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BEWARE THE SIDE EFFECTS:
CAPITAL CONTROLS, TRADE, MISALLOCATION AND WELFARE

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Beware the Side Effects: Capital Controls, Trade, Misallocation and Welfare
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ABSTRACT

We show that capital controls have large adverse effects on misallocation, exports and welfare using a dynamic Melitz-OLG model with heterogeneous firms, monopolistic competition, endogenous trade participation and collateral constraints. Static effects increase misallocation by reducing capital-labor ratios and rising firm prices, dynamic effects reduce it by incentivizing saving and delaying entry into export markets, and general equilibrium effects are ambiguous. Firms at the collateral constraint or at their optimal scale are barely affected but those in between are severely affected. Calibrated to the 1990s Chilean encaje, the model yields higher aggregate misallocation with larger effects on exporters and high-productivity firms. Social welfare falls and welfare of exporters falls significantly more. LTV regulation cuts credit by the same amount at sharply lower costs, because it spreads the burden of the cut more evenly. A panel data analysis of Chilean manufacturing firms yields strong evidence supporting the model's predictions.

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1 Introduction

Views on capital controls (CCs) shifted widely in the last half century. They were considered bad policy from the time of the collapse of the Bretton Woods System in 1971 to the mid-1990s. Then, they began to gain favor after the emerging markets Sudden Stops as an instrument to prevent credit booms and vulnerabilities arising from surging capital inflows, and finally became a widely-accepted macroprudential policy tool after the 2008 Global Financial Crisis. This turnaround was partly supported by research showing that macroprudential CCs can address pecuniary externalities that cause overborrowing and sudden stops via credit constraints linked to collateral prices (see Bianchi and Mendoza (2020) for a literature review). Most research on capital controls, however, focuses on how they 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 emphasize their heterogeneous impact across firms and the resulting aggregate effects. This approach is motivated by ample empirical evidence showing that CCs affect firms differently depending on size, financial dependence, external trade, and capital intensity (e.g., Alfaro et al. (2017), Forbes (2007), Andreasen et al. (2022)). Thus, the data suggest that there is an important transmission mechanism linking CCs to firm dynamics and firm heterogeneity, but to date little is known about this mechanism and its positive and normative implications.¹

We study two key questions: What are the side effects of CCs on misallocation of capital across firms and external trade participation? And, what are the aggregate and social welfare implications of these side effects? This paper provides theoretical, quantitative and empirical answers derived from a dynamic Melitz model with overlapping-generations of monopolistically-competitive entrepreneurs that face a collateral constraint. Entrepreneurs produce differentiated varieties of intermediate goods and sell them to domestic final-good producers and to foreign buyers, if they choose to be exporters. They differ in a one-time exogenous productivity draw, the size of their capital stock, their age, their debt, and whether they export or not. CCs enter as a tax-equivalent levy on foreign borrowing (i.e., an asymmetric tax) that increases the interest rate on debt and thus adds to the financial frictions already present because of the collateral constraint.

We show that, without collateral constraints and CCs, there is no misallocation (i.e., disper-

¹Some of the research and policy debates on macroprudential CCs warn of investment distortions akin to those of capital taxes, but still using representative-agent models. Bianchi and Mendoza (2020) and Darracq-Paries et al. (2019) show that CCs need to be state-contingent in order to avoid “taxing investment” in states in which is inefficient to do so.

sion in marginal revenue products of capital (MRPK) and labor (MRPL)) and factor allocations are efficient. There is also no misallocation in the decentralized equilibrium with monopolistic competition, but the world opportunity cost of capital that pins down MRPK is inefficient, because monopolistic competition distorts prices. Adding the collateral constraint raises MRPKs of some firms and thus causes misallocation of capital, via the mechanism that is standard in the literature: Credit-constrained firms operate below their long-run optimal scale of capital (i.e., they display an “optimal scale gap,” OSG) with an effect that is larger for more constrained firms.

Our analysis focuses on the effects of introducing CCs into an economy with collateral constraints. Misallocation responds to three effects: First, “static” effects on firms’ debt, capital, labor, production and prices taking as given aggregate variables (wages and the price and output of final goods). These effects worsen misallocation by tightening further the firms’ access to credit, which reduces their capital and capital-labor ratios and increases their prices, thus increasing their MRPKs. Second, dynamic effects driven by stronger saving incentives, as tighter credit access increases the marginal return on saving and incentivizes entrepreneurs to grow their net worth faster, and by a delay in the timing with which firms enter export markets that reduces exports and the share of exporting firms. Hence, the static effects increase the MRPK of firms with a given net worth but faster net-worth growth may result in more firms at higher levels of net worth with lower MRPKs in the stationary equilibrium. Third, general equilibrium effects that result from changes in aggregate variables, which change as CCs affect aggregate demand for final goods and labor and demand and supply of intermediate goods. The net impact of these effects on misallocation, aggregate outcomes, and social welfare is, therefore, theoretically ambiguous.²

The effects of capital controls on misallocation differ from those of collateral constraints that are well-known in the literature. In particular, the static effects of collateral constraints reducing capital and increasing MRPK shrink monotonically with net worth, while those resulting from CCs are non-monotonic: Capital falls more and MPRK rises more for firms operating at the pseudo-steady-state of capital consistent with the world opportunity cost *inclusive* of the tax on foreign borrowing, and for larger firms forced to self-finance their growth. MRPKs are unaffected by CCs both for firms at the collateral constraint and at their long-run optimal scale.

We study the model’s quantitative predictions by comparing stationary equilibria before and after the imposition of capital controls for a calibration based on the case of the Chilean *encaje*,

²CCs add another source of misallocation into an economy that is already inefficient because of the collateral constraint. Since inefficient equilibria cannot be ranked in general, the social welfare effect of CCs is theoretically ambiguous.

an unremunerated reserve requirement on capital inflows introduced in 1991 and removed in 1998. The calibration uses targets derived from Chilean firm-level data. With this calibration, the model approximates well the Chilean firm-size distributions from before and after the *encaje* was in place, and it does so largely because of the size difference across exporters and non-exporters.

The model predicts that capital controls have sizable aggregate effects. Real wages fall 0.7% and the output and price of final goods fall 0.85% and 0.36%, respectively. As a result, long-run optimal capital scales and net profits of exporters and non-exporters rise 0.38% and 0.27%, respectively. Aggregate consumption, the credit-value added ratio, exports, and the share of exporters also fall. Misallocation, measured as the mean deviation of MRPKs relative to the world opportunity cost of capital, rises 0.5 percentage points (pp) for the economy as a whole and significantly more for exporters than non-exporters and for firms with large v. small OSG. Across low-productivity firms, which are all non-exporters, misallocation worsens more at higher levels of productivity, but the opposite is true across high-productivity firms, which are mainly exporters.

Capital controls reduce social welfare by 0.61%, in terms of a compensating consumption variation common to all entrepreneurs applied to a utilitarian social welfare function (with weights given by the model's firm-age distribution). The welfare costs are much larger for exporters (1.82%) than non-exporters (0.56%), and they are non-monotonic in productivity: They initially fall as productivity rises from its lowest level to the average (i.e., for non-exporters) and then jump and become increasing in productivity at higher productivity levels (i.e., for exporters and switchers). These results are due to heterogeneous effects on labor and capital income: Low-productivity entrepreneurs suffer more from the fall in real wages because they operate smaller firms and collect a larger share of their income from wages. As productivity and firm-size rise, capital income (i.e., profits) becomes relevant. Profits fall if the firm's relative price rises, and the latter falls as the real wage falls but rises as MRPK rises. As a result, profits rise (fall) for firms with low (high) enough misallocation, and misallocation worsens less for firms with lower productivity.

The quantitative analysis also includes three counterfactual experiments. First, since the 1.75% tax on inflows implied by the Chilean *encaje* is much smaller than the long-run average of estimates of optimal macroprudential CCs in the 3-12% range, we examine the effects of a 6% tax. This yields much larger effects on aggregate variables, misallocation and welfare. Aggregate misallocation rises 2.28pp and social welfare falls 1.41%. There are also important changes in the distribution and magnitude of misallocation and welfare costs across firms due to the much stronger general equilibrium effects and the aggregation with the firm-age distribution.

The second counterfactual examines loan-to-value (LTV) regulation as an alternative policy to reduce credit (by lowering the debt that firms can obtain per unit of capital pledged as collateral). Calibrated to attain the same cut in the credit-value added ratio as the CCs, this policy is far superior. Aggregate misallocation rises 0.29pp and welfare falls only 0.2%. LTV regulation is superior because it spreads the burden of the credit cut more evenly by reducing credit to firms at the collateral constraint that were unaffected by CCs and increasing it to firms affected by them.

The last counterfactual rebates the debt taxes paid by each firm back to them. Capital controls are usually in the form of legal or exchange-rate restrictions, or unremunerated reserves, and as such are not rebated. Still, this experiment sheds light on the role of the income effects of CCs. The results show weaker aggregate effects and smaller welfare costs but larger increases in misallocation at the aggregate level, for exporters and nonexporters and most levels of productivity.

We close the paper with an empirical analysis testing whether the model's quantitative predictions that the adverse effect of capital controls on misallocation is larger for firms with higher productivity, for exporters and for firms further away from their optimal scale hold in the data. We conduct panel estimations using Chilean manufacturing firm-level data from the *Encuesta Nacional Industrial Anual* (ENIA). The results provide statistically significant evidence in favor of the model's predictions, and the results are robust to a number of control checks (e.g., using sales or value added to define misallocation, balanced v. unbalanced panels, exclusion of the late-1990s-crisis periods, macro controls, outliers, backward or forward definition of exporters). Moreover, we also find statistically significant evidence supporting the model's prediction that the effect on misallocation as productivity rises is much stronger for non-exporters than exporters.

The rest of the paper is organized as follows: Section 2 compares our work with the related literature. Section 3 presents the model. Section 4 derives its implications for misallocation. Section 5 discusses the quantitative results. Section 6 conducts the empirical analysis. Section 7 concludes.

2 Related Literature

Our paper is related to the large literature on misallocation and financial frictions that uses heterogeneous-firms models to examine how policies and firm characteristics generate misallocation (e.g., Restuccia and Rogerson (2008), Hsieh and Klenow (2009), Guner et al. (2008)). Several studies focus on closed-economy models under perfect competition. Buera et al. (2011) present a model with sectors that differ in their degree of financial dependence and show that financial frictions can sig-

nificantly distort factor allocations. Midrigan and Xu (2014) propose a two-sector model in which debt constraints distort technology adoption and create misallocation. Both models predict that financial development reduces misallocation. Buera and Moll (2015) examine how shocks to a collateral constraint under three forms of heterogeneity affect wedges used to account for aggregate fluctuations. Our work differs from these studies in that we examine an open-economy model, which links MRPKs to world opportunity costs, assume monopolistic competition and model the firms' life cycle, both of which amplify the effects of financial frictions on MRPKs.

Cavalcanti et al. (2021) propose a model that relaxes the assumption that firms face a collateral constraint at a common financing cost. They obtain dispersion in credit spreads due to lenders' market power and intermediation costs that fall with a firm's assets and productivity, and find larger real effects than with the common financing cost. In our model financing costs also vary, albeit in a simpler way, because CCs cause borrowing and saving rates to differ. We obtain a similar result indicating larger real effects than in a regime with collateral constraints but no CCs.

An important branch of this literature uses open-economy models to examine the effects of financial integration modeled as a fall in the world real interest rate. Gopinath et al. (2017) study a model with infinitely-lived firms and monopolistic competition in partial equilibrium. Productivity shocks and capital adjustment costs, combined with a collateral constraint that is increasing and convex in capital (i.e., size-dependent borrowing capacity), yield the result that capital inflows triggered by the interest-rate drop are misallocated towards high net-worth firms that may be less productive. Firms accumulate precautionary savings and those with more capital can borrow more and speed up convergence to their new optimal scale, but poorer firms may draw higher productivity. They find empirical evidence supporting this result in data for Southern European countries in the 2000s. Our setup also features monopolistic competition, but modeling the firms' life-cycle and using the standard collateral constraint linear in capital.³ Still, our model would predict that, without CCs, a lower interest rate increases misallocation in partial equilibrium, during the transition. This occurs because the collateral constraint makes firms take longer to reach their new, higher optimal scales.⁴ The main focus of our analysis, however, is not a fall in the interest rate but an asymmetric increase that affects firms only when borrowing, representing capital controls. Interestingly, this asymmetry makes borrowing capacity size-dependent: a newborn firm hits first

³We also abstract from precautionary savings because of the Blanchard-Yaari OLG setup and at-birth-only productivity shocks, but we introduce endogenous trade participation and study general equilibrium outcomes, both of which are found to be quantitatively relevant.

⁴In general equilibrium, changes in the price level can alter this result.

the collateral constraint, then outgrows it and repays its debt, and then self-finances the rest of its transition to steady-state. Firms of different age cohorts are at different stages, with the result that the CCs *increase* aggregate misallocation in an economy that already had the collateral constraint.

Asriyan et al. (2021) study a general equilibrium model with infinitely-lived heterogeneous entrepreneurs, financial frictions and an imperfectly-elastic supply of capital. They find that the effect of a lower interest rate on aggregate output is ambiguous. It may fall if a pecuniary externality generated by the elasticity of capital props up investment of less productive firms by enough to crowd out that of more productive firms. Their model is different from ours, but the two highlight the importance of general equilibrium effects, in their case via a pecuniary externality on the cost of capital, in our case via changes in aggregate demand, the price of final goods and wages. Theoretically, the effect of the *higher* interest rate implied by CCs on aggregate output is also ambiguous, but in our calibrated solutions we find that output falls.

This paper is also related to the analysis of capital controls in an economy with financial constraints by Andreasen et al. (2022). Using Chilean manufacturing data, they find that exporters in more capital-intensive sectors are more negatively affected by CCs, while the converse is true for non-exporting firms. Moreover, CCs reduce aggregate production but increase TFP. This paper differs in that it studies the effects of CCs on misallocation and examines their welfare implications.

Another strand of the literature relevant to our analysis studies how the interaction of trade and financial frictions affects misallocation and welfare. Brooks and Dovis (2020) show that misallocation across exporters and non-exporters reduces the gains from trade liberalization with the typical collateral constraint linked to existing capital but not with one linked to future profits. They find evidence consistent with the latter using Colombian data. Our model and theirs are similar in that both feature a dynamic Melitz setup with OLG firms and endogenous trade participation, but we examine the effects of CCs instead of a trade reform, and in an economy that already has a (standard) collateral constraint. Appendix E shows that our main results still hold with a constraint linked to profits. Leibovici (2021) examines the industry-level and aggregate effects of financial development on trade shares (ratios of exports to domestic sales). He uses a rich multi-sector model with infinitely-lived entrepreneurs exposed to idiosyncratic productivity shocks who choose to operate in various tradable or nontradable industries. These industries differ in capital intensity and this induces differences in financial dependence. A cut in the fraction of capital pledgeable as collateral for debt reallocates trade shares to less capital-intensive industries. Our analysis has a simpler sectoral setup and abstracts from recurrent productivity shocks, but we model the firms'

life cycle and examine CCs as a financial friction additional to the collateral constraint. Still, both studies find that exporters are larger and more credit constrained than non-exporters, tighter financial frictions reduce sharply the share of firms that export but the aggregate trade share hardly changes. Finlay (2021) also proposes a model with infinitely-lived firms in which exporters are more credit constrained than non-exporters. Tightening credit constraints for exporters lowers aggregate productivity because they are more productive. Similarly, in our model, exporters are more credit constrained, because their optimal scales are larger, but tightening credit constraints using CCs has non-monotonic effects across exporters and non-exporters depending on productivity. Also, in our setup the life-cycle dynamics of the firms drives the aggregate effects.

Other studies examine the effects of trade integration in two-country Melitz models with pre-existing firm-level distortions but without financial frictions. Bai et al. (2019) find that welfare may fall due to worsened misallocation. Using Chinese data, they obtain an 18% welfare loss. Berthou et al. (2020) show that effects on welfare and productivity are theoretically ambiguous because of different effects from free trade in exports and imports. Our work shares with these studies the interest in examining the effects of international trade on misallocation and welfare, but we study these effects in the context of a model with collateral constraints and capital controls.

Finally, our paper also relates to the empirical literature on the firm-level effects of CCs. Bekaert et al. (2011) show that easing CCs positively affects capital stock growth and TFP. Larrain and Stumpner (2017), focusing on Eastern European countries, find that financial openness increases aggregate productivity via a more efficient allocation of capital across firms. Varela (2017) studies the 2001 financial liberalization in Hungary and shows that it can lead firms to invest in technology adoption and thereby increase aggregate TFP. Alfaro et al. (2017) find a decline in cumulative abnormal returns for Brazilian firms following the imposition of CCs in 2008-2009, and that this effect is stronger for smaller, non-exporting and more financially dependent firms. 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 a third of the fall in TFP. Chen and Irarrázabal (2015) provide suggestive evidence that financial development might be an important factor explaining the fall in misallocation driving growth in output and productivity in Chile between 1983 and 1996. Forbes (2007) finds that smaller firms experienced significant financial constraints, which decreased with firm size. Our paper contributes to this literature by examining the effects of the Chilean *encaje* on misallocation using a large panel dataset of

manufacturing establishments and showing that misallocation increased relatively more for high-productivity and exporting firms and for firms further away from their optimal scale.

3 Model

We propose a model in which overlapping generations of entrepreneurs sell differentiated varieties of intermediate goods to domestic and foreign final-goods producers in monopolistically-competitive markets. Entrepreneurs can make an irreversible choice to become exporters by paying an entry cost. Their access to foreign financing is limited by a collateral constraint and, if present, CCs. The collateral constraint induces dispersion in MRPKs via the standard mechanism from the literature (i.e., constrained firms grow their net worth gradually with MRPKs that are monotonically larger the further away firms are from their optimal scale). CCs operate also as a financial friction, but with a mechanism that changes MRPKs non-linearly as firms grow, as we explain later in this Section. These financial frictions also interact with the entry cost to become an exporter, because firms must accumulate enough assets for them to find it 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 to operate a constant-elasticity-of-substitution (CES) 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:

$$\begin{aligned} \max_{y_{h,t}(i), y_{m,t}} \quad & p_t y_t - \int_0^1 p_{h,t}(i) y_{h,t}(i) di - p_m y_{m,t} \\ \text{s.t.} \quad & y_t = \left[\int_0^1 y_{h,t}(i)^{\frac{\sigma-1}{\sigma}} di + y_{m,t}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \end{aligned} \quad (1)$$

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 demand functions for domestic inputs:

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

Because of monopolistic competition among intermediate goods producers, these are the demand functions that they internalize in their optimization problems. By analogy, we assume that they face the following demand functions from abroad:

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

where $p_{f,t}(i)$ is the price entrepreneur i charges abroad, and p^* and y^* are the exogenous price and production of foreign final goods, respectively. Hence, the real exchange rate is given by p/p^* .

3.2 Intermediate-goods sector

Entrepreneurs supply one unit of labor inelastically and have iso-elastic preferences:

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

where c_t is consumption, $1/\gamma$ is the elasticity of intertemporal substitution, and β is the subjective discount factor. The expectation \mathbb{E}_0 is taken over the probability of death ρ . At the end of each period, deceased entrepreneurs are replaced by a measure ρ of newborn entrepreneurs. In order to remove the effects of the risk of death from the entrepreneur's optimization problem (i.e., make this risk insurable), we adopt a standard Blanchard-Yaari formulation: Entrepreneurs use insurance contracts so that, upon their death, all savings and capital are transferred to existing entrepreneurs. Surviving entrepreneurs are paid an amount that expands their net worth by a proportion $\frac{\rho}{1-\rho}$.⁵

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 a non-exporter retains the option to become an exporter in the future.⁶ 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 ζ units for every unit sold abroad, with $\zeta > 1$.

⁵We acknowledge that assuming well-developed insurance markets is a bit at odds with assuming credit constraints.

⁶This assumption is validated by the Chilean data that show that 71% of firms that export in a given period continue exporting in the next one. For firms that have exported for three periods, this proportion increases to 93%.

Newborn entrepreneurs arrive with zero debt, draw idiosyncratic productivity z that remains constant until they die, and receive a transfer of capital from the government $\underline{k}(z)$ so that they can start operations.⁷ z is log-normal with p.d.f $f(z)$, mean μ_z and standard deviation ω_z . Entrepreneurs produce intermediate goods using capital, k_t , and labor, n_t , to operate a Cobb-Douglas technology with capital intensity $\alpha \in (0, 1)$. The technological constraint requires:

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

Capital depreciates at rate δ and investment is denoted x_t . Taking into account the insurance payments, the law of motion of capital is given by:⁸

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

Entrepreneurs participate in a global market of one-period, risk-free discount bonds. d_{t+1} denotes debt issued (bonds sold) at price q at date t to be repaid at $t+1$.⁹ They also face the collateral constraint typical of the literature, by which entrepreneurs cannot borrow more resources than a fraction $0 \leq \theta \leq 1$ of the value of their capital stock:

$$q d_{t+1} \leq \theta k_{t+1}. \quad (6)$$

Without CCs, the gross interest rate on debt is the world real interest rate $R^* \equiv 1 + r^*$ and the price is $q^* = 1/R^*$. We model CCs on inflows as an asymmetric tax on external borrowing: for $d_{t+1} > 0$, the interest rate is $\hat{r} = r^* + \nu$ and the bond price is $\hat{q} \equiv 1/(1 + \hat{r})$, where ν is the tax-equivalent capital control, and for $d_{t+1} \leq 0$ the interest rate is $r = r^*$ with bond price q^* .¹⁰ Hence, bond prices are given by $q = \mathbb{1}_{d' \leq 0} q^* + \mathbb{1}_{d' > 0} \hat{q}$. Moreover, since CCs prevent borrowing at the rate R^* , entrepreneurs face the additional constraint $q^* d_{t+1} \leq 0$.

⁷ $\underline{k}(z)$ varies with z and is such that even firms with the lowest z start with capital below their optimal scale.

⁸The 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 $k_{t+1} = \frac{1}{1-\rho} [(1-\delta)k_t + x_t]$.

⁹The 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 $r = r^*$.

¹⁰Appendix A.1 describes the mapping from capital controls regulation to values of ν and applies it to Chilean data.

3.3 Recursive formulation of the entrepreneur's problem

We follow Buera and Moll (2015) in formulating the entrepreneurs' recursive optimization problem so that cash-on-hand is the only relevant endogenous state variable.¹¹ The entrepreneur's cash on hand is: $m \equiv [w + \frac{p_h^{1-\sigma}}{p^{1-\sigma}}y + e\frac{p_f^{1-\sigma}}{p^{1-\sigma}}y^* - wn + p(1-\delta)k - pd - T]/p$, where T are lump-sum taxes. Defining net worth a' as $a' \equiv k' - qd'$, the budget constraint of the entrepreneur can be expressed as $c = m - (1-\rho)a'$.¹² 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 a' into a portfolio of k' and d' and by setting p'_h, p'_f and n' .

An entrepreneur with a given z starts each period being a non-exporter ($e = 0$) or an exporter ($e = 1$) from the period before. Since exporting is an absorbent state, if $e = 1$, it remains an exporter and hence $e' = 1$. But if $e = 0$, it decides optimally whether to become a switcher who starts exporting the following period ($e' = 1$) or not ($e' = 0$). The payoff of the entrepreneur is:

$$v(m, z, e) = ev^E(m, z) + (1-e) \left[\max_{e' \in \{0,1\}} \{(1-e')v^{NE}(m, z) + e'v^S(m, z)\} \right], \quad (7)$$

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. Keep in mind that z does not vary over time.

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

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

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

$$\text{s.t.} \quad \left(\frac{p'_h}{p'} \right)^{-\sigma} y' = zk'^{\alpha} n'^{1-\alpha}, \quad a' = k' - qd', \quad \hat{q}d' \leq \theta k', \quad q^*d' \leq 0.$$

where $\tilde{\beta} \equiv \beta(1-\rho)$. 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. Lump-sum taxes vary with z because the government sets them to pay for the capital endowments of newborn firms of each

¹¹Because of the monopolistic competition, however, in our setting the firms' profits and their debt and capital choices are non-linear in net worth, and hence the net worth decision rule is non-linear in cash on hand.

¹²The 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 $pc = w + \frac{p_h^{1-\sigma}}{p^{1-\sigma}}y + e\frac{p_f^{1-\sigma}}{p^{1-\sigma}}y^* - wn + p(1-\delta)k + pd - T - p(1-\rho)a'$. 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.

productivity type: $T(z) = p' \rho \underline{k}(z)$. This avoids the redistribution of income from low- to high- z entrepreneurs that would occur with a uniform tax.

The two-stage-budgeting structure of the solution is evident in that the maximization problem (8) 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) 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 the optimal 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:

$$v^E(m, z) = \max_{a'} \left[u(m - (1 - \rho)a') + \tilde{\beta} v^E(\tilde{m}'(a', z), z) \right], \quad (10)$$

$$\tilde{m}'(a', z) = \max_{k', d', p'_h, p'_f, n'} \left[\frac{w' + \frac{p'_h^{1-\sigma}}{p'^{-\sigma}} y' + \frac{p'_f^{1-\sigma}}{p'^{-\sigma}} y^* - w' n' + p'(1 - \delta)k' - p'd' - T(z)}{p'} \right] \quad (11)$$

$$\text{s.t.} \quad \left(\frac{p'_h}{p'} \right)^{-\sigma} y' + \zeta \left(\frac{p'_f}{p^*} \right)^{-\sigma} y^* = z k'^{\alpha} n'^{1-\alpha}, \quad a' = k' - qd', \quad \hat{q}d' \leq \theta k', \quad q^* d' \leq 0.$$

This problem includes sales abroad as part of cash on hand, adds foreign demand inclusive of the iceberg cost of exporting in the technological constraint, 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 (10).

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

$$v^S(m, z) = \max_{a'} \left[u(m - (1 - \rho)a' - wF) + \tilde{\beta} v^E(\tilde{m}'(a', z), z) \right], \quad (12)$$

$$\tilde{m}'(a', z) = \max_{k', d', p'_h, p'_f, n'} \left[\frac{w' + \frac{p'_h^{1-\sigma}}{p'^{-\sigma}} y' + \frac{p'_f^{1-\sigma}}{p'^{-\sigma}} y^* - w' n' + p'(1 - \delta)k' - p'd' - T(z)}{p'} \right] \quad (13)$$

$$\text{s.t.} \quad \left(\frac{p'_h}{p'} \right)^{-\sigma} y' + \zeta \left(\frac{p'_f}{p^*} \right)^{-\sigma} y^* = z k'^{\alpha} n'^{1-\alpha}, \quad a' = k' - qd', \quad \hat{q}d' \leq \theta k', \quad q^* d' \leq 0.$$

The value function in the right-hand-side of (12) is the one for 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.

The entrepreneur's payoff function can be expressed as:

$$v(m, z, e) = \begin{cases} v^{NE}(m, z) & \text{if } e = 0 \text{ and } e'(m, z, 0) = 0, \\ v^S(m, z) & \text{if } e = 0 \text{ and } e'(m, z, 0) = 1, \\ v^E(m, z) & \text{if } e = 1. \end{cases} \quad (14)$$

The first condition holds when the firm starts the period and continues to the next as non-exporter, the second when it also starts as non-exporter but becomes a switcher, and the third when it starts as an exporter ($e'(m, z, 1) = 1$ for all (m, z) because exporting is an absorbent state). The decision rules for non-exporters, switchers and exporters apply to each of these three cases, respectively.

We verify 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 $v^{NE}(\hat{m}, z) = v^S(\hat{m}, z)$. For a firm born at date $\tau = 0$, there is an associated switching date $\hat{\tau}(\hat{m}(z))$ when it reaches the age at which it decides to become a switcher.¹³

We denote by $\underline{m}(z)$ the cash on hand of a newborn firm, which is given by $\underline{m}(z) = [w + \underline{p}_h(z)z\underline{k}^\alpha \underline{n}(z)^{1-\alpha} - w\underline{n}(z) + p(1-\delta)\underline{k}(z) - T(z)]/p$, where $\underline{p}_h(z)$, $\underline{n}(z)$ are the solutions that maximize m taking as given $k = \underline{k}(z)$ and $d = 0$ and subject to the technological constraint for production of y_h .¹⁴ 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 only via its first-order effect on production. Note also that newborn firms that draw high enough z such that $v^S(\underline{m}(z), z) \geq v^{NE}(\underline{m}(z), z)$ become switchers from the start (i.e., $e' = 1$), otherwise $e' = 0$.

¹³This is helpful for characterizing the equilibrium in terms of the firm-age distribution $\phi(\tau, z)$, as we explain later.

¹⁴At 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 $p_f = \zeta p_h$ and simplify.

3.4 Stationary equilibrium

Our analysis focuses on comparing stationary equilibria in the regimes with and without capital controls (*NCC* and *CC*, respectively). We do this using the stationary firm-age distribution, because the model's Blanchard-Yaari OLG structure implies that $\phi(\tau, z) = \rho(1 - \rho)^\tau f(z)$. Hence, the firm-age distribution is exogenous, and thus invariant to whether capital controls are in place or not.¹⁵ Firms of the same age have different (m, z) in the two regimes, but the fraction of firms of a given age and productivity is the same. We also use the firm-age distribution because the Chilean firm-level dataset we use for the calibration has information on the firms' assets, sales, employment and age, but not on their net worth and debt. Since the model has no risk, we assume $\beta R^* = 1$.

For given q, p^* and y^* , the recursive stationary equilibrium consists of aggregate prices $\{w, p\}$, final goods output $\{y\}$, entrepreneurs' decision rules $\{c'(\tau, z), a'(\tau, z), n'(\tau, z), \tilde{m}'(\tau, z), p'_h(\tau, z), p'_f(\tau, z), y'_h(\tau, z), y'_f(\tau, z), d'(\tau, z), k'(\tau, z)\}$, lump-sum taxes $T(z)$, and value functions $v(\tau, z), v^{NE}(\tau, z), v^S(\tau, z), v^E(\tau, z)$ 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 holds: $\sum_z p \rho \underline{k}(z) f(z) = \sum_z T(z) f(z)$ with $p \rho \underline{k}(z) = T(z)$.
4. The labor market clears: $\sum_\tau \sum_z n(\tau, z) \phi(\tau, z) + F \sum_z \hat{\tau}(\hat{m}(z)) f(z) = 1$.
5. The market of final goods clears: $\sum_\tau \sum_z [c(\tau, z) + \rho \underline{k}(z) + x(\tau, z)] \phi(\tau, z) = y$, where $c(\tau, z) = m(\tau, z) - (1 - \rho)a'(\tau, z) - \mathbb{1}_{\tau=\hat{\tau}(\hat{m}(z))} w F$ and $x(\tau, z) = (1 - \rho)k'(\tau, z) - (1 - \delta)k(\tau, z)$.

4 Capital Controls and Misallocation

This Section derives the model's predictions regarding the effects of CCs on misallocation, defined as the as the deviation of a firm's MRPK from its steady-state level $\overline{MRPK} \equiv p(r^* + \delta)$. We start by examining the exporters' second-stage problem of maximizing \tilde{m}' by choosing d', k', p'_h, p'_f, n'

¹⁵Given the decision rules $a'(m, z)$ and $m'(a', z)$, the solutions obtained for the state space (m, z, e) map into (τ, z) by recursive substitution as follows: When a firm is born ($\tau = 0$), its choices are given by $a'(0, z) = a'(\underline{m}(z), z)$ and $m'(0, z) = m'(a'(0, z), z)$, respectively. Its choices at age 1 are therefore $a'(1, z) = a'(m'(0, z), z)$ and $m'(1, z) = m'(a'(1, z), z)$. Hence, for any age τ the firm's choices are $a'(\tau, z) = a'(m'(\tau - 1, z), z)$ and $m(\tau, z) = m'(a'(\tau, z), z)$. For $0 \leq \tau < \hat{\tau}(\hat{m}(z))$ we use the non-exporter's decision rules, for $\tau = \hat{\tau}(\hat{m}(z))$ we use the switcher's, and for $\tau > \hat{\tau}(\hat{m}(z))$ we use the exporter's. Appendix B explains in detail the algorithm used to solve the model.

for a given a' (i.e., problem (11)).¹⁶ Since dynamic effects (changes in a') and general equilibrium effects (changes in p' , w' , y') are not considered, we refer to the results as the “static effects” of CCs.

The first-order conditions of the second-stage problem simplify to:

$$MRPN \equiv \frac{p'_h}{\varsigma}(1 - \alpha)z(k')^\alpha(n')^{-\alpha} = w', \quad (15)$$

$$MRPK \equiv \frac{p'_h}{\varsigma}\alpha z(k')^{\alpha-1}(n')^{1-\alpha} = \mathbb{1}_{d' \leq 0} [p'(r^* + \delta) + \mu] + \mathbb{1}_{d' > 0} [p'(\hat{r} + \delta) + \eta(1 - \theta)], \quad (16)$$

$$\left(\frac{p'_h}{p'}\right)^{-\sigma} y + \zeta \left(\frac{p'_f}{p^*}\right)^{-\sigma} y^* = zk'^\alpha n'^{1-\alpha}, \quad (17)$$

$$p'_f = \zeta p'_h, \quad (18)$$

$$qd' = k' - a'. \quad (19)$$

where $\varsigma = \sigma/(\sigma - 1)$ is the markup of price over marginal cost, η is the multiplier on the collateral constraint, and μ is the multiplier on the constraint that prevents borrowing at R^* because of the CCs.¹⁷ As shown in Appendix C, the left-hand-sides of (15) and (16) 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. In addition, the complementary slackness conditions $\eta(a' - (1 - \theta)k') = 0$ and $\mu(a' - k') = 0$ must also hold. When $\eta > 0$, k' is set by the collateral constraint at $k'(a') = a'/(1 - \theta)$, and when $\mu > 0$, $k'(a') = a'$.

Note three properties of the above conditions: First, μ and η cannot be positive at the same time. A firm with the collateral constraint binding borrows at \hat{R} , hence $\eta > 0$ 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 choice of k' only depends on a' if either $\eta > 0$ or $\mu > 0$. Otherwise, Fisherian separation holds (the optimal k' is independent of a' and d'). Third, the MRPN of all firms is the same and equals the wage rate. However, the wage is different in the *NCC* and *CC* regimes and in the efficient equilibrium without credit frictions, and thus MRPNs differ. In this sense, there is labor misallocation across regimes (i.e., MRPN differs in the two and both differ from the efficient MRPN) but there is no labor misallocation within each regime since all firms have the same MRPN. In contrast, MRPKs differ both across regimes and across firms within each regime.

Condition (16) drives the static effects of CCs on misallocation. To understand the trans-

¹⁶The second-stage problems of non-exporters and switchers are very similar, except there are no foreign sales and no price associated with them.

¹⁷The budget constraint with CCs is akin to the textbook problem with a kinked budget constraint, which is represented by the constraint $q^* d' \leq 0$ 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 $\mu = \tilde{\mu} \frac{p'}{\beta u'(c')}$.

mission mechanism and contrast it with the one typically at work in the literature, we study its implications first without financial frictions, then introduce the collateral constraint and CCs separately, and finally, add CCs to the economy with the collateral constraint.

4.1 No financial frictions

To remove all financial frictions, assume $\theta \rightarrow \infty$ so that the collateral constraint never binds for any firm, and $\nu = 0$.¹⁸ In this case, MRPK and MRPN are equalized across firms in the decentralized equilibrium. Moreover, a utilitarian social planner without financial frictions sets allocations in a similar manner. These results are contained in the following propositions:

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

Proof. If $\theta \rightarrow \infty$ and $\nu = 0$, the first-order conditions (15) and (16) reduce to:

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

□

Proposition 2. *If $\beta R^* = 1$, the MRPK and MRPN of the decentralized equilibrium without financial frictions (as $\sigma \rightarrow \infty$ and intermediate goods become perfect substitutes) match the efficient real returns on capital and labor attained by a utilitarian social planner free of financial frictions. These MRPs are time-invariant, constant across firms regardless of their age and productivity, and $MRPK_i = \overline{MRPK}$.*

Proof. The proof is provided in Appendix D. There, we also show that the planner equalizes consumption and the real returns on capital and labor across all firms each period. □

Without financial frictions, there is zero dispersion in MRPN and MRPK across firms and this is socially optimal. There is no misallocation (i.e., no factor reallocation across firms is desirable).¹⁹ If $\underline{k}_i < \bar{k}_i$, 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.

¹⁸ $\theta \rightarrow \infty$ is sufficient but not necessary for the collateral constraint to be irrelevant. The necessary condition for a firm of productivity z at birth is $\theta(z) > 1 - (\underline{k}(z)/\bar{k}(z))$, where $\bar{k}(z)$ is the firm's steady-state capital. Intuitively, with this θ even newborn firms can borrow enough to attain $\bar{k}(z)$ in the first period.

¹⁹Due to monopolistic competition, the first-best allocations yield higher production than the decentralized equilibrium, because imperfect substitutability of input varieties implies that firms have market power to set prices. Hence, we could constrain the planner to use the same aggregate capital and labor as in the decentralized equilibrium to obtain the same allocations in both problems. Alternatively, we can compare the *competitive* decentralized equilibrium (as $\sigma \rightarrow \infty$) with a standard utilitarian planner's equilibrium that chooses production efficiently, as we do in Proposition 2.

4.2 Collateral constraints & capital controls separately

Consider next the *NCC* regime, which has collateral constraints ($\theta > 0$) but no CCs ($\nu = 0$).

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. The first-order conditions of the second-stage problem imply:

$$MRPK_i = p(r^* + \delta) + \eta_i(1 - \theta).$$

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 set investment as high as the constraint allows: $k'_i(a'_i) = a'_i/(1 - \theta)$. The firm accumulates capital gradually as it grows its net worth and the constraint binds as long as $k_i < \bar{k}_i$, so $\eta_i > 0$ and $MRPK_i > \overline{MRPK}$.²⁰ \square

These firms behave as those in open-economy models of misallocation caused by credit constraints: MRPK equals $p(r^* + \delta)$ plus the marginal cost of capital associated with the tightness of the constraint. This cost is given by the shadow value of the constraint η_i , which is in terms of marginal utility, multiplied by $(1 - \theta)$ (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, with higher MRPKs for those that are more constrained. Importantly, for a firm of productivity z , the excess of MRPK over its steady-state level decreases monotonically as a' rises.

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

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

Proof. If $\theta \rightarrow \infty$, $\nu > 0$, 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-stage problem imply:

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

Firms with $k_i < \bar{k}_i$ face the CCs and hence can only borrow at \hat{r} . When they are born, they borrow so that $MRPK_i = p(\hat{r} + \delta) > \overline{MRPK}$. This is akin to the optimality condition without financial

²⁰At equilibrium, $u'(c_i)/\beta u'(c'_i) = [1/(1 - \theta)][(MRPK_i/p') + 1 - \delta - \theta]$ for these firms.

frictions but at a higher interest rate. Hence, these firms 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, the dynamic effects studied later induce these firms to gradually pay down their debt and increase their net worth until $d_i = 0$. At this point, they are free from the CCs and can save at r^* . But at r^* they would like to borrow to jump to \bar{k}_i . Hence, the constraint that there is no borrowing at r^* binds ($\mu_i > 0$) and they start accumulating capital gradually, effectively as if they were under financial autarky.²¹ As long as $k_i < \bar{k}_i$, $MRPK_i = p(r^* + \delta) + \mu_i > \overline{MRPK}$. 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. \square

CCs distort the allocation of capital in two ways. First, all firms pay the same tax ν when borrowing, 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 heterogeneity in the financial conditions of firms that those models miss: μ_i is larger for more debt-constrained firms (i.e., firms with lower a' that would have liked to borrow at r^* but not at \hat{r}).

4.3 Static effects of capital controls

Our main goal is to compare the *NCC* regime with the one in which both credit constraints and CCs are present, the *CC* regime. We study first the static effects focusing on how MRPKs differ across regimes (since p is unchanged, changes in misallocation are the same as changes in MRPKs). Figure 1 plots a firm's choice of k' in the interval $a' \in [\underline{k}, \bar{k}]$ (for a given 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 CCs prevent borrowing at R^* . The ray with slope of $1/(1 - \theta) > 1$ is the choice of k' implied by the collateral constraint in both the *NCC* and *CC* regimes. The red and yellow piece-wise linear functions show the optimal second-stage choices of k' as a function of a' in the *CC* and *NCC* regimes, respectively.

Conditions (15)-(19) imply that the choice of k' in the *CC* regime can be broken down into the four regions labeled in the Figure:²²

1. *Binding collateral constraints at higher borrowing costs:* For $a' \in [\underline{k}, (1 - \theta)\bar{k}^{CC}]$, the outcome is like 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

²¹At equilibrium, $u'(c_i)/\beta u'(c'_i) = (MRPK_i/p') + 1 - \delta$ for these firms.

²²For the numerical solution, it is important that in each region the system (15)-(19) 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.

jump to \bar{k}^{CC} but is credit constrained, so it can only attain $k'(a') = a'/(1-\theta)$. Firms in this category have higher MRPK the further away they are from \bar{k}^{CC} . MRPKs differ across them and they all differ from \overline{MRPK} . As we show later, these firms have stronger incentives to save because of they face a higher effective interest rate. Thus, they rise a' and k' gradually until they reach \bar{k}^{CC} .

2. *Higher borrowing costs for firms unaffected by the collateral constraint:* For $a' \in ((1-\theta)\bar{k}^{CC}, \bar{k}^{CC}]$, the outcome is related to Proposition 4. These firms attain the pseudo-steady state consistent with \hat{R} , and since $\beta\hat{R} > 1$, they also have incentives to save and gradually pay down their debt. 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, they are higher for the more debt-constrained, and they all exceed \overline{MRPK} . These firms also have stronger incentives to save because of a higher effective interest rate given by $R^* [1 + (\mu/p')]$. Thus, a' and k' rise gradually until reaching \bar{k} .

4. *Firms at their optimal scale:* For $a' \geq \bar{k}$, the firm is at its optimal scale and $MRPK = \overline{MRPK}$. It does not need to borrow, and neither the collateral constraint nor the CCs affect it.

Figure 1 shows that the static effects of CCs imply that k' is (weakly) smaller for all firms when CCs are introduced. Defining a firm's optimal scale gap as the percent difference between its current capital k and its \bar{k} ($OSG \equiv (\bar{k} - k)/\bar{k}$), the OSGs are larger.²³ k' is the same for firms within either region 1 or 4. In region 2, firms in the *CC* regime are at the pseudo-steady state \bar{k}^{cc} , and $\hat{R} > R^*$ implies that $\bar{k}^{cc} < \bar{k}$. In region 3, firms in the *CC* regime hit the no-borrowing constraint and set $k' = a'$, which is less than \bar{k} , while firms in the *NCC* regime have more capital because they are either already at \bar{k} or they are credit-constrained but at the same a' can sustain higher k' .

Lower k' under CCs increases *MRPKs*. This follows from three conditions derived from eqs. (15)-(19):

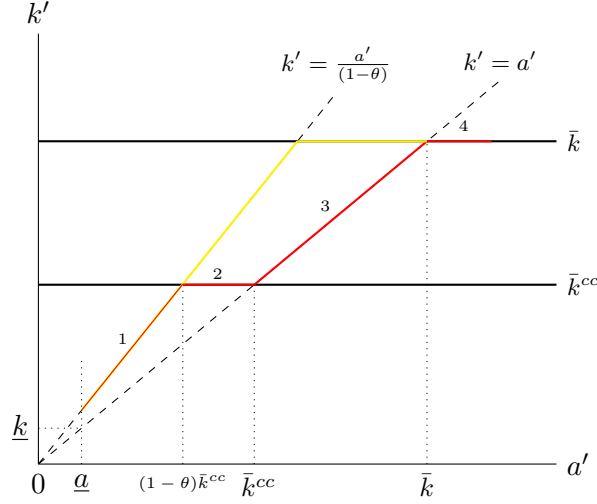
$$p'_h(a') = \left[\frac{[(p')^\sigma y' + e(p^*)^\sigma \zeta^{1-\sigma} y^*]^\alpha}{z (k'(a', z))^\alpha \left[\frac{1-\alpha}{w'\zeta} \right]^{1-\alpha}} \right]^{\frac{1}{1+\alpha(\sigma-1)}} \quad (20)$$

$$\frac{k'}{n'}(a') = \left[\frac{\varsigma}{(1-\alpha)z} \left(\frac{w'}{p'_h(a', z)} \right) \right]^{1/\alpha} \quad (21)$$

$$MRPK(a') = \frac{\alpha z}{\varsigma} \frac{p'_h(a', z)}{\left[\frac{k'}{n'}(a', z) \right]^{1-\alpha}}. \quad (22)$$

²³The interpretation of CCs as size-dependent policies is evident in the similarity of this plot with the one Guner et al. (2008) derived for firm size restrictions represented as taxes on capital above a given level of k .

Figure 1: Static Effects of Capital Controls
(second-stage optimal k' as a function of a')



For given $(a', z; y', p', w')$, the lower $k'(a')$ in the CC regime implies that firms charge higher $p'_h(a')$ (condition (20)) and this lowers $\frac{k'}{n'}(a')$ because it reduces the firm-specific real wage (condition (21)). These two effects increase $MRPK(a')$ (condition (22)). This result can be summarized by defining the static effect of CCs on MRPK as $\Delta MRPK(a') \equiv MRPK_{CC}(a') - MRPK_{NCC}(a')$ and then using condition (22) we obtain:

$$\Delta MRPK(a') = \frac{\alpha z}{\varsigma} \left[\frac{p'_{h,CC}(a')}{\left[\frac{k'}{n'}_{CC}(a')\right]^{1-\alpha}} - \frac{p'_{h,NCC}(a')}{\left[\frac{k'}{n'}_{NCC}(a')\right]^{1-\alpha}} \right] \geq 0, \quad (23)$$

$\Delta MRPK(a') > 0$ in regions 2-3 because CCs raise firm prices and reduce capital-labor ratios relative to those in the NCC regime.

Figure 1 yields another key result: While with the standard collateral constraint the OSGs are decreasing in a' , CCs create a region in which OSGs are invariant in a' (region 2). As a' increases, a firm's OSG falls monotonically in the NCC regime until it vanishes when the firm reaches its optimal scale. In contrast, in the CC regime, the OSG falls with a' in region 1, then it is constant as a' rises in region 2 (since $k(a')$ is constant), and then it decreases again in region 3 until it vanishes (since this region is akin to region 1 but with $\theta = 0$). As a result, the difference in OSGs between the NCC and CC regimes is non-monotonic in a' . OSGs are the same in both regimes with either a' low enough to be in region 1 or high enough to be at the optimal scale, and their difference is at their largest when a' is in region 2. For the same reason, $\Delta MRPK(a')$ is non-monotonic in a' : there is zero change in misallocation for firms in regions 1 and 4, and the firms with the largest

increase in misallocation are found where $a' = \bar{k}^{CC}$ (for each level of z). As we discuss later, this result is important for the quantitative and empirical results examined in Sections 5 and 6.

Condition (23) characterizes the static effects of CCs on MPRKs in “physical” terms. Using condition (16), we can express them in terms of prices and shadow values. In region 2, where firms are borrowing and the collateral constraint may or may not bind in the NCC regime but is not binding in the CC regime, we obtain:

$$\Delta MRPK|_{a'_{CC} > 0}(a') = (p'_{CC} - p'_{NCC})(r^* + \delta) + \nu p'_{CC} - \eta_{NCC}(a')(1 - \theta). \quad (24)$$

This expression splits the effect of CCs on MRPK into three terms: (1) differences in \overline{MRPK} due to changes in p , but evaluated at a common price (since we are abstracting from general equilibrium effects), we can disregard this term; (2) MRPK rises because CCs increase market borrowing costs for all firms by $\nu p'_{CC}$; (3) the gap in MRPKs between the CC and NCC regimes *falls* to the extent that the collateral constraint binds in the latter (i.e., $\eta_{NCC}(a') > 0$). Since $\eta_{NCC}(a')$ is decreasing in a' , however, the differences in MRPKs grow larger as a' rises.²⁴

In region 3, where firms hit the no-borrowing constraint in the CC regime and again the collateral constraint may or may not bind in the NCC regime, we obtain:

$$\Delta MRPK|_{a'_{CC} \leq 0}(a') = (p'_{CC} - p'_{NCC})(r^* + \delta) + \mu_{CC}(a') - \eta_{NCC}(a')(1 - \theta). \quad (25)$$

Disregard again the first term of this expression, since we are abstracting from general equilibrium changes in p . For firms that are already at their optimal scale in the NCC regime, we obtain $\Delta MRPK|_{a'_{CC} \leq 0}(a') = \mu_{CC}(a') > 0$, with the MRPKs of firms that are more constrained by the CCs rising more. If the collateral constraint binds in the NCC regime, the excess of the MRPK under CC relative to NCC depends on how much tighter is the no-borrowing constraint in the former than the collateral constraint in the latter.²⁵

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 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

²⁴ $\nu p'_{CC} > \eta_{NCC}(a')(1 - \theta)$ for a given a' (and z) because, as we showed before, there is more capital and lower MRPK in the NCC regime, and thus $\Delta MRPK|_{a'_{CC} > 0}(a') > 0 \Leftrightarrow \nu p'_{CC} > \eta_{NCC}(a')(1 - \theta)$.

²⁵ $\mu_{CC}(a') > \eta_{NCC}(a')$ for a given a' (and z) because, if firms in the NCC regime are constrained, the collateral constraint allows for more debt ($a'/(1 - \theta)$) than the no-borrowing constraint in the CC regime (a').

foreign demand on p'_h (see condition (20)), 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 (20) 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 its 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 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.

4.4 Dynamic and general equilibrium effects

The static effects do not take into account changes in net worth a' (i.e., *dynamic effects*) and in the aggregate variables (w', p', y') (i.e., *general equilibrium (GE) effects*). We now extend the analysis to incorporate these effects.

The dynamic effects capture differences in the optimal net-worth decision rule that solves the entrepreneurs' first-stage optimization problem, $a'(m, z)$, across the *CC* and *NCC* regimes. These differences imply different locations along the horizontal axis of Figure 1 and hence different $k'(a'(m, z))$ choices. Applying the envelope theorem to problem (12) yields this Euler equation:

$$u'(c) = \beta u'(c') \frac{\delta \tilde{m}'(a', z; y', p', w')}{\delta a'}. \quad (26)$$

Differentiating (13) and simplifying using conditions (15)-(16), we find that:

$$\frac{d\tilde{m}'(a', z; y', p', w')}{da'} = \mathbb{1}_{a' > 0} \left[\hat{R} + \frac{\eta}{p'} \right] + \mathbb{1}_{a' \leq 0} \left[R^* + \frac{\mu}{p'} \right], \quad (27)$$

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.

Combining the above two results yields the result that both the collateral constraint and the CCs incentivize entrepreneurs to grow their net worth faster, because they increase the marginal

benefit of saving above the world interest rate, R^* . The effective return on savings in region 1 is $\hat{R} + \frac{\eta}{p'}$; in region 2, \hat{R} ; and in region 3, $R^* + \frac{\mu}{p'}$. Only in region 4, where both financial constraints are not binding, the return on savings equals R^* .

In region 1, entrepreneurs borrow at \hat{R} and are credit-constrained. Since the optimality conditions of the second-stage problem hold too, we obtain:

$$\frac{u'(c)}{\beta u'(c')} = \hat{R} + \frac{\eta}{p'} = \left[\frac{MRPK'}{p'} + 1 - \delta + \theta \frac{\eta}{p'} \right]. \quad (28)$$

Hence, the increase in the effective return on savings is due to the CCs, since $\hat{R} > R^*$, and to the collateral constraint, since $\eta/p' > 0$. Moreover, the latter varies across firms affecting more firms that are more constrained and thus have higher $MRPK$.

All firms in region 2 have a stock of debt $d' = \hat{R}(\bar{k}^{cc} - a')$ contracted at $\hat{R} > R^*$ because of the CCs, but they are unaffected by the collateral constraint and they are gradually paying down their debt to zero as a' reaches \bar{k}^{cc} . Since $\beta \hat{R} > 1$, these entrepreneurs are at the pseudo-steady state for capital but the dynamic effect is still at work because they desire to reallocate consumption into the future by growing their net worth.

In region 3, entrepreneurs hit the no-borrowing constraint at R^* , and again since the optimality conditions of the second-stage problem hold, we obtain:

$$\frac{u'(c)}{\beta u'(c')} = R^* + \frac{\mu}{p'} = \left[\frac{MRPK'}{p'} + 1 - \delta \right]. \quad (29)$$

Hence, the increase in the effective return on savings is due only to the CCs, because they prevent firms from borrowing at R^* and this constraint binds ($\mu/p' > 0$). This effect varies across firms affecting more those that are more constrained and thus have higher $MRPK$.

Regions 1 and 3 are analogous in that an entrepreneur's intertemporal marginal rate of substitution (IMRS), return on savings, and net marginal return on capital accumulation are equalized using an endogenous effective interest rate that is determined by the multipliers μ or η . Because of this, there is no Fisherian separation of the consumption/saving choice from the investment choice.

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 IMRS in consumption with the world's real interest rate R^* . Since $\beta R^* = 1$, their consumption and net worth are stationary.

We can summarize the dynamic effects of CCs as follows: In regions 1-3, CCs push the

IMRS above R^* which strengthens the entrepreneurs incentive to reallocate consumption into the future by increasing a' . As eqs. (28)-(29) show, this effect is stronger for entrepreneurs borrowing at \hat{R} and affected by the collateral constraint (region 1) and more so for those who are more constrained (for them, $IMRS_i = \hat{R} + \frac{\eta_i}{p'} > \hat{R}$). CCs tighten the collateral constraint, increasing both the contractual interest rate (from R^* to \hat{R}) and the effective interest rate inclusive of the shadow value of the constraint. Firms in region 2 are free from the collateral constraint and hold debt at \hat{R} that is gradually paid out (with $IMRS_i = \hat{R} > R^*$). The contractual rate rises to \hat{R} without affecting borrowing capacity but saving incentives still strengthen, albeit less than in region 1. Firms in region 3 are prevented from borrowing at R^* by the CCs (with $IMRS_i = R^* + \frac{\mu_i}{p'} > R^*$). They cannot borrow but again saving incentives strengthen, although less than in regions 1 and 2. Finally, firms in region 4 are unaffected.

Because of these dynamic effects, even though the static effects predict lower $k'(a')$ and higher $MRPK(a')$ in the *CC* than the *NCC* regime for a common a' , firms have the incentives to build their net worth and grow their capital faster. At equilibrium, we may observe a larger fraction of firms in regions 2 and 3 than 1, but the reason is because of the stronger dynamic effects in region 1. Moreover, it is possible that for some firms the dynamic effects could be sufficiently strong to offset the static effects. In this case, an entrepreneur with some (m, z) may have saved sufficiently more in the regime with CCs (i.e., $a^{CC}(m, z) > a^{NCC}(m, z)$) so that eqs. (20)-(22) would predict that MRPK is higher *without* CCs.

It is worth noting that, while \hat{R} and R^* are exogenous, the effective interest rates faced by credit-constrained firms in regions 1 and 3 are endogenous (they depend on η and μ , see eqs. (28)-(29)). This is akin to a model in which each firm faces an endogenous interest rate 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.

Consider next the GE effects of CCs. These effects alter both the optimal scale of firms and the stringency of the credit constraints, but they are difficult to characterize in analytic form. They reflect differences in (w', p', y') due to changes in the firms' optimal plans and their aggregate effects, which affect aggregate demand and supply of final goods, intermediate goods and labor. Even for firms in region 4, MRPKs differ across regimes because differences in final goods prices alter $\overline{MRPK} = p(r^* + \delta)$. For the same reason, once we allow for GE effects, changes in misallocation (deviations of $MRPK$ from \overline{MRPK}) differ from changes in $MRPK$. MRPNs also differ, since w also differs.

The interaction of the static and GE effects on misallocation can be illustrated by rewriting conditions (24)-(25) in terms of $\Delta mis \equiv \Delta(MRPK - p(r^* + \delta))$. In region 2, we obtain $\Delta mis|_{d'_{CC} > 0}(a') = \nu p'_{CC} - \eta_{NCC}(a')(1 - \theta)$. There is a first-order GE effect by which the magnitude of the effect of CCs increasing misallocation by hiking the interest rate varies with p'_{CC} . In region 3, we obtain $\Delta mis|_{d'_{CC} \leq 0}(a') = \mu_{CC}(a') - \eta_{NCC}(a')(1 - \theta)$. There are only second-order effects: changes in (y, p, w) across the *NCC* and *CC* regimes affect the optimal scales of firms, which alters the tightness of the collateral constraint in the *NCC* regime ($\mu_{CC}(a')$) and the no-borrowing constraint in the *CC* regime ($\eta_{NCC}(a')$). If firms have larger optimal scales in the *CC* regime, as is the case in our calibrated model because p and w fall, the no-borrowing constraint tightens and amplifies misallocation. Something similar happens in region 1. In this case, $\Delta mis|_{d'_{CC} > 0}(a') = [\eta_{CC}(a') - \eta_{NCC}(a)](1 - \theta)$. There is no static effect of CCs because firms make the same decisions in the two regimes ($\eta_{CC}(a') - \eta_{NCC}(a') = 0$), but with GE effects, the larger optimal scales with CCs imply that, at the same a' , $[\eta_{CC}(a') - \eta_{NCC}(a')] > 0$, so misallocation rises. Keep in mind that in the full model solution the dynamic effects are also interacting with these GE and static effects, by altering the fraction of firms with a given a' across regimes.

One caveat of this analysis is that it did not consider the existence of a domestic credit market. Appendix F extends the model in this direction. Entrepreneurs can trade domestic bonds b at a price q^b , with an interest rate $R^b = 1/q^b$. These bonds are in zero net supply so as to clear the market internally. Net worth and the collateral constraint become $a' = k' - qd' + q^b b'$ and $qd' - q^b b' \leq \theta k$, respectively. We obtain two key results: (1) If $R^b > \hat{R}$, the analysis as presented in this Section goes through: Firms that borrow always borrow from abroad so $b' = 0$ for all firms, and those that have attained $a' = \bar{k}^{cc}(z)$ move into region 3 because there is no supply of domestic bonds and the marginal return on saving exceeds R^* .²⁶ (2) If $R^* < R^b \leq \hat{R}$, CCs move the economy to financial autarky, region 3 disappears but region 2 widens and firms never reach the optimal scale consistent with R^* , instead they remain at the steady-state of capital determined by R^b . Aggregate misallocation can be larger or smaller than in the model without domestic debt market depending on whether R^b is closer to \hat{R} or R^* .

²⁶The results also hold if we assume that domestic bonds are taxed so that the after-tax return is R^* . This is reasonable because CCs are a form of financial repression, which implies the existence of wedges between saving and lending rates.

5 Quantitative Analysis

We analyze in this Section the quantitative predictions of the model. The solution method is described in Appendix B. We calibrate the *NCC* regime using Chilean data for 1990-1991, before the *encaje* was introduced. A subset of the parameter values is set to widely-used values or to estimates from the related literature and the rest are set so that the *NCC* stationary equilibrium matches selected data moments. We then construct the *CC* regime by setting the value of ν to the mean of the tax-equivalent of the Chilean *encaje*.

5.1 *NCC* calibration & steady state

The parameters assigned commonly-used values or taken from the 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 calibrated his model to Chilean data and used this value 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.

We set the capital injection to newborn firms as a fraction κ of their steady-state capital: $\underline{k}(z) = \kappa \bar{k}(z)$, taking into account that $\bar{k}(z)$ is higher for exporters.²⁷ Also, in order to capture the empirical fact that exporters have better access to credit (e.g., Muuls (2015)), we set the fraction of capital that they can pledge as collateral higher than for non-exporters by the percent θ_f (i.e., $\theta^E = (1 + \theta_f)\theta^{NE}$). We discretize $f(z)$ over ten nodes, z_i for $i = 1, \dots, 10$, using the Gaussian quadrature algorithm QWLOGN from Miranda and Fackler (2004).

The parameter values determined by targeting data moments are $\{\zeta, \omega_z, F, \theta_f, \theta^{NE}, \kappa, \alpha\}$. The targets are: (1) the share of firms that export (0.18); (2) the sales of exporters divided by those of non-exporters (8.55); (3) the ratio of sales of five- to one-year-old firms, among new firms that survive at least five years (1.26); (4) aggregate exports as a fraction of total sales (0.21); (5) credit to the manufacturing sector as a fraction of manufacturing value added (0.33); (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).

²⁷The analysis of the firm-size distribution shows that the share of exporters increases significantly with firm size. While the share of exporters is only 3% for firms in the lowest 25th percentile, it increases to 30% for firms in the highest 75th percentile and to 54% for firms in the highest 95th percentile

The above data targets are averages for the 1990-1991 period, since the *encaje* was introduced in mid-1991 and, arguably, did not affect the data for those years. All but the ratio of credit to the manufacturing sector as a fraction of manufacturing value added were computed using Chile’s *Encuesta Nacional Industrial Anual* (ENIA). The ENIA has data on all manufacturing establishments with more than ten employees. It includes approximately 4,500 observations per year and provides detailed information on characteristics such as total workers, payroll, domestic sales, exports, inputs, physical assets, etc. The ENIA does not report credit data. Thus, to construct the ratio of credit to the manufacturing sector as a fraction of manufacturing value added, we first compute the ratio of manufacturing credit over total commercial credit for 2000-2005 using data from the Superintendencia de Bancos e Instituciones Financieras de Chile (these data are not reported before 2000), and estimate the 1990-1991 values by linear extrapolation. Then we multiply the results by the ratio of the share of commercial credit in GDP, calculated using data from the Central Bank of Chile, to the share of manufacturing value added in GDP, reported by the World Bank.

The calibration uses an SMM algorithm with equal weight on each parameter (i.e., minimizing the squared differences of model moments from data targets). The resulting parameter values are reported in Table 1. Table 2 shows the data targets and their model counterparts. The calibration delivers model moments quite close to the data moments.

For the *CC* regime, the value of ν is the 1991-1998 average of the tax-equivalent of the Chilean *encaje* computed with the methodology proposed by De Gregorio et al. (2000) applied to a 12-months loan maturity (see Appendix A.1) and the calibrated value of r^* (0.0416). This yields $\nu = 0.0175$, which is sizable relative to the value of r^* .

Table 1: Parameter Values in the *NCC* Calibration

Predetermined parameters				SMM calibration		
β	Discount factor	0.96	Standard	ζ	Iceberg trade cost	3.7134
γ	Risk aversion	2	Standard	ω_z	Productivity dispersion	0.4289
σ	Substitution elasticity	4	Leibovici (2021)	F	Sunk export entry cost	1.5564
δ	Depreciation rate	0.06	Midrigan and Xu (2014)	θ^{NE}	non-exporters collateral coefficient	0.0610
ρ	Death probability	0.08	Chilean data	θ_f	Exporters collateral factor	1.6977
				α	Capital intensity	0.4673
				κ	Fraction of steady-state capital as initial capital	0.3002

To provide additional validation for the calibration of the model as a reasonable approximation to Chilean data upon which to build our quantification of the effects of the *encaje* policy,

Table 2: SMM Data Target Moments & Model Counterparts

Moment	Data target (1990-1991) (1)	Model solution (<i>NCC</i> regime) (2)
Share of exporters	0.18	0.18
Average sales (exporters/non-exporters)	8.55	8.55
Average sales (age 5 / age 1)	1.26	1.27
Aggregate exports / sales	0.21	0.21
Aggregate credit / Value added	0.33	0.33
Aggregate capital stock / wage bill	6.60	6.61
$(\text{Investment} / \text{VA})_{\text{exporters}} / (\text{Investment} / \text{VA})_{\text{non-exporters}}$	1.84	1.85

we examine the extent to which the model’s firm-size distribution matches the data. Table 3 shows the distribution of capital across Chilean firms by quintiles as of 1990 (before the policy was introduced) and in 1997 (the last year the policy was in place) and in the stationary distributions of the *NCC* and *CC* regimes in the model.²⁸ Figure 2 plots the Lorenz curves of the same distributions.

Table 3 and Figure 2 yield three interesting results. First, the model’s firm-size distributions in the *NCC* and *CC* regimes approximate well those observed in the data in 1990 and 1997, respectively. Second, both distributions display significant heterogeneity and concentration of capital ownership in the top quintile of the distribution. In the *NCC* (*CC*) regime, the Gini coefficients are 0.705 (0.671) and 0.634 (0.632) in the data and in the model, respectively. Similarly, the fraction of capital held by each quintile of firms in the data and in the model are very similar, with the lowest quintile holding less than 2% of aggregate capital, while the top quintile holds about 70%. Third, in both model and data the Gini coefficient is lower when CCs are in place.

It is worth noting that, although the misallocation caused by CCs reduces firm sizes, this does not change much how the (smaller) aggregate capital stock is distributed across firms. This is in part because the size of firms in each stationary distribution that are in Region 1 is the same and firms take some time to transit into Regions 2 and 3, where their size is smaller with CCs.

Endogenous trade participation plays a central role in the model’s ability to match the observed firm-size distribution. This is because exporters are a small share of all firms (18%) but they are much larger than non-exporters. The distribution of capital across non-exporters is more equally distributed than across all firms, despite the fact that the productivity of these firms can

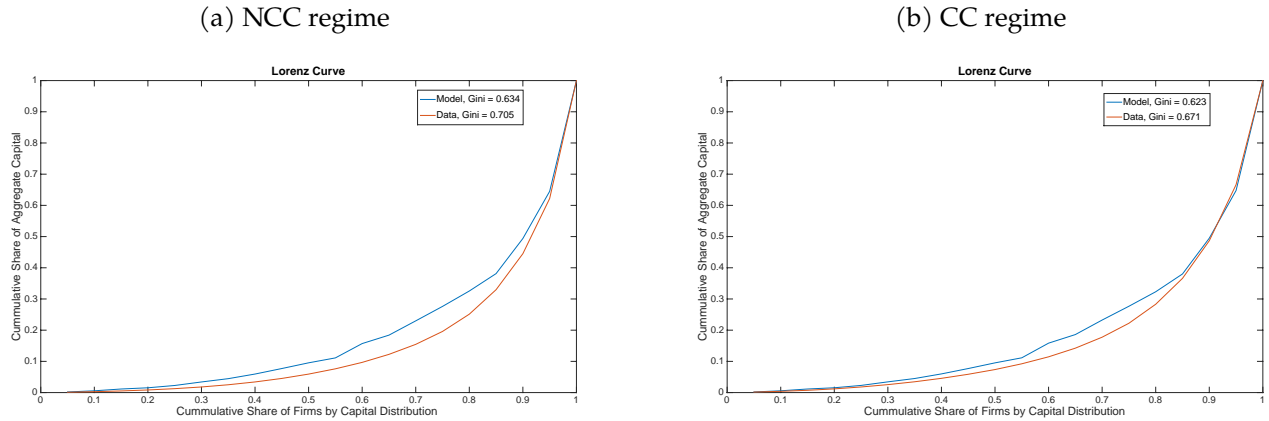
²⁸The firm-size distribution in the data is constructed using the *ENIA* dataset and the definitions of capital and the OSG described in Section 6. To make data and model comparable, firms with optimal scale gaps exceeding 0.7 are excluded, since newborn firms in the calibrated model receive a capital transfer of 30% of their optimal scale.

differ sharply. The same is true for exporters.²⁹ Hence, it is the heterogeneity between exporters and non-exporters what enables the model to produce a distribution of capital across all firms as unequally distributed as in the data.

Table 3: Distribution of Capital by Quintiles

Quintile of firms	Data (1990) (1)	Model (<i>NCC</i> regime) (2)	Data (1997) (3)	Model (<i>CC</i> regime) (4)
0.2	0.0084	0.0154	0.0119	0.0154
0.4	0.0257	0.0441	0.0337	0.0444
0.6	0.0627	0.0977	0.0689	0.0986
0.8	0.1545	0.1684	0.1685	0.1647
1	0.7487	0.6745	0.7169	0.6769

Figure 2: Lorenz Curves of the Firm Size Distribution - Data and Model



Note: The distribution of capital in the data excludes firms for which $OSG > 0.7$ to be consistent with the fact that, in the model, newborn firms receive a transfer of capital equal to 30% of their optimal scale. Firms in the top 1% of the distribution are also excluded.

5.2 Positive effects of capital controls

Column (1) of Table 4 shows the effects of CCs on aggregate variables in the calibrated (benchmark) economy. The magnitude of the changes highlights the relevance of the general equilibrium effects, particularly since they are permanent changes (i.e., in the stationary equilibrium). As explained below, these effects play an important role in the responses of misallocation and welfare to CCs. Output, final good prices and wages fall by 0.85%, 0.36% and 1.06%, respectively. Hence, the real wage in units of final goods (w/p) falls by 0.7%, a similar order of magnitude as the 0.73% fall

²⁹The Gini coefficients for non-exporters and exporters in the model are 0.44 and 0.37, respectively.

in consumption. Investment declines 1.46%, domestic sales of inputs 0.94% and the share of firms that are exporters falls sharply by 5.74%. Interestingly, exports themselves decrease only 0.82%, as the fall in prices embodies lower firm prices for both domestic and foreign sales, so the larger exporter firms become more competitive. The reduction of 4.24pp in the credit-value added ratio shows the effectiveness of the CCs as a policy for reducing credit.

Table 4: Effects of Capital Controls on Aggregate Variables
(percent changes relative to *NCC* regime)

	<i>CC</i> regime (1)	$\nu = 6\%$ (2)	LTV regulation (3)	Tax rebates (4)
Exports	-0.82%	-5.54%	-0.94%	-0.28%
Share of exporters	-5.74%	-6.90%	-1.62%	3.67%
Domestic Sales	-0.94%	-1.71%	-0.21%	-0.43%
Investment	-1.46%	-6.52%	-0.91%	-1.80%
Consumption	-0.73%	-0.88%	-0.08%	-0.27%
Final goods output	-0.85%	-1.78%	-0.21%	-0.51%
Real GDP	-0.56%	-2.81%	-0.38%	-0.72%
Real wage	-0.70%	-2.99%	-0.42%	-0.63%
Wage	-1.06%	-2.68%	-0.40%	-0.31%
Price level (Real ex. rate)	-0.36%	0.31%	0.02%	0.33%
Agg. credit/Value Added	-4.24pp	-30.0pp	-4.24pp	-4.04pp

Note: The change in the credit-value added ratio is shown as the difference in percentage points (*pp*).

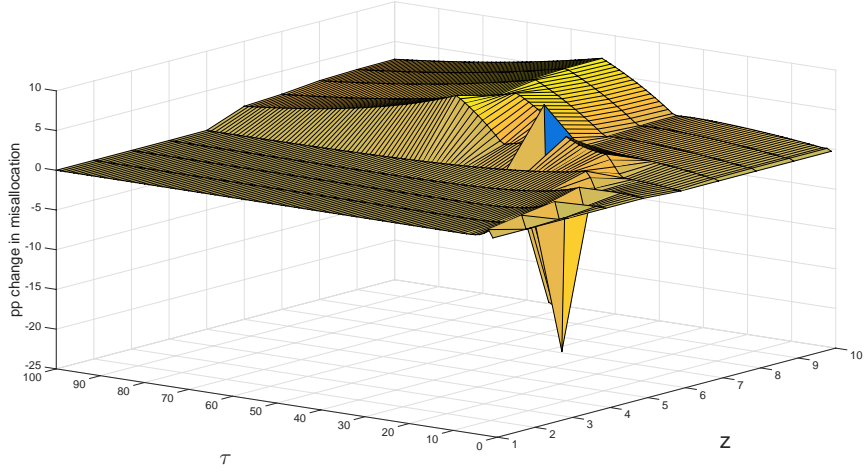
To quantify the effects on misallocation, we first measure misallocation for each firm i in the *CC* and *NCC* regimes as the absolute value of the deviation of the log of the firm's MRPK relative to the log of the long-run level (recall that $\overline{MRPK} = p(r^* + \delta)$):

$$mis_i^j = | \log(MRPK_i^j) - \log(\overline{MRPK}) |, \quad (30)$$

where $j = \{NCC, CC\}$. Since both terms are in logs, mis_i^j is the percent deviation from each regime's \overline{MRPK} . Figure 3 shows a surface plot of the difference $mis_i^{CC} - mis_i^{NCC}$ (i.e., the change in percentage points in mis when moving from the *NCC* to the *CC* regime) across firms of different productivity and age, including all 10 values of z and cohorts of τ from 0 to 100 years of age. We truncate at this age because older firms have negligible values in $\phi(\tau, z)$.

This Figure combines the static, dynamic and GE effects. Still, the four regions identified in Figure 1 to characterize the static effects are visible. At birth, firms are generally in region 1 (for $z \geq z_3$), borrowing to finance investment subject to the collateral constraint as they grow their net worth. Misallocation worsens gradually with τ for each z and only because of the dynamic and

Figure 3: Effects of Capital Controls on Misallocation: Benchmark Model



Note: Misallocation for a firm i is computed as $mis_i = | \log(MRPK_i) - \log(\overline{MRPK}) |$, where \overline{MRPK} is the steady-state level of MRPK. The chart plots $mis_i^{CC} - mis_i^{NCC}$ for each firm i including firms for all z values and $\tau \in [0, 100]$.

GE effects, since the static effects do not alter the MRPKs of firms in region 1 across the NCC and CC regimes (see Figure 1). When firms reach their pseudo steady state in the CC regime (region 2), misallocation worsens at a sharply faster rate. Firms with $z \leq z_2$ start near this region.³⁰ As firms move from region 1 into regions 2, 3 and 4, the pattern of the misallocation effects shown in this Figure also follows the non-monotonic pattern of the changes in MRPKs shown in Figure 1. Misallocation peaks at the vertex between regions 2 and 3 and then starts declining until it converges to a minimum at the vertex of regions 3 and 4, as firms first repay debt and then self-finance investment until they reach their optimal scale in region 4, where there is no misallocation.

The pattern with which the misallocation effects of CCs change with age is qualitatively similar for each z , but there are important quantitative differences due to interactions with the trade participation choice and the age distribution of firms. The role of the former is reflected in the discrete jump for firms with $z \geq z_6$. This occurs because firms with $z \leq z_5$ are always non-exporters, those with z_6 are switchers (at ages 27 and 31 in the NCC and CC regimes, respectively), and those with $z \geq z_7$ are switchers from birth. Exporters have larger optimal scales and thus go through longer transitions to reach them. Hence, for younger (older) firms, the misallocation effect suddenly drops (rises) as we move to higher z values. The large negative effect (i.e., $mis^{NCC} > mis^{CC}$) for the firm with z_6 and $\tau = 27$ is because it delays four more periods the decision to become exporter in the CC regime. Thus, at age 27, this firm's MRPK as a switcher in the NCC

³⁰Entrepreneurs with low z still collect labor income w , and if this is large relative to their optimal investment choice, these firms do not need to borrow to accumulate capital even when they are very young.

regime is much higher than as a non-exporter in the CC regime. Conversely, at age 31, this firm's MRPK as an exporter in the NCC regime is markedly lower than as a switcher in the CC regime.

The age distribution of firms matters because it assigns higher probability mass to younger firms. As noted above, firms with low z start out close to region 2, so they arrive earlier in their life cycle to the area where the misallocation effect of CCs is strongest, and the mass of firms is larger. Firms with higher z , have larger and more persistent changes in misallocation as they transit across regions, but the largest effects occur when they are older and their mass smaller. These differences are reflected in the aggregations of misallocation effects across firms, as we explain next.

Table 5 shows the change in aggregate misallocation from the NCC to the CC regime in the benchmark economy (column 1), as well as changes for groupings by trade status, OSG and productivity. Aggregate misallocation in each regime is the mean deviation of firm-specific misallocation: $\sum_{\tau} \sum_z mis^j(\tau, z) \phi(\tau, z)$, for $j = NCC, CC$. To break it down by trade status and OSG, since these differ with age across regimes, we use the results of the CC regime to classify firms accordingly, and then aggregate the change in misallocation for each group using the resulting conditional distributions.³¹ For example, for exporters we use the switching time of firms in the CC regime, so that the fraction of all firms that are non-exporters is $\sum_z \left(\sum_{\tau=0}^{\hat{\tau}^{CC}(z)} \phi(\tau, z) \right)$, where $\hat{\tau}^{CC}(z)$ is the date in which firms with productivity z switch to become exporters in the CC regime (notice, this counts switchers as non-exporters). This is then used to compute the conditional probability distributions of exporters and non-exporters which are used to construct the corresponding group moments. These moments would differ using the NCC results because $\hat{\tau}^{NCC}(z) < \hat{\tau}^{CC}(z)$.

Capital controls increase aggregate misallocation by 0.5pp. As it is evident from Figure 3, however, there is substantial heterogeneity across firms. Breaking down firms by z , we again observe the non-monotonic effect of CCs on misallocation: For relatively low z , the percent change in misallocation increases with z and peaks at z_5 , and then it stays relatively flat for high levels of z .³² The intuition for this result is the same provided for Figure 3: Firms with very low z experience small increases in misallocation, even at the peak, because they reach their optimal scales quickly. As z increases, this takes longer and regions 2 and 3, where the misallocation effects of CCs are larger, expand. Firms with high z , however, spend several periods in region 1, where misallocation

³¹An 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, compute an aggregate measure of misallocation and then compute the change in misallocation between the CC and NCC regimes. We prefer the computation described in the text because it is closer in spirit to the empirical exercise of Section 6. The results using the latter specification are qualitatively and quantitatively similar.

³²The lower effect for $z = z_6$ is due to the large negative misallocation effect at age 27 because of the delay in the decision to switch, as shown in Figure 3.

worsens less, and thus reach regions 2 and 3 later in life, when the fraction of surviving firms is small. This explains why, despite the large firm-specific increases in misallocation for high- z -firms shown in Figure 3, misallocation actually worsens slightly less as z rises from z_7 to z_{10} in Table 5.

Capital controls worsen misallocation for exporters (1.25pp) much more than non-exporters (0.34 pp) and the economy as a whole (0.5pp). The intuition is similar as for high- v. low- z firms, since the former are exporters and the latter not: The longer transitions of exporters to their larger optimal scales makes them more financially dependent and thus more vulnerable to the distortions caused by CCs. Similarly, Table 5 shows that CCs worsen misallocation more for firms with larger than smaller OSGs (0.51pp v. 0.23pp).³³ This is also evident in Figure 3. The relation between OSG and the misallocation caused by CCs is also non-monotonic, because very young firms with the largest OSGs are typically in region 1, where the change in misallocation is small.

Table 5: Effects of Capital Controls on Misallocation & Welfare

	Capital controls		LTV regulation		Tax rebates	
	misallocation (1)	welfare (2)	misallocation (3)	welfare (4)	misallocation (5)	welfare (6)
All firms	0.50pp	-0.61%	0.29pp	-0.20%	0.74pp	-0.23%
Exp. status						
Exporters	1.25pp	-1.82%	0.91pp	-0.15%	1.55pp	0.89%
Non-exporters	0.34pp	-0.56%	0.16pp	-0.20%	0.55pp	-0.23%
OSG						
Large	0.51pp	—	0.31pp	—	0.76pp	—
Small	0.23pp	—	0.04pp	—	0.23pp	—
Productivity						
1	0.11pp	-0.69%	0.02pp	-0.42%	0.12pp	-0.62%
2	0.22pp	-0.67%	0.05pp	-0.41%	0.23pp	-0.59%
3	0.43pp	-0.59%	0.10pp	-0.39%	0.43pp	-0.51%
4	0.61pp	-0.47%	0.18pp	-0.33%	0.61pp	-0.37%
5	0.64pp	-0.44%	0.25pp	-0.22%	0.63pp	-0.27%
6	0.24pp	-0.89%	0.21pp	-0.11%	0.88pp	0.01%
7	0.67pp	-1.13%	0.70pp	0.11%	0.81pp	-0.56%
8	0.60pp	-1.20%	0.72pp	0.19%	0.73pp	-0.51%
9	0.58pp	-1.22%	0.73pp	0.21%	0.71pp	-0.49%
10	0.57pp	-1.23%	0.73pp	0.22%	0.70pp	-0.49%

In Section 6, we provide empirical evidence in favor of the model's prediction indicating that the Chilean capital controls worsened misallocation more for firms that were more productive, exporters or had larger OSGs. We also provide evidence of the non-linearity indicating a stronger

³³We define firms with small OSGs as those with a capital stock within 5% of their optimal scale.

(weaker) effect of CCs on misallocation as productivity rises for non-exporters (exporters).

5.3 Welfare effects of capital controls

We measure the effect of CCs on social welfare using a utilitarian social welfare function. The welfare weights correspond to the fraction of entrepreneurs of a particular age cohort and productivity that exists in the stationary state, as given by $\phi(\tau, z)$. The metric to assess welfare is a compensating (percent) consumption variation applied to the *CC* solution, constant across entrepreneurs, such that social welfare in the *CC* and *NCC* regimes is the same (i.e., an increase in each entrepreneur's consumption that makes society indifferent to whether CCs are implemented or not):

$$G = \left[\frac{\sum_{\tau} \sum_z V^{CC}(\tau, z) \phi(\tau, z)}{\sum_{\tau} \sum_z V^{NCC}(\tau, z) \phi(\tau, z)} \right]^{\frac{1}{1-\gamma}} - 1, \quad (31)$$

It is straightforward to compute analogous measures for each value of z , since z is exogenous: $G(z) = \left[\frac{\sum_{\tau} V^{CC}(\tau, z) \phi(\tau, z)}{\sum_{\tau} V^{NCC}(\tau, z) \phi(\tau, z)} \right]^{\frac{1}{1-\gamma}} - 1$. We also compute welfare measures for exporters G^E and non-exporters G^{NE} , which are more involved because the date at which firms switch to become exporters varies across regimes. As before, we use the switching time $\hat{\tau}^{CC}(z)$ of firms in the *CC* regime to classify a firm as exporter:

$$G^{NE} = \left[\frac{\sum_z \left(\sum_{\tau=0}^{\hat{\tau}^{CC}(z)} V^{CC}(\tau, z) \phi(\tau, z) \right) / \sum_z \left(\sum_{\tau=0}^{\hat{\tau}^{CC}(z)} \phi(\tau, z) \right)}{\sum_z \left(\sum_{\tau=0}^{\hat{\tau}^{CC}(z)} V^{NCC}(\tau, z) \phi(\tau, z) \right) / \sum_z \left(\sum_{\tau=0}^{\hat{\tau}^{CC}(z)} \phi(\tau, z) \right)} \right]^{\frac{1}{1-\gamma}} - 1, \quad (32)$$

$$G^E = \left[\frac{\sum_z \left(\sum_{\tau=\hat{\tau}^{CC}(z)+1}^{\infty} V^{CC}(\tau, z) \phi(\tau, z) \right) / \sum_z \left(\sum_{\tau=\hat{\tau}^{CC}(z)+1}^{\infty} \phi(\tau, z) \right)}{\sum_z \left(\sum_{\tau=\hat{\tau}^{CC}(z)+1}^{\infty} V^{NCC}(\tau, z) \phi(\tau, z) \right) / \sum_z \left(\sum_{\tau=\hat{\tau}^{CC}(z)+1}^{\infty} \phi(\tau, z) \right)} \right]^{\frac{1}{1-\gamma}} - 1. \quad (33)$$

Since these welfare measures are driven by the entrepreneurs' income profiles, we shed some light on the determinants of the welfare effects by analyzing differences in labor and capital income across entrepreneurs in the *CC* and *NCC* regimes. Since all entrepreneurs supply one unit of labor, their labor income falls uniformly with the fall in the real wage. The shares of labor v. capital income and the changes in capital income, however, differ sharply across entrepreneurs.

To characterize changes in capital income, we use the optimality conditions of the entrepreneurs' second-stage problem to obtain these expressions:

$$\frac{p^h(\tau, z)}{p} = \frac{\varsigma(r + \delta)^\alpha}{(1 - \alpha)^{1-\alpha} \alpha^\alpha z} \left(\frac{w}{p}\right)^{1-\alpha} \left(\frac{MRPK(\tau, z)}{p(r + \delta)}\right)^\alpha \quad (34)$$

$$\frac{\pi(\tau, z)}{p} = \frac{y + e^{\frac{1}{\varsigma^{\sigma-1}}} \left(\frac{p^*}{p}\right)^\sigma y^*}{\left(\frac{p^h(\tau, z)}{p}\right)^{\sigma-1}} \left[1 - \frac{(1 - \alpha)}{\varsigma}\right], \quad (35)$$

where $\pi/p \equiv [p^h y^h + p f^y f - wn]/p$ are real profits (i.e., capital income) of an entrepreneur. Condition (34) shows that a firm's relative price is a geometric weighted average of the real wage and the ratio of its MRPK relative to the efficient one (i.e., its misallocation). Since MRPK changes non-monotonically as firms age (for a given z) in the *CC* regime relative to the *NCC* regime, as shown in Figure 3, the effect on relative prices is also non-monotonic. The -0.7% drop in real wages dominates for firms with low misallocation. These firms charge lower prices and collect higher profits in the *CC* regime. This applies to low- z firms of all ages, but for them profits are a tiny share of total income, and to cohorts of young firms with higher z and small enough misallocation for p^h/p to still fall. In contrast, for old enough firms with high enough z , higher misallocation dominates the lower real wage, so they charge higher p^h/p and collect lower profits in the *CC* regime. Hence, the misallocation caused by capital controls redistributes income (and consumption) across firms of different ages and productivity.

Profits are also affected by the GE declines in y and p and the trade status of firms. Lower y reduces profits for all firms as demand for all inputs shrinks. For exporters, however, the effect is weaker because they sell some of their output abroad, where y^* is unchanged, and also the real depreciation (as p falls -0.36%) increases profits because the real value of exports rises as p^*/p rises.

Table 5, column (2) shows the welfare measures for the benchmark economy. Capital controls reduce social welfare by 0.61%. This is a sizable loss, considering that it is due to a 175-basis-points hike in the interest rate and a 424-basis-points cut in the credit-value added ratio. Welfare costs for exporters are roughly three-times larger than for non-exporters, at 1.82% v. 0.56%. As discussed before, exporters are high-productivity firms that experience much higher misallocation and for longer periods than non-exporters (or low- z firms), so their profits fall more as they transit to their optimal scales. Given that $\rho = 0.08$, firms younger than 50 years have nontrivial weights in $\phi(\tau, z)$, and Figure 3 shows that this includes the entire region where CCs worsen misallocation.

The welfare effects by productivity show that all firms suffer losses. The losses, however, are non-monotonic in z , reflecting the income re-distribution mentioned earlier. They fall as z rises up to $z = z_5$. This occurs because firms with the lowest z collect mainly labor income and suffer the brunt of the -0.7% drop in w/p , but as z rises profits start to matter and misallocation is not large enough to prevent profits from rising as w/p falls. The welfare costs then jump to 0.89% for firms with $z = z_6$ (which includes the switcher cohort) and worsen as z rises further.³⁴ Firms with $z > z_6$ have larger welfare costs as z rises because their higher misallocation causes their profits to fall, and by more as their misallocation peaks. These entrepreneurs suffer the most because their income from both labor and capital falls. Note also that the fall in y caused by CCs reduces profits for all firms, but for those that are exporters, the 0.36% real depreciation allows them to increase exports and thus moderate the fall in profits. These results are also indicative of the relevance of the GE effects on w/p , y and p in affecting labor and capital income and welfare.

5.4 Counterfactuals: Tighter capital controls, LTV regulation & tax rebates

We examine next three important counterfactual experiments: (1) tighter CCs (higher tax rates on inflows); (2) LTV regulation (a cut in θ that yields the same 4.24pp drop in the credit-value added ratio as the CCs); and (3) rebates of the revenue of the debt tax ν to entrepreneurs.

Tighter capital controls: Studying values of ν higher than the 1.75% calibrated to the 1990s Chilean *encaje* is important because estimates of average optimal debt taxes from the macroprudential policy literature are sharply higher, in the 3-to-12% range.³⁵ In this experiment, we compare taxes set to $\nu = 1.75\%$ and $\nu = 6\%$. Columns (1) and (2) of Table 4 compare the effects on aggregate variables, and Table 6 compares results for misallocation and welfare.

The effects of CCs on aggregate variables worsen sharply with $\nu = 6\%$ (see column (4) of Table 4). Importantly, output, investment, exports, and real wages fall much more, and the price level rises 0.31% instead of falling -0.36%. Note that in this case the ratio of aggregate credit to value added is reduced by 30pp. Columns (1) and (7) of Table 6 show that the effects on misallocation for all firms, for exporters and non-exporters, for firms with large OSGs, and for firms at

³⁴The jump for z_6 is due to the one-time switching cost paid by the switcher firm. In addition, since CCs delay the switching date from $\tau = 27$ to 31, the firm at age 28 is already exporting and generating higher income in the *NCC* regime but remains a non-exporter in the *CC* regime.

³⁵3.6% in Bianchi and Mendoza (2018) using a model with land as collateral, 3% to 6% in Bianchi (2011) for different nontradable-GDP shares and collateral coefficients, 5.1% in Bianchi et al. (2016) using a model with news shocks, 5% to 12% in Hernandez and Mendoza (2017) using a model with production and intermediate goods.

all levels of z are also much larger. Intuitively, as ν rises, $\bar{k}^{cc}(z)$ falls, and regions 1 and 2 shrink, creating a larger area where misallocation exists.

Columns (3) and (9) of Table 6 show that the social welfare loss is 2.3 times larger with $\nu = 6\%$ (1.41% v. 0.61% in the benchmark case). However, the result that welfare falls more for exporters than non-exporters reverses. Exporters make a small gain and the loss for non-exporters rises from 0.56% to 1.45%. As we explain below, these results are due to the stronger GE effects and to the aggregation with the firm-age distribution. To help us explain why, we added to Table 6 results computed in partial equilibrium (PE), by imposing the values of (p, y, w) from the *NCC* solution in the solutions with CCs, and welfare evaluations aggregating only over newborn firms.

Comparing columns (1) and (2) or (7) and (8) shows that aggregate misallocation rises more when GE effects are included for both values of ν . It also rises more for non-exporters and for firms with small and large OSG, but it rises less for exporters. Examining the breakdown by z , we see that GE effects worsen misallocation only for firms with $z \leq z_6$, while for firms with higher z it falls slightly or is nearly unchanged. Since all firms with $z \geq z_7$ ($z \leq z_5$) are exporters (non-exporters) at all times, this result reflects the way in which GE effects affect non-exporters v. exporters, and it also accounts for the increase (fall) in misallocation for the former (latter). The declines in y , w and w/p affect exporters less because of their foreign sales, and their static effects get weaker (see eqs. (20)-(22)). With $\nu = 6\%$, GE effects reduce the increase in exporters' misallocation by 6 basis points (5.38pp in GE v. 5.43pp in PE), whereas for non-exporters the increase in misallocation is 40 basis points larger (1.66pp in GE v. 1.26pp in PE).

To analyze how the aggregation method and the GE effects affect the welfare measures, consider first the results with $\nu = 1.75\%$. Columns (3) and (5) of Table 6 show that the social welfare loss is only slightly larger aggregating with the firm-age distribution v. newborn firms, at 0.61% and 0.58%, respectively. However, the costs for exporters and non-exporters, and the result that the costs are larger for the former, change sharply. The firm-age distribution yields costs of 1.82% and 0.56% for exporters and non-exporters, respectively, compared with 0.44% and 0.66% aggregating across newborn firms. The key difference between the two aggregations is in that the firm-age distribution assigns some weight to the lifetime utility of entrepreneurs of all age cohorts for each z (with exponentially decreasing weights for older cohorts given by $\phi(\tau, z)$), and each cohort is at a different point in the four regions identified in Figures 1 and 3. In contrast, the aggregation over newborn firms values only the lifetime utility of entrepreneurs for each z as of their birth date, with weights given by $f(z)$. Non-exporters are low- z firms and their welfare costs

are bigger when aggregating by newborn firms because they are born close to their optimal scales and the early periods during which their consumption is more affected by higher MRPKs (lower profits) weigh more in their lifetime utility. In contrast, exporters are high- z firms and their costs are smaller aggregating across newborn firms because, as Figure 3 shows, the region in which their MRPKs rise sharply (profits fall more) is distant into the future, and thus more heavily discounted in their lifetime utility. Hence, exporters fare better (worse) than non-exporters aggregating over newborn firms (the firm-age distribution).

A key element in the above argument is that the GE effects on capital and profits are relatively weak with $\nu = 1.75\%$. The optimal scale of capital and the associated gross and net profits rise 0.38% and 0.27% relative to the *NCC* regime for exporters and non-exporters, respectively.³⁶ As we show next, the strong GE effects with $\nu = 6\%$ turn the losses of exporters and high- z firms lower than those of non-exporters and low- z firms even aggregating with the firm-age distribution, and they can even produce welfare gains.

The social welfare cost of setting $\nu = 6\%$ is large regardless of the aggregation method (see columns (9) and (11), although it is a bit lower aggregating with the firm-age distribution instead of newborn firms (1.41% v. 1.87%). Welfare costs are also lower aggregating with the firm-age distribution for firms at each level of z and for exporters and non-exporters. Exporters and firms with $z \geq z_8$ actually obtain welfare gains relative to the *NCC* regime.

These results are due to the much stronger GE effects with the 6% tax: Real wages fall 2.99% instead of 0.7% and net profits at the optimal scale of capital rise 3.11% and 3.09% for exporters and non-exporters, respectively, instead of 0.38% and 0.27%. The larger drop in real wages hurts non-exporters and low- z firms because most of their income is labor income. They have even larger welfare losses aggregating across newborn firms because their higher future profits are more heavily discounted, while aggregating with $\phi(\tau, z)$ includes cohorts with higher profits, even if those profits are a small share of their income. In contrast, exporters and high- z firms benefit from both the higher profits and the drop in real wages (since it props up profits and wages are a small share of their income). Note that, as firms age, MRPKs still follow a trajectory for each z qualitatively similar to that of Figure 3, so profits fall and then rise, but with two key differences: Profits rise to reach a level 3% higher than in the *NCC* regime at the optimal scale of capital and, because regions

³⁶The percent change in $\bar{k}(z)$ across a policy regime i and the *NCC* regime is given by $\ln(\bar{k}^i(z)) - \ln(\bar{k}^{NCC}(z)) = \ln(\tilde{y}^i) - \ln(\tilde{y}^{NCC}) - (\sigma - 1)(1 - \alpha)[\ln((w/p)^i) - \ln((w/p)^{NCC})]$, where $\tilde{y} = y + e\zeta^{1-\sigma}(p^*/p)^\sigma y^*$. Hence, $\bar{k}(z)$ changes by the same percentage for all firms that are exporters and all firms that are non-exporters. This is because $MRPK = p(r^* + \delta)$ at the optimal scale for all firms. The associated steady-state profits and net profits (i.e., profits net of taxes and inclusive of depreciated capital) are linear in $\bar{k}(z)$ and hence they increase by the same percentage.

1 and 2 shrink, now even high- z firms reach the region of increasing profits when they are young.

Comparing columns (9) with (10) and (11) with (12) shows that removing GE effects reduces sharply the social welfare costs of tighter CCs regardless of the aggregation method, from 1.41% (1.87%) to 0.22% (0.37%) aggregating with the firm-age distribution (newborn firms). Without GE effects, (w, p, y) , the optimal scales of capital, net profits at the optimal scale, and initial capital transfers are the same with and without CCs. Moreover, exporters now fare worse than non-exporters, and by a large margin, 2.84% (0.81%) v. 0.28% (0.13%) with the firm-age distribution (newborn firms). Also, the ranking of welfare costs by productivity reverses, with much smaller losses for low- z firms and larger losses for high- z firms. Aggregating with the firm-age distribution, firms with $z \leq z_5$ make welfare gains. Aggregating over newborn firms, the welfare of firms with $z \leq z_2$ is nearly unchanged, because their misallocation rises very little.³⁷ Conversely, high- z firms no longer benefit from GE effects via lower real wages and higher profits, so their welfare costs due to sizable misallocation are larger.

Summing up, these results show not only that tighter CCs have significantly larger adverse effects on misallocation and social welfare, but that these larger effects are due to strong general equilibrium effects on real wages and profits. Moreover, they also show that the welfare effects of CCs are affected by the interaction of these general equilibrium effects with the method used to aggregate welfare valuations. The result that social welfare costs rise sharply with tighter CCs is independent of the aggregation method, but welfare comparisons across exporters and non-exporters and across firms with different productivity change sharply. Aggregating with the firm-age distribution, cohorts of high-productivity or exporting firms sufficiently advanced in their transition to sharply higher profits can be better off with CCs than without.

LTV regulation: In this experiment, we set $\nu = 0$ and reduce θ^{NE} to a value θ^{LTV} such that the model yields the same cut of 4.24pp in the credit-value added ratio obtained in the *CC* benchmark. This requires setting $\theta^{NE} = \theta^{LTV} = 0.0545$, 82 basis points lower than the 0.0627 of the *NCC* calibration. Since we keep θ_f unchanged, this also reduces θ^E .

Column (3) of Table 4 shows that the effects of LTV regulation on aggregate variables are much weaker than those of CCs in the benchmark case. The real wage falls 0.42% (instead of 0.7%),

³⁷In the PE solution, none of the newborn firms can make welfare gains because the choices they make with CCs remain feasible in the *NCC* regime (e.g., they can choose not to borrow and move to region 3 under CCs). This is not the case in general equilibrium. In particular, the 3% increase in $\bar{k}(z)$ with $\nu = 6\%$ is due to the effect of lower w/p dominating that of lower \bar{y} . Higher $\bar{k}(z)$ also implies larger capital transfers to newborn firms. This makes little difference for low- z firms, which collect mainly labor income, but for high- z firms it implies higher wealth.

Table 6: Effects of Capital Controls on Misallocation & Welfare at Different Tax Rates.

	$\nu = 1.75\%$						$\nu = 6\%$					
	Misallocation		Welfare by age		Welfare newborn		Misallocation		Welfare by age		Welfare newborn	
	GE (1)	PE (2)	GE (3)	PE (4)	GE (5)	PE (6)	GE (7)	PE (8)	GE (9)	PE (10)	GE (11)	PE (12)
All firms	0.50pp	0.44pp	-0.61%	-0.31%	-0.58%	-0.18%	2.28pp	1.90pp	-1.41%	-0.22%	-1.87%	-0.37%
Exp. status												
Exporters	1.25pp	1.29pp	-1.82%	-3.27%	-0.44%	-0.38%	5.38pp	5.43pp	0.03%	-2.84%	-0.90%	-0.81%
Non-exporters	0.34pp	0.28pp	-0.56%	-0.25%	-0.66%	-0.07%	1.66pp	1.26pp	-1.45%	-0.28%	-2.39%	-0.13%
OSG												
Large	0.51pp	0.45pp	—	—	—	—	2.36pp	1.97pp	—	—	—	—
Small	0.23pp	0.21pp	—	—	—	—	0.27pp	0.19pp	—	—	—	—
Productivity												
1	0.11pp	0.11pp	-0.69%	0.01%	-0.70%	0.00%	0.15pp	0.11pp	-2.96%	0.01%	-2.97%	0.00%
2	0.22pp	0.21pp	-0.67%	0.03%	-0.70%	0.00%	0.41pp	0.30pp	-2.90%	0.03%	-2.95%	0.00%
3	0.43pp	0.40pp	-0.59%	0.09%	-0.69%	-0.01%	0.84pp	0.62pp	-2.71%	0.09%	-2.88%	-0.01%
4	0.61pp	0.56pp	-0.47%	0.16%	-0.68%	-0.03%	1.43pp	1.08pp	-2.29%	0.20%	-2.70%	-0.04%
5	0.64pp	0.58pp	-0.44%	0.08%	-0.65%	-0.10%	1.97pp	1.58pp	-1.58%	0.21%	-2.22%	-0.17%
6	0.24pp	0.16pp	-0.89%	-0.99%	-0.45%	-0.27%	1.92pp	1.38pp	-0.64%	-0.84%	-0.89%	-0.41%
7	0.67pp	0.69pp	-1.13%	-1.74%	-0.38%	-0.99%	4.59pp	4.61pp	-0.10%	-2.00%	-0.97%	-2.83%
8	0.60pp	0.61pp	-1.20%	-2.05%	-0.37%	-1.21%	5.15pp	5.16pp	0.39%	-2.35%	-0.68%	-3.39%
9	0.58pp	0.59pp	-1.22%	-2.15%	-0.36%	-1.29%	5.30pp	5.30pp	0.56%	-2.50%	-0.57%	-3.58%
10	0.57pp	0.58pp	-1.23%	-2.18%	-0.36%	-1.31%	5.34pp	5.34pp	0.61%	-2.54%	-0.53%	-3.64%

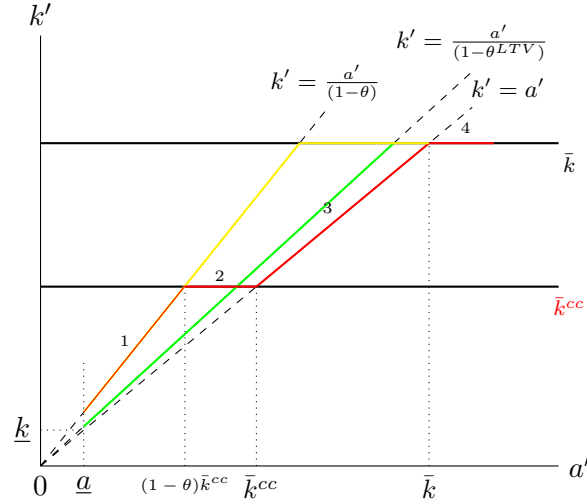
p is nearly unchanged (instead of falling 0.36%), so that exporters no longer benefit from a slight real depreciation, and output and consumption also fall less, by 0.38% and 0.08%, respectively (instead of 0.56% and 0.73%). Exports fall about the same but the share of exporters falls much less (1.62% instead of 5.74%). In contrast with the tighter CCs experiment, where *stronger* aggregate effects coincided with higher $\bar{k}(z)$, in this case *weaker* aggregate effects coincide with higher $\bar{k}(z)$. Relative to the *NCC* regime, the optimal scales of capital and net profits at the optimal scales rise by 0.46% and 0.47% for exporters and non-exporters, respectively. This is nearly twice as much as in the *CC* benchmark and is again due to the effect of lower w/p dominating the change in \tilde{y} .

Column (5) of Table 5 shows the LTV effects on misallocation. Aggregate misallocation worsens much less than with CCs (by 0.29pp instead of 0.5pp). Misallocation also worsens much less for both exporters and non-exporters and for firms with large and small OSGs. Examining the breakdown by z , however, misallocation worsens less than with CCs for firms with $z \leq z_6$ but more for those with $z \geq z_7$. Thus, as in the case of higher ν , this pattern reflects differential effects across exporters and non-exporters. It is worth noting that the 0.91pp rise in misallocation for exporters reflects the sharp increase in mis_i for the cohorts with $z = 6$ that are old enough to be exporters. This is not visible in the overall misallocation of firms with $z = 6$ because the younger cohorts are non-exporters for which misallocation falls and these have higher probability mass.

The above results can be explained by studying how the static effects change with LTV regulation, as shown in Figure 4. The capital decision rule of the LTV regime when the collateral constraint binds is the ray from the origin $k' = a'/(1 - \theta^{LTV})$. It must be flatter than the one corresponding to region 1 in the *CC* regime because increasing θ reduces credit for firms that were in region 1 and a subset of region 2 but increases it for those in the remainder of region 2 and all of region 3. Hence, to yield the *same* aggregate credit reduction of the *CC* regime, it must be that $\theta^{LTV} > \theta$, so that the total extra credit that the latter group of firms gain (relative to the *CC* regime) is exactly matched by the credit cut to the former group. Intuitively, the burden of reducing aggregate credit is distributed more evenly with LTV than CCs. Firms that were in region 1 with CCs, and those in region 2 close to the vertex with 1, have larger OSGs and higher misallocation with the LTV, while region-2 firms far enough from the vertex with region 1 and all those in region 3 have the opposite, including some that now reach their optimal scale at lower a' (i.e., sooner).

The above analysis explains the quantitative results showing smaller increases in misallocation with LTV than with CCs for firms with $z \leq z_6$ and the opposite for those with $z \geq z_7$ (i.e., the latter includes more firms that were in region 1 or 2 close to the vertex with 1 with CCs, and the

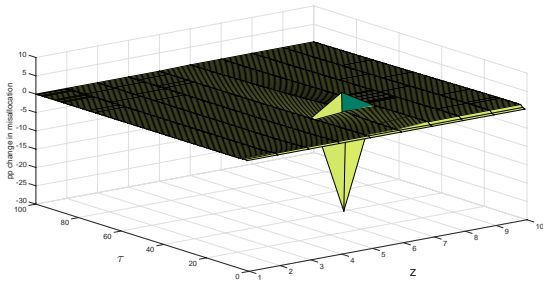
Figure 4: Static Effects of LTV & Capital Controls
(second-stage optimal k' as a function of a')



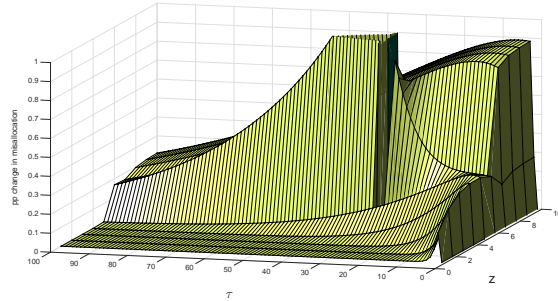
former includes more region-2 firms away from that vertex and in region 3). Since there is a larger fraction of firms with $z \leq z_6$, aggregate misallocation falls. Keep in mind, however, that these results show the combined static, dynamic and GE effects. The different static effects of LTV regulation relative to CCs reflect changes in the tightness of the credit constraint across entrepreneurs, which alter saving incentives and thus the dynamic effects. Also, the marked changes in misallocation across firms imply changes in firm pricing decisions and in aggregate demands for capital and labor and in supply of intermediate goods that affect aggregate variables.

Figure 5: Effects of *LTV* Regulation on Misallocation

(a) Full scale



(b) Truncated scale



Note: Misallocation for a firm i is computed as $mis_i = |\log(MRPK_i) - \log(\overline{MRPK})|$, where \overline{MRPK} is the steady-state level of $MRPK$. The chart plots $mis_i^{LTV} - mis_i^{NCC}$ for each firm i including firms for all z values and $\tau \in [0, 100]$.

The combined static, dynamic and GE effects are illustrated in Figure 5, which shows the change in mis with the LTV relative to the *NCC* regime by age and productivity. Since the full plot

(Plot (a)) hides important details because of the large drop associated with switching firms, Plot (b) shows a version of the plot with the vertical axis truncated.³⁸ Misallocation worsens more for firms with higher z as they are more credit constrained and take more time to reach their optimal scales. Since the same is true for exporters, this also explains why misallocation worsens more for exporters, $0.91pp$, than non-exporters, $0.16pp$. The Figure also shows that, since regions 2 and 3 disappear, most firms (except the switcher firm with $z = z_6$), start out in the segment of the LTV capital decision rule where misallocation peaks and starts to fall with age.

The welfare effects of LTV regulation are also very different from those of CCs. Column (6) of Table 5 shows that the social welfare cost is smaller by a factor of 3 (at 0.2%). Like in the case of $\nu = 6\%$, non-exporters have a larger loss than exporters, but both groups have much smaller losses than in the *CC* regime. In the productivity breakdown, all firms also fare better than in the *CC* regime and we obtain again the result that high- z firms ($z \geq z_7$) obtain small welfare gains, in the 0.11%-0.22% range. As before, the GE effects and the aggregation using $\phi(\tau, z)$ play a key role in these results, and the changes in the profile of misallocation as firms age matter too because all firms (except the switcher, $z = z_6$) start out at or near where misallocation peaks and starts to fall (profits at their lowest and start to rise), as shown in Figure 5. Hence, weighing with $\phi(\tau, z)$, a nontrivial mass of firms of each cohort is already in the region where misallocation is low enough for profits to be higher than in the *NCC* regime. The smaller losses for low- z firms, which collect most income from labor, are due to the smaller drop in real wages and smaller rise in misallocation. Firms with $z \geq z_7$, which are all exporters, make welfare gains because they attain higher profits than in the *NCC* regime at a young age, and thus when aggregating with the firm-age distribution we have a large set of young cohorts with higher lifetime utility than in the *NCC* regime.

Overall, these findings indicate that, as a tool for reducing credit, LTV regulation is far superior to CCs. LTV regulation worsens much less both aggregate misallocation and the misallocation of firms that are exporters and nonexporters, as well as those with larger and smaller optimal scale gaps. Misallocation worsens, however, for high-productivity firms that are more credit constrained with LTV regulation than with capital controls. Social welfare also falls much less, and the welfare of exporters and non-exporters, and cohorts of firms at all productivity levels also fall less. The main reason for these results is that LTV regulation distributes the burden of reducing credit more evenly across firms: Low-net-worth firms unaffected by CCs share in the credit reduction with the

³⁸As with CCs, there is a large drop in misallocation for the firm with $z = z_6$ because the LTV induces a delay in the decision to become an exporter, followed by a large increase the next period, once the firm becomes an exporter.

LTV and firms with higher net worth have improved credit access.

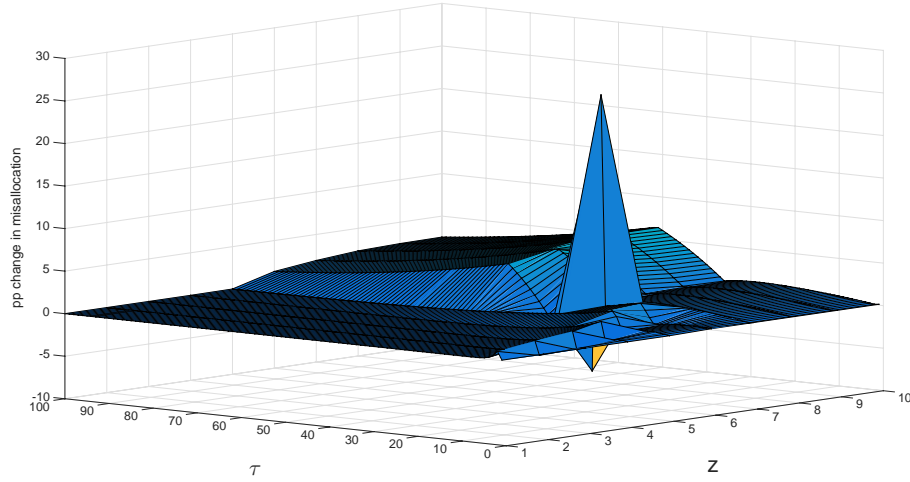
Tax rebates: We now introduce lump-sum transfers to entrepreneurs that rebate the debt taxes paid by each, so as not to introduce redistribution among entrepreneurs. Firms in regions 1 and 2 receive a rebate of $\nu(1 - \rho)pqd(\tau, z)$ and firms in regions 3 and 4, which carry zero debt, do not receive a rebate. We can infer from Figure 3 and the firm-age distribution $\phi(\tau, z)$ that a large fraction of firms carry debt, particularly very young cohorts with $z \leq z_5$ and cohorts up to 50 years old with $z \geq 6$. Hence, the rebates should alter the results. In practice, however, the benchmark results without rebates are more representative of the effects of CCs, because these are generally in the form of quantitative restrictions on capital flows, mandated exchange-rates or, as in the case of the Chilean *encaje*, compulsory, unremunerated reserve requirements.

Column (4) of Table 4 shows the effects of CCs on aggregate variables. Interestingly, w falls much less than in the *CC* regime (-0.31% instead of -1.06%) but since p rises 0.33% instead of falling 0.36%, the fall in the real wage is about the same (0.63% instead of 0.7%). Final goods output and consumption fall 0.51% and 0.27%, respectively, 34 and 46 basis points less than in the *CC* regime. The trade effects also differ. Exports fall 0.28% (instead of 0.82%) and the share of exporters rises 3.67% (instead of falling -5.7%). The drop in credit as a share of value added is about the same, at 4.04pp. The optimal scales of capital and associated net profits relative to the *NCC* regime increase by similar magnitudes as with LTV regulation, by 0.48% and 0.51% for exporters and non-exporters, respectively, roughly twice as much as in the benchmark *CC* regime.

Although real wages, long-run profits and aggregate credit change by similar magnitudes with the rebates as with LTV regulation, the effects on misallocation and welfare differ because with the rebates the capital decision rule still displays the four regions implied by the presence of CCs. Figure 6 shows that misallocation effects across firms with different (τ, z) display a similar qualitative pattern as in the benchmark *CC* regime, with one key difference: With the tax rebates, firms with $z = z_6$ make the decision to start exporting at age 25, one period earlier than in the *NCC* regime, so there is a positive spike in misallocation for z_6 instead of a negative one as in Figure 3.

Column (5) of Table 5 shows that overall misallocation rises more with rebates than without, 0.74pp instead of 0.5pp. Misallocation also worsens more for exporters (1.55pp v. 1.25pp), non-exporters (0.55pp v. 0.34pp) and firms with large OSG (0.76pp v. 0.51pp), but is nearly unchanged for firms with small OSG. Comparing Figures 3 and 6 shows that the increase in misallocation with the rebates is larger and peaks at higher values than in the *CC* regime for firms with

Figure 6: Effects of Capital Controls on Misallocation with Tax Rebates



Note: Misallocation for a firm i is computed as $mis_i = |\log(MRPK_i) - \log(\overline{MRPK})|$, where \overline{MRPK} is the steady-state level of MRPK. The chart plots $mis_i^{TR} - mis_i^{NCC}$, where TR denotes the regime with tax rebates, for each firm i including firms for all z values and $\tau \in [0, 100]$.

$z \geq z_6$, and also that misallocation peaks when firms are younger (i.e., for cohorts with higher probability mass in the firm-age distribution).

In line with Figure 6, the breakdown of misallocation effects by productivity in Table 5 shows little to no change for firms with $z \leq z_5$, which reach regions 3 and 4 quickly and thus receive no rebates, and marked increases for those with $z \geq z_6$, which reach region 2 faster and have weakened incentives to save, as we explain below. Since the set of non-exporters is made of all firm cohorts with $z \leq z_5$ for which misallocation barely changes, plus those with $z = z_6$ younger than the switching age, it follows that the higher misallocation of non-exporters is mainly due to the latter group and in particular to the cohort that makes the switch a period earlier than in the NCC regime. Misallocation worsens for firms with $z \geq z_6$ because these are the more credit-constrained firms and the tax rebates thus go mainly to them, reducing their financial dependence and the tightness of their collateral constraints. As a result, these firms reach regions 2 and 3 sooner and in this region misallocation is higher. This also weakens the dynamic effects for these firms, since their multipliers of the collateral constraint (η_i) fall.

Column (6) of Table 5 shows that the social welfare cost of CCs is much smaller with rebates (0.23% v. 0.61%). Welfare falls less for exporters and non-exporters and firms across all values of z , with exporters and firms with $z = z_6$ making welfare gains. The slightly smaller drop in w/p explains again the (slight) reduction in welfare costs for non-exporters and low- z firms. Exporters

and high- z firms fare much better because of the reduced tightness of their credit constraints with the rebates and the higher long-run profits that start accruing earlier. For firms with $z = z_6$, we capture an additional sizable gain from the rebates, because they switch to export sooner and thus start collecting the extra profits from foreign sales when they are younger. Combined with the benefit of the smaller drop in real wages when they are very young, the result for all firms with $z = z_6$ is a welfare gain of 0.01%.

6 Cross-Sectional Empirical Analysis

This Section provides empirical evidence showing that the Chilean *encaje* had effects consistent with the model's key predictions. In particular, more-productive firms experienced an increase in misallocation relative to less-productive firms, and the same happened to exporters relative to non-exporters and for firms with larger optimal scale gaps. Moreover, the nonlinear effect indicating that misallocation changes relatively less with a firm's productivity for exporters than non-exporters is also present in the data.

6.1 Data

The three variables needed for the empirical analysis are: a proxy for the CCs policy, firm-level estimates of misallocation and firm- and aggregate-level data for a set of control variables. The empirical proxy for the Chilean *encaje* is the same debt-tax-equivalent implied by the CCs used in the calibration (see Appendix A for details). This tax hovered around a peak of roughly 2.7% between 1994 and 1997, and averaged 1.98% 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 policy changes (the fractional reserve requirement and the holding period) and less so from changes in the risk-free rate.

We construct firm-level measures of capital and productivity using the ENIA data. A firm's fixed capital (the proxy for k) is defined as the sum of cars, machinery, land and buildings deflated by the price of capital. Since ENIA does not have depreciation data before 1995, we use a standard annual depreciation rate of 6% for the 1990-1994 period. Moreover, the data needed to construct this estimate of k is unavailable before 1992, so we impute it using investment and the 6% depreciation rate. We follow Wooldridge (2009) to measure productivity at the establishment level, deflating the relevant variables using 4-digit NAICS code deflators and the price of capital pro-

vided by ENIA.³⁹ Additionally, we use the wholesale price and fuel price indexes reported by the *Instituto Nacional de Estadística* (INE) to deflate electricity and fuel use, respectively.

Misallocation is measured by first constructing MRPK estimates. Following Gopinath et al. (2017) and Hsieh and Klenow (2009), we combine the condition that defines MRPK in the model with the firm-level data. Rewriting condition (16), a firm's MRPK is:

$$MRPK = \frac{(\sigma - 1)}{\sigma} (p_h y_h + p_f y_f) \frac{\alpha}{k}. \quad (36)$$

Since in the model intermediate-goods producers do not use intermediate goods themselves but in the data they do, our baseline specification proxies $p_h y_h + p_f y_f$ using the firm's value added, so that the model and data definitions of MRPK are compatible. To show that this does not matter for our findings, we also report results using total sales instead of value added to calculate MRPK. σ and α are set to the values calibrated in the previous Section. Also in line with the previous Section, misallocation for a firm i in industry j at date t is constructed as $mis_{ijt} = | \log(MRPK_{ijt}) - \log(\overline{MRPK}_{jt}) |$, with the yearly industry mean as a proxy for \overline{MRPK}_{jt} . We define industries at the 4-digit ISIC code. All firm-level variables used in the regressions are expressed in logs.

6.2 Panel estimation results

We estimate a set of panel regressions aimed at studying how the CCs had differential effects on firm-level misallocation depending on the firms' TFP, OSGs and exporter status. The main regression model is the following:

$$mis_{ijt} = \omega_0 + \omega_1 CC_{t-1} * \log_TFP_{ijt} + \omega_2 CC_{t-1} * OSG_{ijt} + \omega_3 CC_{t-1} * Exp_{ijt} + \omega_4 X_{ijt} + A_i + B_t + \epsilon_{ijt}, \quad (37)$$

CC_{t-1} denotes the tax-equivalent CCs, lagged one period. OSG_{ijt} is the percentage gap between the firm's capital in period t with respect to the year average capital of the firms older than 10 years old. Thus, if we interpret the latter as a proxy of the steady-state size of firms in the industry, OSG_{ijt} is an estimate of the firm's distance from its steady-state size. We classify as exporters ($Exp_{ijt} = 1$) all firms that export in the current period.⁴⁰

X_{ijt} is a set of time-varying firm characteristics that includes the direct effect of TFP_{ijt} ,

³⁹The results are robust to computing TFP as in Levinsohn and Petrin (2003).

⁴⁰The results are robust to using backward- and forward-looking definitions of exporters instead (see Appendix H).

OSG_{ijt} and Exp_{ijt} , as well as other standard firm-level controls—i.e., fixed capital, payroll and the ratio of interest expenditures to total capital, as a proxy for a firm’s debt.⁴¹ A_i is a vector of firm-level 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. Note that these time fixed effects absorb the direct effect of the CCs and the effect of any other aggregate time-varying change.⁴² Although this strategy has the disadvantage of only allowing us to identify the firm-level heterogeneous effects of CCs, it also has the desirable feature of considerably reducing potential endogeneity problems due to omitted variables. Standard errors are clustered at the firm level.

Table 7 presents the regression results. Columns (1) to (3) show results using value added to calculate MRPK, and columns (4) to (6) show results using total sales.⁴³ Columns (1) and (4) use the full (unbalanced) panel of firms and Columns (2) and (5) used a balanced panel with firms that existed between 1990 and 2003 and fixing the values for TFP, Export status and OSG in 1990. Finally, columns (3) and (6) show results restricting the sample to firms not born around the period of the Russian crisis of 1998 and its aftermath –i.e., between 1998 and 2000.

In line with the findings of the quantitative analysis (see Figure 3 and Table 5), the main insight from Table 7 is that CCs caused a larger increase in misallocation for more productive firms relative to less productive firms. Namely, assuming the direct effect of CCs on misallocation was positive (negative), misallocation rose more (fell less) for firm with higher productivity. The same happened to firms that were relatively further away from their optimal scale—i.e., that have a larger OSG—and for exporters with respect to non-exporters. The three interaction coefficients are statistically significant in all the regressions.

The regression results are similar using value added or total sales to measure misallocation. Comparing balanced and unbalanced panels (i.e., column (1) with (2) and column (4) with (5)), the results are qualitatively similar, suggesting that the findings derived from the full sample are not driven by the possibility of endogenous firm entry or exit nor by changes in the interacted variables driven by the introduction of CCs. Also, the coefficients of the balanced panel are markedly larger, suggesting that the results with all firms may be a lower bound of the actual effects.

Columns (3) and (6) show that the results are also robust to restricting the sample to

⁴¹Table G.6 presents the summary statistics of these variables.

⁴²Hence, the empirical analysis and the quantitative experiments differ in that the former can only speak to firm-level effects of CCs while the latter covers both firm-level and aggregate effects.

⁴³There are fewer observations using total sales because 3931 firm-year observations report value added but zero total sales. The results are robust to dropping them from the value-added regressions too.

firms born outside the periods around the Russian crisis of 1998 (when Chile experienced a Sudden Stop). The three interaction coefficient estimates are about the same and with very similar t-statistics. This is relevant since there is important evidence from the work by Ates and Saffie (2021) showing that firms born during this period are different in size (30 percent smaller) and productivity (64 percent more productive) than the average firm born in normal times.

In regressions reported in Appendix H, we show that the results are also robust to: (i) introducing the interaction of macroeconomic controls with the firms' characteristics; (ii) winsorizing the top and bottom 1% observations of the database with respect to alternative dimensions—i.e., dependent variable, controls, and sectors' productivity; (iii) using backward- and forward-looking definitions of exporters;⁴⁴ and (iv) using data at the industry level instead of the firm level.

Table 7: Heterogeneous Effects of the Chilean *Encaje*: TFP, OSG and Export Status

VARIABLES	MRPK (Value Added)			MRPK (Sales)		
	All firms (1)	Balanced Panel (2)	W/o crisis cohort (3)	All firms (4)	Balanced Panel (5)	W/o crisis cohort (6)
CC*TFP	0.876*** (0.130)	1.363*** (0.197)	0.883*** (0.135)	0.713*** (0.083)	1.108*** (0.196)	0.728*** (0.085)
CC*Exp	0.224*** (0.032)	0.296*** (0.062)	0.208*** (0.032)	0.317*** (0.033)	0.410*** (0.066)	0.299*** (0.034)
CC*OSG	0.248*** (0.033)	0.309*** (0.058)	0.244*** (0.033)	0.255*** (0.034)	0.380*** (0.062)	0.250*** (0.034)
TFP	-6.190*** (0.236)		-6.190*** (0.237)	-2.263*** (0.181)		-2.263*** (0.182)
Export Decision	-0.323*** (0.060)		-0.292*** (0.060)	-0.505*** (0.064)		-0.471*** (0.064)
Fixed Capital	0.425*** (0.019)	0.636*** (0.040)	0.435*** (0.020)	0.441*** (0.019)	0.608*** (0.041)	0.454*** (0.021)
OSG	-1.000*** (0.105)		-0.995*** (0.108)	-0.990*** (0.099)		-0.976*** (0.102)
Int.Exp_Fixed_K	0.119*** (0.027)	0.184** (0.075)	0.139*** (0.028)	0.168*** (0.029)	0.245*** (0.068)	0.195*** (0.030)
Payroll	-0.392*** (0.030)	-0.505*** (0.069)	-0.396*** (0.031)	-0.431*** (0.031)	-0.372*** (0.068)	-0.435*** (0.032)
Observations	91,374	22,204	90,359	87,469	21,935	86,524
R-squared	0.624	0.579	0.625	0.600	0.573	0.601
Firm FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES

Note: Columns (1) and (3) include the full sample of firms, columns (2) and (5) use the 1990-2003 balanced panel with TFP, OSG and Exp fixed at their 1990 values. Finally, columns (3) and (6) use the subsample that leaves out the cohort of firms born between 1998 and 2000. All regressions include a constant term, firm and time fixed effects, and standard errors clustered at the firm level in parenthesis. ***, **, and * indicate significance at the 1%,5%, and 10% level.

Next, we explore whether the data validates the non-linearity of the quantitative results in terms of misallocation rising relatively less with a firm's productivity for exporters than non-

⁴⁴The former aims at capturing that firms that exported in the past can be differently affected as they typically have higher steady-state capital and are more productive. The latter 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.

exporters. We do this by adding triple-interaction terms and by splitting the panel into exporters and non-exporters. Both results are reported in Table 8. Columns (1)-(3) add the triple interactions, $CC_{t-1} * TFP_{ijt} * Exp_{ijt}$ and $CC_{t-1} * OSG_{ijt} * Exp_{ijt}$. In columns (1) and (2) we add them one at a time, and in column (3) we add both. Columns (4) and (5) shows results for the original regression specification splitting the panel into non-exporters and exporters, respectively.

The results show that becoming an exporter changes how TFP alters the effect of CCs on misallocation in the direction predicted by the model. The quantitative exercise (see Table 5) shows that the increase in misallocation caused by CCs increases with TFP until firms become exporters, while it falls or becomes constant for exporters—i.e. firms with productivity higher or equal than z_6 . In line with this result, the triple interaction $CC_{t-1} * TFP_{ijt} * Exp_{ijt}$ has a negative sign in columns (1) and (3), and the coefficient for the interaction $CC_{t-1} * TFP_{ijt}$ becomes non-significant in the subsample of exporters but is significant and positive in the subsample of non-exporters in columns (4)-(5). For the case of OSG, the empirical exercise does not capture a significant difference in terms of the behavior of exporting and non-exporting firms with respect to the OSG.

Table 8: Heterogeneous Effects of the Chilean *Encaje* by Export Status

VARIABLES	All firms (1)	All firms (2)	All firms (3)	Non-Exporters (4)	Exporters (5)
CC*TFP	0.990*** (0.142)	0.880*** (0.130)	0.995*** (0.144)	1.029*** (0.135)	0.243 (0.236)
CC*Exp	1.326** (0.523)	0.215*** (0.046)	1.339** (0.540)		
CC*OSG	0.246*** (0.032)	0.237*** (0.036)	0.248*** (0.037)	0.268*** (0.037)	0.220*** (0.073)
CC*TFP*Exp	-0.500** (0.240)		-0.501** (0.244)		
CC*TFP*OSG		0.010 (0.072)	-0.032 (0.073)		
Observations	91,374	91,374	91,374	72,751	17,755
R-squared	0.624	0.624	0.625	0.658	0.578
Controls	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES

Note: Columns (1-3) include the following triple interactions $CC_{t-1} * TFP_{ijt} * Exp_{ijt}$ 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 errors clustered at the firm level in parenthesis. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

7 Conclusions

This paper examines the effects of capital controls 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 capital controls are introduced. The episode of the Chilean *encaje* (an 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 analysis.

In the model, capital controls affect misallocation via three effects: Static effects (i.e., keeping net worth and aggregate variables unchanged) that unambiguously worsen misallocation by tightening the firms' financial constraints, which increase their MRPKs as their capital-labor ratios fall and their prices rise; dynamic effects that weaken misallocation as tighter financial constraints incentivize firms to accumulate net worth faster, and thus spend less time at points in which misallocation is large; and general equilibrium effects due to changes in wages, aggregate output and the price of final goods that can go in different directions. Moreover, the static effects of capital controls on misallocation differ from the effects of collateral constraints in that they do not weaken monotonically as net worth rises. Instead, the effects are irrelevant for firms with either little net worth (or very young) and for firms with enough net worth (or old enough) to be close to reaching their optimal scale than for firms in between. This occurs because the capital controls effectively make the severity of financial frictions vary with firm size.

The model's quantitative predictions are examined using a calibration to Chilean data from before the *encaje* period and then comparing the resulting stationary equilibrium with the one produced by adding a debt-tax-equivalent of the *encaje*. The model predicts that capital controls worsened aggregate misallocation by about 0.5pp, with much larger effects for exporters (1.25pp) and larger effects also for firms with high productivity or large optimal scale gaps. Exports and the share of firms that are exporters also fall, and strong general equilibrium effects result in sizable drops in real wages and aggregate output. Misallocation effects across firms of different productivity displays the non-monotonic pattern of the static effects, increasing first gradually and then rapidly as firms age and then falling gradually until they vanish as firms reach their optimal scale.

The welfare implications are significant. The model predicts that the *encaje* reduced social welfare by 2/3rds of a percent, in terms of a compensating variation in permanent consumption

across all entrepreneurs that equates utilitarian social welfare with and without capital controls. Welfare losses are much larger for exporters (1.82%). The non-monotonic misallocation effects across firms, an endogenous delay in the decision to start exporting, and sizable general equilibrium effects on real wages and output, play a key role in these findings and induce significant heterogeneity in welfare effects. Entrepreneurs that rely mostly on labor income are hurt by the fall in real wages without being affected much by misallocation. Those with some capital income but weak misallocation effects suffer less than them because the fall in wages also pushes up their profits and their misallocation is not large enough to undo this gain. But those with large misallocation are hurt the most because their profits shrink as the large misallocation outweighs the benefit of lower wage costs, and their labor income falls too.

A counterfactual experiment with debt taxes set at the average level predicted by the literature on optimal macroprudential capital controls yields significantly larger misallocation effects and welfare losses. In contrast, a second experiment in which LTV regulation (i.e., a cut in the fraction of capital pledgeable as collateral) is used to reduce the credit-value added ratio by the same amount as capital controls shows that LTV regulation is a far superior policy. It has much weaker effects on misallocation and a third of the social welfare cost. This is because LTV regulation distributes more evenly the burden of reducing credit across firms, whereas the CCs affect disproportionately more indebted firms with intermediate levels of net worth.

We also conduct a detailed cross-sectional empirical analysis using a large firm-level dataset for the Chilean manufacturing sector. The results provide strong and robust evidence indicating that, in line with the model's quantitative predictions, the Chilean *encaje* increased misallocation more for firms that were more productive, for exporters and for those with larger optimal scale gaps. Moreover, in line with the non-linearities predicted by the model, the misallocation effects of capital controls as productivity increases are weaker for exporters than non-exporters.

The findings of this paper have implications beyond capital controls. The model's theoretical predictions apply to the broader question of the effects of financial repression (i.e., situations in which borrowing and lending rates differ), capital income taxation and the effects of size-dependent industrial policies. The analysis also sheds light on the misallocation, trade and real-exchange-rate implications of altering the degree of financial openness in an economy.

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