20% URR extended to foreign currency deposits with proportional HP
May-1992	Holding period (months)=12 URR increased to 30% for bank credit lines
Aug-1992	URR increased to 30% Repo discount= US$ libor +2.5
Oct-1992	Repo discount= US$ libor +4.0
Jan-1995	Holding currency=US$ only
Sep-1995	Period to liquidate US$ from Secondary ADR tightened
Dec-1995	Foreign borrowing to be used externally is exempt of URR
Oct-1996	FDI committee considers for approval productive projects only
Dec-1996	Foreign borrowing <US$ 200,000 (500,000 in a year) exempt of URR
Mar-1997	Foreign borrowing <US$ 100,000 (100,000 in a year) exempt of URR
Jun-1998	URR set to 10%
Sep-1998	URR set to zero

Note: URR=Unremunerated Reserve Requirement
Source: De Gregorio et al. (2000).

Table 8: Summary statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Fixed Capital	92,690	0	0	0	0
Total Workers	92,690	3.578	1.112	0	8.656
TFP	92,690	2.151	0.149	-3.536	2.858
L_Exp	92,690	0.334	0.472	0	1
F_Exp	92,690	0.195	0.396	0	1
Misallocation	92,690	4.715	3.127	0	17.72
Rel_Size	92,690	0.879	6.026	0	963.0
Int.Exp_Fixed_K	92,690	0.00248	0.743	0	226.3
Payroll	92,690	11.44	1.541	0	18.20
Number of id	12,155	12,155	12,155	12,155	12,155

Table 9: Summary Statistics: Macroeconomic Indicators 1990-2007

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
CC	18	0.881	1.109	0	2.649
Inflation	18	0.017	0.536	-0.626	1.887
RER_dev	18	-0.009	0.055	-0.082	0.113
Growth	18	0.055	0.028	-0.021	0.120
World Growth	18	3.054	1.000	1.369	4.476
Private Credit/GDP	18	0.613	0.107	0.442	0.743
Libor 12m	18	4.918	1.799	1.364	8.415

Note: Capital Controls are calculated following the methodology of De Gregorio et al. (2000). Inflation, RER_dev, Growth and World Growth are from the Central Bank of Chile. RER_dev is calculated as the yearly variation of the real exchange rate, which is defined as the inverse of the nominal exchange rate multiplied by an international price index relevant for Chile and deflated by the chilean price index. The Private Credit to GDP ratio is from the Financial Structure Database (see Beck et al. (2000)). The 12-month Libor interest rate is obtained from the FRED Economic Data.

Table 10: Heterogeneous effects of CC: TFP, Rel_Size and Export status

VARIABLES	(1) All firms	(2) Balanced panel	(3) W/o crisis cohort
CC*TFP	0.804***	1.502***	0.791***
	(0.124)	(0.214)	(0.129)
CC*Exp	0.113***	0.182***	0.109***
	(0.022)	(0.046)	(0.022)
CC*OSG	0.004**		0.004**
	(0.002)		(0.002)
TFP	-6.291***	-6.678***	-6.279***
	(0.237)	(0.512)	(0.239)
Exp	-0.143***	-0.278***	-0.137***
	(0.037)	(0.094)	(0.038)
Total Workers	-0.394***	-0.260**	-0.395***
	(0.045)	(0.111)	(0.047)
Fixed Capital	0.493***	0.599***	0.508***
	(0.015)	(0.040)	(0.016)
OSG	-0.013**		-0.013**
	(0.005)		(0.005)
Int.Exp_Fixed_K	0.141***	0.202***	0.163***
	(0.026)	(0.072)	(0.026)
Payroll	-0.137***	-0.194**	-0.135***
	(0.038)	(0.086)	(0.040)
CC_OSG_BP		0.010**	
		(0.005)	
OSG_BP		-0.026	
		(0.016)	
Observations	92,690	22,203	91,659
R-squared	0.226	0.197	0.225
Number of id	12,155	1,586	12,039
Firm FE	YES	YES	YES
Time FE	YES	YES	YES

Note: This table examines the effect of the interaction of CC with Ln_TFP, OSG and Exp on misallocation, defined as the absolute value of the difference between the firm's MRPK to the mean of the industry. Column (1) considers the full sample of firms, column (2) presents the results of a balanced panel between 1990 and 2003, in order to make sure that entry and exit decisions are not affecting the results and column (3) considers the subsample of firms that leaves out the cohort of firms born between 1998 and 2000. All regressions include a constant term, firm and time fixed effects, and robust standard errors. T-statistics in parenthesis. ***, **, and * indicate significance at the 1%,5%, and 10% level.

Table 11: Heterogeneous effects of CC

VARIABLES	(1) All firms	(2) All firms	(3) All firms	(4) Non-Exporters	(5) Exporters
CC*TFP	1.005***	0.965***	1.020***	1.030***	0.195
	(0.157)	(0.136)	(0.157)	(0.155)	(0.175)
CC*OSG	0.004**	0.506***	0.012***	0.019***	0.003*
	(0.002)	(0.050)	(0.004)	(0.007)	(0.001)
CC*Exp	1.189***	0.293***	1.246***		
	(0.426)	(0.080)	(0.428)		
CC*TFP*EXP	-0.495**		-0.521***		
	(0.199)		(0.199)		
CC*OSG*EXP		-0.215**	-0.009**		
		(0.094)	(0.004)		
Observations	92,690	78,810	92,690	61,725	30,965
R-squared	0.226	0.232	0.226	0.240	0.211
Number of id	12,155	11,489	12,155	9,257	9,147
Firm FE	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES

Note: Columns (1-3) include the following triple interactions $CC_{t-1} * Ln\_TFP_{ijt} * Exp_{ijt}$ and $CC_{t-1} * OSG_{ijt} * Exp_{ijt}$ first one at a time in columns (1) and (2) and then together in column (3). Columns (4-5) explore whether the heterogeneous effect of CC changes between the subsamples of exporters and non-exporters. All regressions include a constant term, firm and time fixed effects, and robust standard errors. T-statistics in parenthesis. ***, **, and * indicate significance at the 1%,5%, and 10% level.

Appendix

Appendix A: The Chilean encaje

The resumption of capital flows to emerging market economies after the Latin American debt crisis of the 1980s led to a new wave of inflows to Chile starting in 1988. This surge in capital inflows exerted upward pressure on the real exchange rate, created symptoms of overheating, and made the trade-off between different macroeconomic objectives increasingly difficult and costly. As a response, in 1991, the Chilean authorities established a capital account restriction in the form of an unremunerated reserve requirement. Specifically, the capital control was an obligation to hold an unremunerated fixed-term reserve equivalent to a fraction of the capital inflow at the central bank. Hence, it was analogous to a tax per unit of time that declined with the permanence or maturity of the affected capital inflow (see Section 5.1 for a detailed derivation of the tax equivalence).[33]

We focus our analysis on the *Chilean encaje* because, for several reasons, it is a good laboratory in which to explore the firm-and industry-level consequences of capital controls. First, the *Chilean encaje* was one of the most well-known examples of market-based controls, –i.e. taxes and reserve requirements, as opposed to administrative controls with which the authority limits some specific assets, and the market is not allowed to operate. Moreover, during the 2000s, many countries, such as Colombia, Thailand, Peru and Uruguay, imposed CCs similar to the ones imposed in Chile. Second, the *Chilean encaje* was economically relevant: the total equivalent reserve deposit represented 1.9 percent of GDP during the period 1991-1998, reaching 2.9 percent of GDP in 1997 and 30 percent of that year's net capital inflows (Gallego et al. (2002)).[34] Finally, the CC period in Chile was long enough to generate sufficient variation in the data for the empirical analysis and to allow us to perform a numerical steady-state analysis. As Table 7 shows, various features of the *Chilean encaje*

[33]The tax equivalence was made more explicit by its alternative form: foreign investors were allowed to pay the central bank an up-front fee instead of depositing the unremunerated reserve fraction with the central bank.

[34]In terms of the macroeconomic effects of the introduction of the Chilean capital control on inflows, the empirical evidence suggests that the more persistent and significant effect was on the time-structure of the capital inflows, which was tilted towards a longer maturity (see De Gregorio et al. (2000), Soto (1997), Gallego and Hernández (2003)). The policy also increased the interest rate differential (although without a significant long-run effect) and had a small effect on the real exchange rate, while there is no evidence on a significant effect on the total amount of capital inflows to the country.

were altered during its existence. These modifications, together with changes in the foreign interest rate, generated significant variability on the effective cost of the CC over time (see Figure 6).[35]

Appendix B: Tax equivalent of Chilean encaje

The introduction of the CC varies the effective interest rate faced by domestic private agents, depending on whether they want to save or borrow. If they want to save, the interest rate remains equal to the risk- free interest rate r. However, if they want to borrow, the effective interest rate they face is higher and given by $r + \nu_g$, where ν_g is the tax equivalent of the CC. In order to compute ν_g, we first need to define r_g, the interest rate ignoring risk premia for a g-months investment in Chile at which an investor makes zero profits:

$$r_g = r + \nu_g.$$

Let u be the fraction of the loan that the investor has to leave as an unremunerated reserve and h the period of time that the reserve must be kept at the Central Bank. Then, if the investment period is shorter than the reserve fixed-time–, i.e., $g < h$–, borrowing US$1 abroad at an annual rate of r to invest at r_g in Chile for g months generates the following cash flows:

- At $t = 0$, the entrepreneur can invest $(1 - u)$ at r_g.
- At $t = g$, repaying the loan implies the following cash flow: $-(1 + r)^{g/12}$.
- At $t = h$, the reserve requirement is returned generating a cash flow u.

Therefore, the annual rate r_g at which the investor is indifferent between investing at home and abroad (computing all values as of time h, when u is returned) is:

$$(1 - u)(1 + r_g)^{g/12}(1 + r)^{(h-g)/12} + u = (1 + r)^{h/12}.$$

Solving for r_g, we find the tax-equivalent of the CC:

[35] Although the initial coverage of the restriction was actually partial in practice, over time, authorities made a great effort to close the loopholes that allowed for evasion of controls. For instance, in 1995, the control was extended to include ADRs, and, in 1996, the rules on FDI were tightened to exclude speculative capital.

$$(1+r_g)^{g/12} = \frac{(1+r)^{g/12} - u(1+r)^{(g-h)/12}}{1-u} \equiv (1+r+\nu_g)^{g/12}.$$

If the investment horizon exceeds the term of the reserve requirement–, i.e., $h > g$–, the investor has to decide, at the end of the h-month period, whether to maintain the reserve requirement in Chile or to deposit the amount outside the country. In order to obtain closed-form solutions, we assume that the investor deposits outside the country at the risk-free interest rate. Under this assumption, the previous arbitrage condition remains the same for longer investment horizons.

Using the approximation that $(1+j)^x \approx 1+xj$, the approximate tax-equivalent is found by solving the following equation:

$$1 + gr - u(1 + (g-h)r) = (1-u)(1 + g(r+\nu_g)),$$

which yields:

$$\nu_g = r\frac{u}{1-u}\frac{h}{g}. \tag{48}$$

Appendix C: Solution Method

The solution method exploits the fact that there is no uncertainty except for the exogenous probability of death that each entrepreneur faces at the beginning of every period. This uncertainty, however, is absent from investment decisions because the annuity market perfectly insures against this event. Then, provided that we know the policy function for assets for a given region of the state space, we can perfectly recover the policies outside of this region by using the first order conditions and the constraints of the problem. To see this, we re-write these here:

- F.O.C. n:

$$-\lambda w + \gamma\left((1-\alpha)zk^{\alpha}n^{-\alpha}\right) = 0 \tag{49}$$

- F.O.C. k:

$$-\lambda p(\hat{r}+\delta) - \mu(1+\hat{r}-\theta) + \gamma z\alpha k^{\alpha-1}n^{1-\alpha} = 0 \tag{50}$$

- F.O.C. p_h:

$$p_h = \frac{\gamma\sigma}{\lambda(\sigma-1)} \tag{51}$$

- F.O.C. p_f:

$$p_f = \frac{\tau\gamma\sigma}{\lambda(\sigma-1)} \tag{52}$$

- F.O.C. c:

$$p\lambda = c^{-\gamma} \tag{53}$$

- Budget constraint:

$$pc + pa'(1-\rho) + pk(\hat{r}+\delta) + wn + wF\mathbb{I}_{e=0,e'=1} = w + \frac{p_h^{1-\sigma}}{p^{-\sigma}}y + \frac{p_f^{1-\sigma}}{\bar{p}^{*-\sigma}}\bar{y}^* + pa(1+\hat{r}) - T, \tag{54}$$

- Production function:

$$\left(\frac{p_h}{p}\right)^{-\sigma} y + \tau\left(\frac{p_f}{p^*}\right)^{-\sigma} \bar{y}^* = zk^{\alpha}n^{1-\alpha} \tag{55}$$

- Collateral constraint:

$$k(1+\hat{r}-\theta) \leq (1+\hat{r})a \tag{56}$$

- Euler equation:

$$c^{-\gamma} = \beta(1+\hat{r})(c'^{-\gamma}+\lambda') \tag{57}$$

where λ is the Lagrange multiplier associated to the collateral constraint (56). Primed variables indicate they are next period's.

The algorithm consists of the following steps:

1. Given prices and aggregate quantities p, w, y, solve for the optimal long-run levels of capital k_{ss} and labor n_{ss} for a firm with productivity z by solving the system of equations given by (49), (50), (51), (52) and (55) and noticing that the collateral constraint does not bind once the firm reaches its optimal scale.

2. For a state space interval $[a_{min}; a_{upper}]$ where $a_{min} = k_{ss}$ and a_{upper} is a desired level of assets such that $a_{upper} > a_{min}$, compute the policy functions of the problem of exporters and non-exporters by a global solution method. For the exercise at hand, we use the endogenous grid method.

3. Obtain the trajectories of variables for $a^f > a_{upper}$, using the fact that $k^f = k_{ss}$, $n^f = n_{ss}$, $\mu^f = 0$, from equations (54) and (57).

4. Obtain the trajectories of variables for $a^b < a_{min}$. Two possible situations arise here:

   (a) There is no capital control: in this case, the collateral constraint (56) binds for all $a^b < a_{min}$. Then, setting $c' = c_{min}$, $\mu' = 0$, from (57) we can recover c. From (49), (51), (52), (54), (55) and (56) we can obtain a, k and n. Using (50) we obtain μ. In this fashion, the policy function $a' = f(a; z)$ for $a < a_{min}$ is computed.

   (b) There is a capital control: in this case, the firm accumulates capital through debt paying an interest rate of $\hat{r} = r + \mu > r$ until reaching k_{ss}^{cc}, which would be the optimal scale for the firm if this was the symmetric interest rate it faced.[36] From then onwards, $\hat{r}$ is too high for the firm to continue financing investment through

[36] k_{ss}^{cc} can be obtained in a similar fashion as k_{ss}.

debt, so it starts repaying debt until $d = 0$. Given that from then onwards the relevant interest rate for the firm is r, the firm starts accumulating capital through self-financing until $k = k_{ss}$.[37] Taking into account the behavior of investment and debt just described, the policy function $a' = f(a; z)$ for $a < a_{min}$ is computed in a similar fashion as before.

5. At every point of the state variable space, check whether $G(a', e' = 1; z, e = 0) > G(a', e' = 0; z, e = 0)$. If so, the firm becomes an exporter at that point and remains an exporter for all a larger than that.

6. Iterate on $1 - 5$ until p, w, y are such that the labor market, the markets for domestic varieties and the final-good market clear.

Appendix D: Derivation of Marginal Revenue Products

A firm's revenue is defined by the value of its sales: $RV \equiv p_h y_h + p_f y_f$. Hence, the MRPs of labor and capital are given by $MRPN \equiv \delta RV/\delta n$ and $MRPK \equiv \delta RV/\delta k$, respectively. The results for the two MRPs used in conditions (25) and (26) were obtained as follows.

First, taking derivatives of RV with respect to n and k,we obtain:

$$MRPN = [p_h + y_h(\delta p_h/\delta y_h)](\delta y_h/\delta n) + [p_f + y_f(\delta p_f/\delta y_f)](\delta y_f/\delta n) \tag{58}$$

$$MRPK = [p_h + y_h(\delta p_h/\delta y_h)](\delta y_h/\delta k) + [p_f + y_f(\delta p_f/\delta y_f)](\delta y_f/\delta k) \tag{59}$$

Solving the demand functions faced by the entrepreneur (2)-(3) for p_h and p_f, respectively, yields $p_h = (y_h/y)^{-1/\sigma}p$ and $p_f = (y_f/y^*)^{-1/\sigma}p^*$, and from these expressions we obtain:

$$\frac{\delta p_h}{\delta y_h} = \frac{-1}{\sigma}\left(\frac{y_h}{y}\right)^{-(\frac{1}{\sigma})-1}\frac{p}{y}, \qquad \frac{\delta p_f}{\delta y_f} = \frac{-1}{\sigma}\left(\frac{y_f}{y^*}\right)^{-(\frac{1}{\sigma})-1}\frac{p^*}{y^*}, \tag{60}$$

which multipliying by y_h and y_f, respectively, and simplifying yields:

$$\frac{\delta p_h}{\delta y_h} = \frac{-p_h}{\sigma}, \qquad \frac{\delta p_f}{\delta y_f} = \frac{-p_f}{\sigma}, \tag{61}$$

Substituting these expressions into (58)-(59) and simplifying using the equilibrium condition

[37] In this region of the state space, an extra equilibrium condition is that $d \leq 0$.

$p_f = \tau p_h$ we obtain:

$$MRPN = \frac{p_h}{\varsigma}\left(\frac{\delta y_h}{\delta n} + \tau\frac{\delta y_f}{\delta n}\right), \qquad MRPK = \frac{p_h}{\varsigma}\left(\frac{\delta y_h}{\delta k} + \tau\frac{\delta y_f}{\delta k}\right), \tag{62}$$

where, as defined in the paper, $\varsigma = \sigma/(\sigma - 1)$.

Now differentiate the market-clearing condition $y_h + \tau y_f = z k^{\alpha} n^{1-\alpha}$ with respect to n and with respect to k to obtain:

$$\frac{\delta y_h}{\delta n} + \tau\frac{\delta y_f}{\delta n} = z(1-\alpha)\left(\frac{k}{n}\right)^{\alpha}, \qquad \frac{\delta y_h}{\delta k} + \tau\frac{\delta y_f}{\delta k} = z\alpha\left(\frac{n}{k}\right)^{1-\alpha} \tag{63}$$

Substituting these results into those obtained in (62) yields the expressions used in conditions (25) and (26) of the paper:

$$MRPN = \frac{p_h}{\varsigma} z(1-\alpha)\left(\frac{k}{n}\right)^{\alpha}, \tag{64}$$

$$MRPK = \frac{p_h}{\varsigma} z\alpha\left(\frac{n}{k}\right)^{1-\alpha}. \tag{65}$$

Appendix E: Proofs

Proof of Proposition 2

Proof. The planner's problem can be written as:

$$\max_{\{c_q, n_q, x_q, k'_q, y_{h,q}, y_{f,q}\}_{i\in\mathcal{S}}} \int_{\mathcal{S}} \xi_q \sum_{t=0}^{\infty} [\beta(1-\rho)]^t U(c_{q,t})\phi(q)dq$$

s.t.

$$\int_{\mathcal{S}} [c_{q,t} + x_{q,t}]\phi(q)dq = y_t \quad \forall t, \tag{66}$$

$$\left[\int_0^1 y_{h,t}(i)^{\frac{\sigma-1}{\sigma}} di + y_{m,t}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} = y_t \quad \forall t, \tag{67}$$

$$y_{h,t}(i) + \tau y_{f,t}(i) = z_i k_{i,t}^{\alpha} n_{i,t}^{1-\alpha} \quad \forall i, \forall t, \tag{68}$$

$$k_{i,t+1} = \frac{1}{1-\rho}((1-\delta)k_{i,t} + x_{i,t}) \quad \forall i, \forall t, \tag{69}$$

$$\int_{\mathcal{S}} n_{q,t}\phi(q)dq = 1 \quad \forall t, \tag{70}$$

$$\int_0^1 p_{f,t}(i)y_{f,t}(i)di - p_{m,t}y_{m,t} = \overline{TBD} \quad \forall t, \tag{71}$$

$$y_{f,i}(i) = \left(\frac{p_{f,t}(i)}{p^*}\right)^{-\sigma} y^* \quad \forall i, \forall t. \tag{72}$$

Equation (71) represents the trade balance of this economy, where $\overline{TBD}$ is a given level of trade balance deficit, and equation (72) is the foreign demand for domestic varieties. After some algebra, the planner's problem becomes

$$\max_{\{c_q,n_q,x_q,k'_q,y_{h,q},y_{f,q}\}_{i\in\mathcal{S}}} \int_{\mathcal{S}} \xi_q \sum_{t=0}^{\infty}[\beta(1-\rho)]^t U(c_{q,t})\phi(q)dq$$

s.t.

$$\int_{\mathcal{S}}[c_{q,t} + (1-\rho)k_{q,t+1} - (1-\delta)k_{q,t}]\phi(q)dq = \left[\int_0^1 (z_i k_{i,t}^{\alpha} n_{i,t}^{1-\alpha} - \tau y_{f,t}(i))^{\frac{\sigma-1}{\sigma}} di + y_{m,t}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \quad \forall t, \tag{73}$$

$$\int_{\mathcal{S}} n_{q,t}\phi(q)dq = 1 \quad \forall t, \tag{74}$$

$$y^{*1/\sigma} p^* \int_0^1 y_{f,t}(i)^{\frac{\sigma-1}{\sigma}} di - p_{m,t}y_{m,t} = \overline{TBD} \quad \forall t, \tag{75}$$

Assuming $\xi_i = \xi_j$ for all $i, j \in \mathcal{S}$, the FOC of the planner with respect to capital reads:

$$\lambda_t = \beta\lambda_{t+1}\left[(1-\delta) + \left[\int_0^1 (z_i k_{i,t}^{\alpha} n_{i,t}^{1-\alpha} - \tau y_{f,t}(i))^{\frac{\sigma-1}{\sigma}} di + y_{m,t}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1}{\sigma-1}} \left(z_i k_{i,t}^{\alpha} n_{i,t}^{1-\alpha} - \tau y_{f,t}(i)\right)^{\frac{-1}{\sigma}} z_i \alpha \left(\frac{n_{i,t}}{k_{i,t}}\right)^{1-\sigma}\right]$$

$\forall t$, $\forall i$. After some algebra, this expression becomes

$$\lambda_t = \beta\lambda_{t+1}\left[(1-\delta) + \left(\frac{y_t}{y_{h,t}(i)}\right)^{1/\sigma} \frac{\alpha}{k_{i,t}}\left(y_{h,t}(i) + \tau y_{f,t}(i)\right)\right] \quad \forall i, \forall t.$$

Notice that, from equation (65) and using (2), we can write

$$\lambda_t = \beta\lambda_{t+1}\left[(1-\delta) + \frac{MRPK_{i,t}}{p}\frac{\sigma}{\sigma-1}\right] \quad \forall i, \forall t.$$

This condition needs to hold for every $i \in \mathcal{S}$. Then,

$$MRPK_i = MRPK_j \quad \forall i, j \in \mathcal{S}$$

□

Appendix F: Robustness

In this section, we conduct a set of tests that document the robustness of our empirical findings. In particular, we show that our results are robust to: (i) introducing an alternative (forward-looking) classification of exporters; (ii) introducing the interaction of alternative macroeconomic controls with our firms' characteristics; (iii) winsorizing the top and bottom 1% observations of our database with respect to alternative dimensions–i.e., dependent variable, controls, and sectors' productivity.

Forward-looking definition of exporters: To make sure that our definition of exporters is not biasing our results Table 12 replicates our baseline regression using a forward-looking, instead of backward-looking definition of exporters. In particular the alternative classification defines exporters as firms that report exports at least once in the subsequent two years. This classification aims at capturing that firms that want to export in the future might have to undertake more extensive investments today, thus being more exposed to CCs. Our results are robust to this alternative classification

Interaction with macroeconomic controls: A potentially important concern is that the estimates of the interaction terms with CCs could be capturing the effect of an interaction between TFP_{ijt}, Rel_Size_{ijt} and Exp_{ijt} and other macroeconomic variables. To explore this issue, Table 13 presents the results of a set of regressions adding to the CCs interaction terms the interactions of a set of candidate macroeconomic variables (one at a time) with TFP_{ijt}, Rel_Size_{ijt} and Exp_{ijt}. The macro variables are: the LIBOR rate, inflation, growth, RER, private credit_GDP and world growth. All macroeconomic variables are lagged one period. Table 9 presents the summary statistics of these variables). With only two exceptions the coefficients of the interactions of the CCs are similar in size, sign and significance when any of the macro controls are introduced. The exceptions are the interaction term of CCs with F_Exp_{ijt} that becomes statistically insignificant when interactions with growth are introduced and the interaction of CCs with Rel_Size_{ijt}, that becomes statistically insignificant when interactions with RER are introduced.

Winsorize: In order to make sure that potential outliers are not driving our results Table 14 presents a series of exercises where we run our baseline regression after winsorizing the top and bottom 1% observations of our database with respect to alternative dimensions. Columns (1) and (2) present the results when winsorizing the dependent variable; columns (3) and (4) present the results when winsorizing the control variables; and columns (5) and (6) present the results when winsorizing all the firms in sectors whose average productivity is on the top and bottom tails of the distribution. All our results are robust to the different winsorization exercises implying that they are not driven by outliers in terms the dependent variable, controls or sectors.

Table 12: Heterogeneous effects of CC: Alternative definition of exporters

VARIABLES	(1) All firms	(2) Balanced panel	(3) W/o crisis cohort
CC*TFP	0.812***	1.531***	0.805***
	(0.125)	(0.212)	(0.130)
CC*OSG	0.004**		0.004**
	(0.002)		(0.002)
CC*F_Exp	0.091***	0.127***	0.078***
	(0.028)	(0.046)	(0.029)
CC_OSG_BP		0.009**	
		(0.005)	
Constant	13.886***	16.971***	13.072***
	(0.810)	(1.150)	(0.832)
Observations	92,690	22,203	91,659
R-squared	0.225	0.196	0.225
Number of id	12,155	1,586	12,039
Firm FE	YES	YES	YES
Time FE	YES	YES	YES

Note: This table examines the effect of the interaction of CC with _TFP, OSG and F_Exp on misallocation. Column (1) considers the full sample of firms, column (2) presents the results of a balanced panel between 1990 and 2003, in order to make sure that entry and exit decisions are not affecting the results and column (3) considers the subsample of firms that leaves out the cohort of firms born between 1998 and 2000. All regressions include a constant term, firm and time fixed effects, and robust standard errors. T-statistics in parenthesis. ***, **, and * indicate significance at the 1%,5%, and 10% level.

Table 13: Interaction with macroeconomic controls

VARIABLES	(1) Libor	(2) Inflation	(3) Growth	(4) RER	(5) PrivCreditGDP	(6) WorldGrowth
CC*TFP	0.812***	0.778***	0.935***	0.371***	0.986***	0.855***
	(0.123)	(0.121)	(0.128)	(0.104)	(0.128)	(0.120)
CC*OSG	0.004**	0.007***	0.006***	0.000	0.007***	0.004***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
CC*Exp	0.110***	0.115***	0.074***	0.106***	0.134***	0.128***
	(0.022)	(0.022)	(0.024)	(0.024)	(0.023)	(0.022)
L_Exp*Libor	0.011					
	(0.011)					
TFP*Libor	-0.040					
	(0.039)					
OSG*Libor	0.001					
	(0.001)					
L_Exp*Inflation		-0.000				
		(0.004)				
TFP*Inflation		-0.097***				
		(0.015)				
OSG*Inflation		-0.002***				
		(0.001)				
L_Exp*Growth			0.037***			
			(0.008)			
TFP*Growth			-0.136***			
			(0.031)			
OSG*Growth			-0.002**			
			(0.001)			
L_Exp*TCR				-0.002		
				(0.003)		
TFP*TCR				-0.087***		
				(0.012)		
OSG*TCR				-0.001***		
				(0.000)		
L_Exp*PrivCreditGDP					0.632**	
					(0.292)	
TFP*PrivCreditGDP					7.521***	
					(1.212)	
OSG*PrivCreditGDP					0.100***	
					(0.035)	
L_Exp*WorldGrowth						0.221***
						(0.024)
TFP*WorldGrowth						0.541***
						(0.100)
OSG*WorldGrowth						0.007**
						(0.003)
Observations	92,690	92,690	92,690	92,690	92,690	92,690
R-squared	0.226	0.227	0.226	0.227	0.227	0.228
Number of id	12,155	12,155	12,155	12,155	12,155	12,155
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES

Note: This table examines the robustness of the interaction of CC with TFP, OSG and Exp on misallocation when introducing, one at a time, the interactions of macroeconomic variables and our variables of interest, TFP_{ijt}, OSG_{ijt} and Exp_{ijt}. The macroeconomic variables under consideration are: the Libor rate, inflation, growth, RER, private

Table 14: Heterogeneous effects of CC: Winsorized samples.

VARIABLES	(1) Wins. MRPK	(2) Wins. Controls	(3) Wins. Sectors
CC*TFP	0.845***	1.233***	1.001***
	(0.089)	(0.093)	(0.117)
CC*Exp	0.115***	0.148***	0.119***
	(0.021)	(0.022)	(0.021)
CC*OSG	0.006***	0.072***	0.004**
	(0.002)	(0.009)	(0.002)
Observations	90,841	83,632	91,764
R-squared	0.223	0.232	0.235
Number of id	11,887	11,003	12,030
Firm FE	YES	YES	YES
Time FE	YES	YES	YES

Note: This table examines the effect of the interaction of CC with TFP, Rel_Size and Exp on misallocation while winsorizing the top and bottom 1% observations with respect to: (i) the dependent variable, columns (1) and (2); (ii) the control variables, columns (3) and (4); and (iii) the average productivity of the sector, columns (5) and (6). All regressions include a constant term, firm and time fixed effects, and robust standard errors. T-statistics in parenthesis. ***, **, and * indicate significance at the 1%,5%, and 10% level.

Table 15: Heterogeneous effects of CC: Additional results

VARIABLES	(1) Within group mean MRPK Non-Exporters	(2) Within group mean MRPK Exporters	(3) Positve OSG Non-Exporters	(4) Positve OSG Exporters	(5) Negative OSG Non-Exporters	(6) Negative OSG Exporters
CC*TFP	0.897***	0.387***	1.269***	0.041	0.243	0.655**
	(0.148)	(0.147)	(0.155)	(0.225)	(0.297)	(0.292)
CC*OSG	0.018***	0.004***	0.585***	0.449***	-0.008*	0.000
	(0.006)	(0.001)	(0.052)	(0.109)	(0.005)	(0.001)
Observations	61,725	30,965	56,070	22,740	5,655	8,225
R-squared	0.221	0.224	0.243	0.217	0.240	0.220
Number of id	9,257	9,147	8,742	8,358	1,361	1,619
Firm FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES

Note: