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Abstract

We explore the consequences of international trade in an economy that encompasses technology choice and an endogenous distribution of mark-ups due to credit market frictions. We show that in such an environment a gradual opening of trade may – but not necessarily must – have a negative impact on productivity and overall output. The reason is that the pro-competitive effects of trade reduce mark-ups and hence make access to credit more difficult for smaller firms. As a result, smaller firms – while not driven out of the market – may be forced to switch to less productive technologies.

Keywords

International trade, credit market frictions, productivity, polarization

JEL Classification

O11, F13, O16

1 Introduction

How and through what channels does international trade affect productivity and overall output in an economy? The recent literature emphasizes several beneficial pro-competitive effects of trade: Stiffer competition is predicted to boost economic performance by reallocating production factors from less to more productive firms (e.g., Bernard et al., 2003; Melitz, 2003; Melitz and Ottaviano, 2008) or by improving within-firm efficiency as companies are forced to trim their fat (Pavcnik, 2002) or to upgrade technology (e.g., Lileeva and Trefler, 2010; Bustos, 2011). This paper, by contrast, identifies channels through which intensified foreign competition may have negative consequences for productivity and overall output. These channels are related to the presence of significant credit market frictions.

We explore the impact of trade in a setup where firms have some degree of monopoly power and loan repayment is imperfectly enforceable. Imperfect enforceability implies that an entrepreneur's borrowing capacity depends on her private wealth. Less affluent entrepreneurs are therefore forced to run smaller firms – and hence charge higher prices and mark-ups. Greater exposure to trade, however, is bound to reduce these mark-ups: Competition from abroad reduces the maximum prices smaller firms can charge; moreover, there is a rise in the cost of borrowing since larger firms increase capital demand to take advantage of new export opportunities. Lower mark-ups, in turn, reduce the borrowing capacity of less affluent firm owners – which means that they may no longer be able to make the investments required to operate the high-productivity (i.e., state-of-the-art) technology.

The magnitude and consequences of this reduction in the access to credit depend on the degree to which a country integrates into the world economy. A strong reduction of trade barriers has an unambiguously positive effect on economic performances as the dispersion of goods prices becomes smaller and low-productivity firms are driven out of the market. A smaller reduction, however, may actually hurt the economy through two different channels, both of which related to credit market frictions. First, there is what we call a *polarization effect*. A gradual reduction of trade barriers reduces the maximum amount smaller firms can borrow and invest. As a result, some of these firms are forced to switch to less productive (i.e., "traditional") technologies. But because trade is not yet frictionless, even these firms are not forced to leave the market – which means that average productivity may fall. So a partial opening up reinforces the polar structure of the economy, i.e., the coexistence of small low-productivity firms and efficient large-scale companies. Second, we identify a *replacement effect*. The integration-induced fall in smaller firms' borrowing capacities and output levels requires the economy to increase imports and hence to spend more resources on trade-related costs (e.g., transportation costs). Put differently, an intermediate reduction of trade barriers leads to a "costly" partial replacement of domestically-produced supplies with imports. This replacement effect is particularly strong in the neighborhood of the autarky equilibrium, i.e., if a reduction of trade barriers pushes the economy from an equilibrium without trade to one with some trade. At this point, the replacement effect necessarily dominates the positive effect of trade (which is operating through a reduction in price dispersion). Our quantitative analysis suggests that in case of a gradual reduction in trade barriers the negative pro-competitive effects of trade (i.e., the polarization effect and the replacement effect) may significantly outweigh the positive effect associated with stiffer competition.

So far, there has been little empirical research on how a reduction of trade barriers affects the ability of small firms to obtain external financing. The present paper offers some suggestive evidence in this regard. Although intensified foreign competition may also be expected to influence firms' access to finance in advanced economies, we focus on evidence from developing or emerging economies because of the prevalence of credit market frictions in these places. More specifically, we rely on a firm-level dataset that has recently been put together by Foellmi, Legge, and Tiemann (2015). The dataset, which has a two-period panel structure, covers seven Latin American countries and contains 544 manufacturing firms, surveyed in the years 2006 and 2010. The empirical findings are supportive of the key mechanism we describe in our framework: A reduction in tariff protection makes small and medium-sized businesses much more likely to respond "access to finance" when asked which element of the current business environment represents the biggest obstacle; among large firms, on the other hand, such an effect of tariff reductions cannot be identified.

Considering that credit market frictions are particularly severe in developing economies, our model can also offer a coherent perspective on a growing body of empirical evidence on the effects of trade in the developing world. At the most aggregate level, the predicted ambiguity regarding the impact on overall output is consistent with a voluminous cross-country literature on trade policy and economic performance. This literature fails to identify a robust link between policies related to openness and economic growth, particularly among developing countries.[1] Moreover, the model features a genuine mechanism which makes the richest segment of society benefit disproportionally – and hence may explain why liberalizing trade went hand in hand

[1]There are a number of studies (e.g., Dorwick and Golley; 2004; DeJong and Ripoll, 2006) that identify a positive impact of openness on growth in more advanced economies but no clear effect in developing countries. Other papers find that – in developing countries – more openness is harmful for growth (Yanikkaya, 2003); others again suggest exactly the opposite effect (e.g., Warner, 2003). See Kehoe and Ruhl (2010) for an overview.

with surging top income shares in Argentina (Atkinson et al., 2011, Figure 11), India (Banerjee and Piketty, 2005, Figure 4), and other developing countries. At a more disaggregate level, the model accounts for recent observations regarding misallocation and firm productivity. Among them are findings from India which suggest that allocative efficiency deteriorated (Hsieh and Klenow, 2009) and that the pro-competitive effects of trade did not promote average firm productivity in a broad sample of formal sector firms (Nataraj, 2011).[2]

In modeling credit market frictions, we follow an approach taken by Foellmi and Oechslin (2010). Relying on a setup with a simple linear technology, Foellmi and Oechslin (2010) explore the impact of trade liberalization on the income distribution by comparing the autarky to the free-trade equilibrium. This paper, by contrast, presents a model that encompasses heterogeneity in firm-level productivity and focuses on the behavior of aggregate productivity as trade barriers are continuously reduced from prohibitive levels to zero; it is thus more closely related to the literature on trade and heterogeneous firms (e.g., Bernard et al., 2003; Melitz, 2003; Melitz and Ottaviano, 2008). We add to the growing sub-field of this literature that focuses on the effects of financial frictions. A series of recent papers explores how financial frictions constrain export-oriented firms, thereby distorting aggregate export flows (e.g., Caggese and Cunat, 2013; Manova, 2013; Feenstra et al., 2014; Besedeš et al., 2014) or impeding technology upgrading (e.g., Peters and Schnitzer, 2015). Relying on a general equilibrium framework, we are more interested in how trade affects mark-ups and, through this channel, the borrowing conditions of smaller (and not necessarily export-oriented) firms.[3] The use of a general-equilibrium model with profit-dependent borrowing limits connects our work to a recent paper by Brooks and Dovis (2018). They show (in a model with constant markups, CRS-technology, and exogenous productivity) that the way credit constraints are modeled matters for the extent to which liberalization produces gains from trade; however, they do not address how the pro-competitive effects of trade – by reducing the borrowing capacity of smaller firms – may harm firm-level productivity. By focusing on how trade affects the distribution of mark-ups, our analysis is further related to Epifani and Gancia (2011) who show that the pro-competitive effects of trade can reduce welfare when they increase the mark-

[2]Focusing on big formal-sector firms in India, Topalova and Khandelwal (2011) do find a positive pro-competitive effect on average firm productivity. Yet, this effect is small: A 10-percentage-point fall in output tariffs lifts productivity by just 0.32%. Moreover, results by Nataraj (2011) suggest that this effect is limited to big companies, as it cannot be detected in a representative sample of formal-sector firms. However, both papers find that a fall in input tariffs boosts productivity (as firms gain access to cheaper inputs).

[3]Earlier papers which rely on general-equilibrium models include Banerjee and Newman (2004), Matsuyama (2005), and Antràs and Caballero (2009). However, these contributions elaborate variants of the Ricardo-Viner model or, in the case of Antràs and Caballero (2009), the Heckscher-Ohlin model.

up dispersion. This paper, by contrast, shows that international trade may reduce welfare even if it leads to a more even distribution of mark-ups.

More broadly, our analysis is connected to a literature that explores how distortions and factor market imperfections lead to resource misallocation and hence compromise productivity in low-income countries. Papers by, for instance, Banerjee and Newman (1993), Matsuyama (2000), Banerjee and Duflo (2005), or Song et al. (2011) also examine the role of credit market imperfections, partly in connection with wealth or income inequality. Yet, these papers do not address whether greater exposure to international trade affects the resource allocation in a positive or a negative way – which is the prime focus here.[4]

The rest of this paper is organized as follows. The next section presents some new evidence on trade liberalization and access to finance. Section 3 develops and solves the closed-economy model. In Section 4, we explore the effects of opening up to international trade. We proceed in two steps. First, focusing on an intermediate-openness case, we describe the different channels by which trade affects economic performance. Second, we systematically analyze the adjustments associated with a continuous fall in trade costs from prohibitive levels to zero and discuss some quantitative implications. Section 5 concludes.

2 Evidence on Trade and Access to Finance

We use a firm-level dataset compiled by Foellmi, Legge, and Tiemann (2015) to develop motivating evidence on trade liberalization and access to finance. The dataset combines two data sources, the World Bank's Enterprise Surveys (WBES) and the World Integrated Trade Solution (WITS) database. WBES provides firm-level survey data, including information on access to finance, firm size, and industry classification. WITS contains information on tariff rates at the four-digit ISIC level, allowing us to infer the degree of tariff protection enjoyed by each firm. To ensure comparability across countries, the dataset focuses on Latin America where firms were interviewed with standardized questionnaires. It covers all Latin American countries in which firms were interviewed twice (in 2006 and 2010) and for which tariff rates were available: Argentina, Bolivia, Chile, Colombia, Paraguay, Peru, and Uruguay. Only manufacturing firms are included, of which 880 were interviewed in both years. Among these 880 firms, 320 changed their industry classification between 2006 and 2010, implying that any difference in

[4]We share this prime focus with other recent work by, e.g., Egger and Kreickemeier (2009), Kambourov (2009), Helpman et al. (2010), Felbermayr et al. (2011), or McMillan and Rodrik (2011). However, all of these contributions consider the role of labor market frictions.

tariff protection between 2006 and 2010 is affected by the firm's own decision to switch industries. Excluding these firms leaves us with a small but clean two-period panel dataset that contains 560 manufacturing firms from seven Latin American countries. Tariff information is lacking in 16 cases, however, so that our sample consists of 544 firms.

The variable of interest is a dummy variable, called *FIN_CONS*, that takes on the value 1 if a firm responds "access to finance" when asked which element of the business environment represents the biggest obstacle affecting the operation of the establishment ("access to finance" is one of 15 possible answers). We are interested in two related questions. First, did the share of firms responding "access to finance" increase by more in the subset of firms operating in industries that experienced a substantial tariff reduction? Second, is the negative effect (if any) of such tariff reductions on access to finance stronger among smaller firms than among larger firms? Throughout, we consider tariff cuts of 0.5 percentage points or more to be substantial. In the set of industries that faced a substantial tariff cut according to this definition, tariffs fell on average by 4 percentage points (while the average relative cut was 30%).[5] We further consider firms with less than 100 employees in the year 2006 to be "smaller firms" (while firms with 100 or more employees in 2006 are treated as "larger firms").

Table 1 here

Table 1 presents the main empirical pattern. The table reports results based on the full firm sample (Columns 1 and 2); on the subset of smaller firms (Columns 3 and 4); and on the subset of larger firms (Columns 5 and 6). To answer the first of the above questions, we look at the results for the full sample. We observe that – indeed – the share of firms identifying access to finance as their major problem rose markedly (but not significantly) in the subset of firms that experienced a substantial decrease in tariffs (Column 1); on the other hand, this share fell slightly in the subset of firms that did not experience such a decrease (Column 2). This uneven development is also reflected in the two difference-in-difference (DiD) estimates. Our DiD model includes country (and industry) dummies, thereby allowing for country- (and industry-) specific trends in the access to finance.[6] According to the DiD estimates, a substantial tariff reduction is associated with a significant increase in the probability that a firm identifies access

[5]Average tariff protection in 2006 was about 10%. Tariffs changes between 2006 and 2010 were heterogenous across countries. The major reductions occurred in Peru and Uruguay. In 2006, Peru signed the US-Peru Trade Promotion Agreement (PTPA) which eliminated (or phased out) most existing tariffs between the two countries. Similarly, Uruguay signed several bilateral trade agreements with the US between 2006 and 2008.

[6]The DiD results are based on an OLS estimate of $\Delta FIN\_CONS_i = \beta_0 + \beta_1 RT_i + \gamma' \mathbf{C}_i + \delta' \mathbf{I}_i + \epsilon_i$, where RT_i is a dummy that takes on the value 1 if firm i was subject to a substantial tariff reduction; $\mathbf{C}_i$ is a vector of country dummies; $\mathbf{I}_i$ is a vector of industry dummies (at the 2-digit level); and ϵ_i represents the error term.

to finance as the biggest obstacle. The magnitude of the impact is in the range of 11 to 13 percentage points, depending on the DiD model used. As for the second question, comparing Columns 3 and 4 (smaller firms) to 5 and 6 (larger firms) confirms that the results obtained in the full sample are driven by smaller firms: While the estimated effect of a substantial tariff reduction is even bigger among smaller firms, we do not find such an effect at all in the subset of larger firms. Therefore, overall, Table 1 provides evidence in support of the relevance of a key mechanism in the model to be developed below: A reduction in tariff protection makes it harder for smaller firms, but not for larger ones, to obtain credit.

The results in Table 1 are fairly robust to changes in the definition of what amounts to a "substantial tariff reduction". Setting the threshold at either -0.25 or -0.75 percentage points leads to similar results. In the former case, a substantial tariff cut is associated with a 10.9-percentage-point increase in the probability that a firm identifies access to finance as the biggest obstacle (p-value: 0.054); in the latter case, the corresponding number is 11.4 percentage points (p-value: 0.038).[7] Finally, we note that the results in Table 1 are robust to the use of comparable relative (instead of absolute) thresholds.

3 The Closed Economy

3.1 Endowments, Technologies, and Preferences

Assumptions. We consider a static economy that is populated by a continuum of (potential) entrepreneurs. The population size is normalized to 1. The entrepreneurs are heterogeneous with respect to their initial capital endowment $\omega_i, i \in [0,1]$, and their production possibilities. The capital endowments are distributed according to the distribution function $G(\omega)$ which gives the measure of the population with an endowment below ω. We further assume that $g(\omega)$, which refers to the density function, is positive over the entire positive range. The aggregate capital endowment, $\int_0^\infty \omega dG(\omega)$, will be denoted by K.

Entrepreneurs operate under monopolistic competition. Each entrepreneur is a supplier of a single differentiated good. However, unlike in a standard monopolistic competition model, we consider a fixed number of established entrepreneurs. This setup captures the short run (Melitz and Ottaviano, 2008) or may reflect a situation in which market entry is associated

[7] These numbers are based on the full firm sample and the DiD specification that includes country as well as industry dummies. In the set of industries that faced a tariff cut of 0.25 percentage points or more, tariffs fell by an average of 3.6 percentage points (while the average relative cut was 27%). The corresponding numbers for the 0.75-percentage-point threshold are 4.2 percentage points and 32%, respectively.

with prohibitive fixed costs.[8] All goods are produced with a simple technology that requires physical capital as the only input into production. Following much of the related literature on credit market imperfections (e.g., Galor and Zeira, 1993; Matsuyama, 2000; Banerjee and Moll, 2010), this technology is characterized by a simple non-convexity. In particular, its productivity is relatively low if the level of investment is below a critical threshold:

$$y_i = \begin{cases} bk_i & : \quad k_i < \kappa \\ ak_i & : \quad k_i \geq \kappa \end{cases}, \; b < a, \tag{1}$$

where y_i and k_i denote output and capital of entrepreneur i, respectively, and κ refers to the critical scale of investment. In what follows, we say that an entrepreneur operates the "low-productivity technology" if she invests less than κ; similarly, we say that an entrepreneur operates the "high-productivity technology" if the investment exceeds κ.

Regarding technology, a standard approach in the recent trade literature is that firms directly draw an invariant productivity level from some exogenous distribution. By assuming a technology of the form (1), we deviate from this standard. This allows us to capture the idea that opening up to international trade, by exposing firms to tougher import competition, may affect firm productivity if the credit market is imperfect.

The entrepreneurs' utility function is assumed to be of the familiar CES-form,

$$U = \left(\int_0^1 c_j^{(\sigma-1)/\sigma} dj \right)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where c_j denotes consumption of good j and $\sigma > 1$ represents the elasticity of substitution between any two goods. Each entrepreneur i maximizes objective function (2) subject to

$$\int_0^1 p_j c_j dj = m(\omega_i), \tag{3}$$

where p_j is the price of good j and $m(\omega_i)$ refers to entrepreneur i's nominal income (which, in turn, will depend on the initial capital endowment, as is discussed further below).

Finally, for tractability purposes, we impose a sufficient parameter restriction which puts an upper bound on the critical scale of investment:

$$\kappa < K(b/a)^{\sigma-1}. \tag{R1}$$

[8] Such fixed costs of entry may include the cost of complying with entry regulations, which tend to be particularly high in low-income countries (Djankov et al., 2002).

Implications. Under these conditions, entrepreneur i's demand for good j is given by

$$c_j(y(\omega_i)) = \left(\frac{p_j}{P}\right)^{-\sigma} \frac{m(\omega_i)}{P}, \tag{4}$$

where $P \equiv (\int_0^1 {p_j}^{1-\sigma} dj)^{1/(1-\sigma)}$ denotes the CES price index. In a goods market equilibrium, aggregate demand for good j must be equal to the supply of good j, y_j. Taking this into account, we can express the real price of good j as a function of y_j and Y/P,

$$\frac{p_j}{P} = \frac{p(y_j)}{P} \equiv \left(\frac{Y}{P}\right)^{\frac{1}{\sigma}} {y_j}^{-1/\sigma}, \tag{5}$$

where $Y \equiv \int_0^1 p(y_j) y_j dj$ denotes the economy-wide nominal output and the ratio Y/P refers to the aggregate real output. Notice further that, in a goods market equilibrium, the real price of a good is strictly decreasing in the quantity produced. The reason is simple: Since the marginal utility from consuming any given good falls in the quantity consumed, the only way to make domestic consumers buy larger quantities is to lower the price.

Later on, it will be helpful to have an expression for the aggregate real output (or, equivalently, for the aggregate real income) that depends only on the distribution of firm outputs. Using (5) in the definition of Y, we obtain

$$\frac{Y}{P} = \left(\int_0^1 y_j^{(\sigma-1)/\sigma} dj\right)^{\frac{\sigma}{\sigma-1}} = \frac{M}{P}, \tag{6}$$

where $M \equiv \int_0^1 m(\omega_i) di$ denotes the aggregate nominal income.

3.2 The Credit Market

Assumptions. Entrepreneurs may borrow and lend in an economy-wide credit market. Unlike the goods market, the credit market is competitive in the sense that both lenders and borrowers take the equilibrium rental rate of capital as given. However, the credit market is imperfect in the sense that borrowing at the equilibrium rate may be limited. As in Foellmi and Oechslin (2010), credit-rationing may arise from imperfect enforcement of credit contracts. More specifically, borrower i can avoid repayment altogether by incurring a cost which is assumed to be a fraction $\lambda \in (0, 1]$ of the current firm revenue, $p(y_i)y_i$.

The parameter λ mirrors how well the credit market works. A value that is close to one represents a near-perfect credit market, while a near-zero value of λ means that the credit market functions poorly. In the latter case, lenders are not well protected since the borrowers can "cheaply" default on their repayment obligations – which invites ex post moral hazard. As a result, lenders are reluctant to provide external finance.

There is a large literature showing that credit market frictions are a particularly important phenomenon in poor countries. On average, developing economies are more strongly afflicted by credit market frictions than advanced economies are. Poor protection of lenders, as is assumed here, is one explanation: It is well documented that – throughout the developing world – insufficient collateral laws or unreliable judiciaries often make it extremely hard to enforce credit contracts in a court (see, e.g., Banerjee and Duflo, 2005; 2010).

Implications. Taking the possibility of ex post moral hazard into account, a lender will give credit only up to the point where the borrower just has the incentive to pay back. In formal terms, this means that the amount of credit cannot exceed $\lambda p(y_i)y_i/\rho_i$, where ρ_i denotes the rental rate of capital borrower i faces. Note further that – since in equilibrium borrowers always repay and because there are no individual-specific risks – the rental rate of capital must be the same for all agents ($\rho_i = \rho$). Using this information, and accounting for (1), we find that borrower i does not default on the the credit contract ex post if

$$\lambda p(y_i)y_i/\rho \geq \begin{cases} y_i/b - \omega_i & : \quad y_i < a\kappa \\ y_i/a - \omega_i & : \quad y_i \geq a\kappa \end{cases}, \tag{7}$$

where the right-hand side of (7) gives the size of the credit.

We now derive how the maximum amount of borrowing, and hence the maximum output, depends on the initial capital endowment, ω.[9] To do so, suppose that there is an endowment level $\omega_\kappa < \kappa$ which permits borrowing exactly the amount required to meet the critical investment size κ. Taking (5) and (7) into account, this threshold level is defined by

$$\omega_\kappa + \lambda x \left(a\kappa\right)^{(\sigma-1)/\sigma} = \kappa, \tag{8}$$

where

$$x \equiv P^{(\sigma-1)/\sigma} Y^{1/\sigma}/\rho = (Y/P)^{1/\sigma}/(\rho/P). \tag{9}$$

With these definitions (and expressions 5 and 7) in mind, it is immediately clear that the maximum firm output is implicitly determined by

$$\overline{y} = \begin{cases} b\left(\omega + \lambda x \overline{y}^{(\sigma-1)/\sigma}\right) & : \quad \omega < \omega_\kappa \\ a\left(\omega + \lambda x \overline{y}^{(\sigma-1)/\sigma}\right) & : \quad \omega \geq \omega_\kappa \end{cases} \tag{10}$$

and hence depends on the initial capital endowment. It is the purpose of the following lemma to clarify the relationship between $\overline{y}$ and ω.

[9]Since the initial capital endowment is the only individual-specific factor that determines maximum borrowing, the index for individuals will be dropped in the rest of this section.

Lemma 1 *A firm's maximum output, $\overline{y}(\omega)$, is a strictly increasing function of the initial capital endowment, ω.*

Proof. See Appendix. ■

Maximum firm output increases in ω for two different reasons. First, and most directly, an increase in ω means that the entrepreneur owns more resources that can be invested. Second, there is an indirect effect operating through the credit market: An increase in ω allows for a higher level of borrowing since the entrepreneur has more "skin in the game" (Banerjee and Duflo, 2010). Figure 1 shows a graphical illustration of $\overline{y}(\omega)$.

Figure 1 here

Besides the positive slope, the figure highlights two additional properties of the $\overline{y}(\omega)$-function. First, the function is locally concave. This mirrors the fact that the marginal return on investment falls in the level of investment; thus, the positive impact of an additional endowment unit on the borrowing capacity must decrease. Second, there is a discontinuity at ω_κ since, at that point, an entrepreneur is able to switch to the more productive technology.

3.3 Output Levels

We now discuss how individual firm outputs depend on initial capital endowments, holding the aggregate variables Y/P and ρ/P (and hence x) constant. Our discussion presumes

$$x \geq \frac{1}{a}\frac{\sigma}{\sigma-1}(a\kappa)^{1/\sigma}, \tag{11}$$

which will turn out to hold in equilibrium (see Proposition 1).

Firms using the low-productivity technology. First consider entrepreneurs who are able to use the more productive technology ($\omega \geq \omega_\kappa$). Resources permitting, these entrepreneurs increase output up to the point where the marginal revenue, $((\sigma-1)/\sigma)P^{(\sigma-1)/\sigma}Y^{1/\sigma}y^{-1/\sigma}$, equals the marginal cost, ρ/a. We denote this profit-maximizing output level by $\widetilde{y}$ and we use $\widetilde{\omega}$ to denote the initial capital endowment that puts an agent exactly in a position to produce $\widetilde{y}$. Using these definitions, we have

$$\widetilde{y} = \left(ax\frac{\sigma-1}{\sigma}\right)^{\sigma} \quad \text{and} \quad \widetilde{\omega} = \left(1-\lambda\frac{\sigma}{\sigma-1}\right)\frac{\widetilde{y}}{a}, \tag{12}$$

where $\widetilde{y}/a \geq \kappa$ due to (11).

Two points should be noted here. First, because of Lemma 1 and $\widetilde{y} \geq a\kappa$, we have $\widetilde{\omega} \geq \omega_\kappa$. Second, as can be seen from the second expression in (12), $\lambda < (\sigma-1)/\sigma$ is sufficient for having a group of credit-constrained entrepreneurs, i.e., entrepreneurs who have too little access to credit to produce the profit-maximizing output level. On the other hand, if $\lambda \geq (\sigma - 1)/\sigma$, even entrepreneurs with a zero capital endowment can operate at the profit-maximizing scale. Why? The smaller the elasticity of substitution, the higher is the constant mark-up $\sigma/(\sigma - 1)$ over marginal costs. So, if σ is small, even poor agents are able to generate revenues that are large relative to the payment obligation. This means that only a very low λ may induce a borrower to default ex post. Put differently, the credit market imperfection is binding for some entrepreneurs only if it is "more substantial" than the imperfection in the product market.

The following lemma is an immediate corollary of the above discussion:

Lemma 2 *Suppose $\lambda < (\sigma - 1)/\sigma$. Then, entrepreneurs (i) with $\omega \in [\omega_\kappa, \widetilde{\omega})$ produce $\overline{y}(\omega) < \widetilde{y}$; (ii) with $\omega \in [\widetilde{\omega}, \infty)$ produce $\widetilde{y}$. Otherwise, if $\lambda \geq (\sigma - 1)/\sigma$, all entrepreneurs produce $\widetilde{y}$.*

Proof. See Appendix. ■

Firms using the high-productivity technology. We now focus on the investment behavior of less affluent entrepreneurs, i.e., agents with a capital endowment that is less than ω_κ. As established above, such entrepreneurs can only exist if $\lambda < (\sigma - 1)/\sigma$.

Lemma 3 *Suppose $\lambda < (\sigma - 1)/\sigma$. Then, entrepreneurs with an initial capital endowment that is less than ω_κ produce $\overline{y}(\omega)$.*

Proof. See Appendix. ■

Putting things together. An immediate implication of Lemmas 2 and 3 is that equilibrium individual firm output is given by

$$y(\omega) = \begin{cases} \overline{y}(\omega) & : \quad \omega < \widetilde{\omega} \\ \widetilde{y} & : \quad \omega \geq \widetilde{\omega} \end{cases}, \tag{13}$$

where $\overline{y}(\omega)$ is implicitly determined by (10) and $\widetilde{y}$ is given in (12). Note that the case $\omega < \widetilde{\omega}$ is only relevant if the parameter restriction $\lambda < (\sigma - 1)/\sigma$ holds (and hence $\widetilde{\omega} > 0$). Assuming that the restriction does hold, Figure 2 gives a graphical illustration of (13). The figure shows two possible situations. In panel *a.*, we have $\omega_\kappa > 0$ so that a positive mass of entrepreneurs is forced to use the less productive technology. Panel *b.* shows a situation where $\omega_\kappa \leq 0$ so that all entrepreneurs have access to the more productive technology.

Figure 2 here

The distribution of firm outputs is mirrored in the distribution of output prices. Since each firm faces a downward-sloping demand curve (equation 5), smaller firms charge higher prices – despite the fact that each good enters the utility function symmetrically. Only if there is no credit rationing do output levels across firms fully equalize so that all prices are the same.

3.4 The Equilibrium under Autarky

When characterizing the use of technology and individual firm outputs, we kept constant aggregate real output and the real rental rate of capital (and hence the ratio $x = (Y/P)^{1/\sigma}/(\rho/P)$). We now establish that, in fact, both Y/P and ρ/P are uniquely determined in the macroeconomic equilibrium. To do so, note that we can write aggregate gross capital demand (i.e., the sum of all physical capital investments by firms) as a function of x,

$$K^D(x) = \int_0^{\omega_\kappa} \frac{\overline{y}(\omega; x)}{b} dG(\omega) + \int_{\omega_\kappa}^{\widetilde{\omega}} \frac{\overline{y}(\omega; x)}{a} dG(\omega) + \int_{\widetilde{\omega}}^{\infty} \frac{\widetilde{y}(x)}{a} dG(\omega), \tag{14}$$

where aggregate capital supply, $K = \int_0^\infty \omega dG(\omega)$, is exogenous and inelastic.

Proposition 1 *There exists a unique macroeconomic equilibrium (i.e., real output, Y/P, and the real rental rate of capital, ρ/P, are uniquely pinned down). If $\lambda < (\sigma - 1)/\sigma$, a positive mass of entrepreneurs is credit-constrained (and the poorest among them may be forced to use the low-productivity technology). Otherwise, if $\lambda \geq (\sigma - 1)/\sigma$, no one is credit-constrained.*

Proof. See Appendix. ■

Figure 3 here

Figure 3 shows K^D as a function of x (for the case $\lambda < (\sigma - 1)/\sigma$). The figure also highlights that condition (11), on which both Lemma 2 and 3 rely, is indeed satisfied.[10]

Finally, note that – if the credit market friction is sufficiently severe – the properties of this equilibrium are consistent with a large body of firm-level evidence from developing countries. In particular, we have a coexistence of (i) more and less advanced technologies; (ii) high and low marginal (revenue) products of capital (see Banerjee and Duflo, 2005, for empirical evidence). Moreover, there is substantial variation in the revenue productivities (TFPR) across firms, as is the case in China and India (see Hsieh and Klenow, 2009, for empirical evidence).

[10]If $\lambda \geq (\sigma - 1)/\sigma$, we have $K^D(x) = (x(\sigma - 1)/\sigma)^\sigma a^{\sigma - 1}$, and it can be easily checked that $K^D(x) = K$ defines a unique x (with $Y/P = aK$ and $\rho/P = a(\sigma - 1)/\sigma$).

4 Integrating into the World Economy

We now explore the consequences of opening up to trade. After introducing the assumptions (Subsection 4.1), we focus first on an equilibrium that arises if trade costs are in an intermediate range (4.2). We do so because this equilibrium is very suitable for illustrating the channels by which trade affects the economy. We then move on to a full characterization of how the economy responds as trade costs fall from prohibitive levels to zero (4.3). Finally, we examine the robustness of our results to modifications in the assumptions (4.4).

4.1 Assumptions

The home economy – which may represent a developing country – will be called the "South". The rest of the world (i.e., the South's trading partner) is referred to as the "North" and represents an advanced economy. So far, the trade barriers have been assumed to be sufficiently high to prevent trade between South and North. This section focuses on a situation in which trade between the two regions may occur. Yet, North and South are less than perfectly integrated due to the existence of trade costs (which may be composed of tariffs and transport costs). We rely on the usual "iceberg" formulation and assume that $\tau \geq 1$ units of a good have to be shipped in order for one unit to arrive at the destination. Moreover, we continue to assume that the southern and the northern credit markets are not integrated.

The North differs from the South in that its markets function perfectly: The northern credit market is frictionless, implying that there are no credit constraints.[11] Moreover, the North has perfectly competitive goods markets in the sense that each good is produced by a large number of price-taking firms. Regarding access to technology and preferences, there are no differences between the two regions (i.e., technology and preferences are also represented by equations 1 and 2), and the North is assumed to produce the same spectrum of goods as the South does (Subsection 4.4 considers alternative assumptions about the northern goods spectrum and market structure). The assumptions regarding northern markets and goods allow us to capture in a parsimonious way the notion that the South, being a relatively small and initially protected economy, will face an increase in the degree of competitiveness – and eventually turn into a small open economy – when opening up to a big (world) market. More specifically, a gradual reduction of trade barriers exposes each southern firm to competition

[11] Since we assume that credit markets are not integrated, southern firms cannot apply for credit in the North. However, even if they could, southern firms would still be subject to credit constraints: the weak enforcement of credit contracts in the South would affect northern lenders in the same way as it affects southern lenders.

from a large number of suppliers that offer a very similar – or, in fact, identical – good; as a result, the mark-ups that can maximally be charged by southern firms will fall as well.

Our assumptions about markets and technologies imply that all northern firms operate the high-productivity technology and charge a uniform price – which, in turn, is equal to the marginal cost. In what follows, we take the northern marginal cost as the numéraire. This choice of numéraire implies that all goods prices in the North equal one, too.

4.2 An Equilibrium with Intermediate Trade Costs

Under the assumptions made above, τ gives the (marginal) cost of producing one unit of a good in the North and selling it in the South. Since the northern firms operate under perfect competition, it follows that the price of any good produced in the North and exported to the South is given by τ. This, in turn, implies that all southern producers face a northern competitive fringe and cannot set a price that would exceed τ.

4.2.1 Characterizing the Equilibrium

In what follows, we focus on an "intermediate" τ which makes a positive fraction of entrepreneurs – but not all of them – unable to set the price that would make domestic demand equal to the output produced by the firm. More specifically, we discuss an equilibrium where τ is such that (i) the price that would imply domestic demand of $a\kappa$ units exceeds the upper bound τ; (ii) the profit-maximizing price charged by unconstrained entrepreneurs lies below the upper bound. In formal terms, we focus on

$$p(a\kappa) > \tau > p(\widetilde{y}), \tag{15}$$

where $p(y)$ and $\widetilde{y}$ are defined in (5) and (12), respectively.

Allowing for international trade leads to two formal adjustments. First, the fact that there is a binding upper bound on prices changes the relationship between the endowment and the maximum firm output. For price-constrained firms, the relationship is now given by

$$\overline{y}^I = \begin{cases} b\left(\omega + \lambda\tau\rho^{-1}\overline{y}^I\right) & : \quad 0 \leq \omega < \omega_\kappa^I \\ a\left(\omega + \lambda\tau\rho^{-1}\overline{y}^I\right) & : \quad \omega_\kappa^I \leq \omega < \omega_\tau^I \end{cases}, \tag{10'}$$

where ω_κ^I denotes the level which permits borrowing of exactly the amount required to meet the critical investment size κ; ω_τ^I refers to the threshold which allows an entrepreneur to produce a quantity of output that goes exactly along with an equilibrium price of τ.[12] A straightforward

[12] For initial capital endowments equal to or larger than ω_τ^I, the maximum output a firm can produce continues to be implicitly determined by $\overline{y}^I = a(\omega + \lambda x \left(\overline{y}^I\right)^{(\sigma-1)/\sigma})$.

derivation of the two thresholds in (10') gives

$$\omega_\kappa^I = \left(1 - \frac{\lambda a \tau}{\rho}\right)\kappa \;\text{ and }\; \omega_\tau^I = \left(1 - \frac{\lambda a \tau}{\rho}\right)(Y/P)(\tau/P)^{-\sigma}/a. \tag{16}$$

The second formal change concerns the determination of the rental rate of capital. Since we are looking at an equilibrium in which a positive mass of entrepreneurs is price-constrained, the economy imports goods from abroad. This, in turn, implies that aggregate exports must be positive (since the static framework requires trade to be balanced). The fact that the equilibrium involves exports allows us to explicitly pin down the rental rate of capital. Since exporting one unit of an arbitrary good (which requires $\tau \cdot 1/a$ units of capital) generates an income of 1, ρ must be equal to a/τ. If ρ were higher, nobody would export since lending would generate a higher return; if ρ were lower, demand for capital would exceed supply since even the richest agents in the economy would seek credit in order to export as much as possible.

In the North, on the other hand, the rental rate of capital, denoted by ρ^*, is equal to a: This follows immediately from taking the northern marginal cost ρ^*/a as numéraire. So, as long as long as $\tau > 1$, we have $\rho = a/\tau < \rho^* = a$. It is exactly this gap between the two rental rates of capital that turns capital-rich southern firms into competitive exporters.[13] We put down these crucial results in the following lemma:

Lemma 4 *In an equilibrium with intermediate trade costs (equation 15), the southern rental rate of capital ρ must be equal to a/τ. The northern rental rate of capital ρ^* equals a and exceeds the southern rate for $\tau > 1$.*

Proof. In text. ■

We now work towards a description of the parameter constellations under which this equilibrium arises. The first step is to note that using $\rho = a/\tau$ in (16) yields

$$\omega_\kappa^I = \left(1 - \lambda\tau^2\right)\kappa \;\text{ and }\; \omega_\tau^I = \left(1 - \lambda\tau^2\right)(Y/P)(\tau/P)^{-\sigma}/a.$$

Thus, for a positive mass of price-constrained entrepreneurs to exist, we need $\tau^2 < 1/\lambda$. Secondly, observe that condition (15) implies a lower bound on τ. Using both $\rho = a/\tau$ (Lemma 4) and the definition of $\widetilde{y}$ in expression (5) yields

$$p(\widetilde{y}) = \frac{1}{\tau}\frac{\sigma}{\sigma - 1}. \tag{17}$$

[13]Capital-rich southern entrepreneurs supply the profit-maximizing quantity $\widetilde{y}$ in the southern market (where they enjoy monopoly power). Capital that is not used in the production of the domestically sold units is either used to produce for the (competitive) northern market or is supplied in the domestic credit market. As noted above, at $\rho = a/\tau$, the capital-rich southern entrepreneurs are exactly indifferent between these two alternatives.

As a result, $\tau > p(\widetilde{y})$ is equivalent to $\tau^2 > (\sigma/(\sigma-1))$. In sum, we must therefore have

$$\frac{\sigma}{\sigma-1} < \tau^2 < \frac{1}{\lambda}. \tag{R2}$$

Finally, we want to make sure that entrepreneurs with $\omega < \omega_\kappa^I$ do indeed run a firm (instead of becoming lenders). To get the required condition, note that each capital unit invested in a low-productivity firm generates a return of τb while lending is associated with a return of a/τ. We assume that the former exceeds the latter:

$$a/b < \tau^2. \tag{R3}$$

4.2.2 Establishing the Equilibrium

We now establish the existence of the equilibrium described above, assuming that the two additional parameter restrictions hold. We proceed in two steps. First, we derive an expression for aggregate imports. Second, we establish that the real output is uniquely pinned down.

Aggregate exports. Total consumption expenditures on an arbitrary good supplied by an entrepreneur with $\omega < \omega_\tau^I$ are $\tau c(\tau) = YP^{\sigma-1}\tau^{1-\sigma}$. To get the value of imports, we have to deduct the value of the domestic production. Moreover, with balanced trade, the total value of all imports must be equal to the value of all exports, EXP. As a result, we have

$$\begin{aligned} EXP &= YP^{\sigma-1}\tau^{1-\sigma}G(\omega_\tau^I) \\ &\quad -\tau\int_0^{\omega_\kappa^I}\frac{b}{1-\lambda\tau^2 b/a}\omega dG(\omega) - \tau\int_{\omega_\kappa^I}^{\omega_\tau^I}\frac{a}{1-\lambda\tau^2}\omega dG(\omega), \end{aligned}$$

where the first term on the right-hand side gives total expenditures on all goods that are imported (i.e., goods produced by firms with $\omega < \omega_\tau^I$); the second term is the total value of goods produced by domestic firms with $\omega < \omega_\kappa^I$ (i.e., by low-productivity firms); and the third term gives the total value of goods produced by domestic firms with $\omega_\kappa^I \leq \omega < \omega_\tau^I$ (i.e., by high-productivity firms with an output that is too small to meet demand at price τ).

Resource constraint. To find an expression for (gross-)capital demand, note first that from (12) and $\rho = a/\tau$ we have $\widetilde{y} = (Y/P)P^\sigma\tau^\sigma\left((\sigma-1)/\sigma\right)^\sigma$ and $\widetilde{\omega} = (1-\lambda(\sigma/(\sigma-1))\left(\widetilde{y}/a\right)$. With these expressions in mind, the credit market equilibrium condition reads

$$\begin{aligned} K &= \int_0^{\omega_\kappa^I} \frac{1}{1-\lambda\tau^2 b/a}\omega dG(\omega) + \int_{\omega_\kappa^I}^{\omega_\tau^I} \frac{1}{1-\lambda\tau^2}\omega dG(\omega) + \int_{\omega_\tau^I}^{\widetilde{\omega}} \frac{\overline{y}^I(\omega)}{a} dG(\omega) \\ &\quad + \int_{\widetilde{\omega}}^{\infty} \frac{\widetilde{y}}{a} dG(\omega) + \tau \frac{EXP}{a}, \end{aligned}$$

where $\overline{y}^I(\omega)$ is implicitly determined by (10'). Using the expression for total exports, EXP, derived above, the equilibrium condition can be rewritten as

$$\begin{aligned} K &= \int_0^{\omega_\kappa^I} \frac{1-\tau^2 b/a}{1-\lambda\tau^2 b/a}\omega dG(\omega) + \int_{\omega_\kappa^I}^{\omega_\tau^I} \frac{1-\tau^2}{1-\lambda\tau^2}\omega dG(\omega) + \int_{\omega_\tau^I}^{\widetilde{\omega}} \frac{\overline{y}^I(\omega)}{a} dG(\omega) \\ &\quad + \frac{1}{a} Y P^{\sigma-1} \tau^{\sigma} \left(\frac{\sigma-1}{\sigma}\right)^{\sigma} [1-G(\widetilde{\omega})] + \frac{1}{a} Y P^{\sigma-1} \tau^{2-\sigma} G(\omega_\tau^I). \end{aligned}$$

The following proposition shows that this condition pins down a unique equilibrium.

Proposition 2 *Suppose that conditions (R2) and (R3) hold and that κ is sufficiently low (in a sense clarified in the proof). Then, there exists a unique macroeconomic equilibrium (i.e., an equilibrium with the values of Y/P and ρ/P uniquely pinned down) where (i) the poorest entrepreneurs use the low-productivity technology; (ii) all poorer entrepreneurs are price-constrained and face import competition; (iii) all richer entrepreneurs set the profit-maximizing price; (iv) the richest entrepreneurs export parts of their output.*

Proof. See Appendix. ■

The properties of this equilibrium are – in addition to the evidence discussed after Proposition 1 – consistent with stylized facts about the relative performance of exporting firms (see, e.g., Bernard et al., 2003). In particular, the firms that export parts of their production tend to be the biggest ones and they are also more productive than the average firm in the economy (since some import-competing small firms use the low-productivity technology). Moreover, to the extent that the set of richest entrepreneurs is relatively small, exporting firms are a minority. The mechanism behind these implications is, however, entirely different from the one in the standard models of trade and heterogeneous firms (i.e., Bernard et al., 2003; Melitz, 2003). Here, in an environment characterized by credit market frictions and inequality, it is the initial capital endowment that determines whether an entrepreneur can access the resources required to operate the high-productivity technology and to enter export markets. This is consistent with empirical findings suggesting that credit-rationed firms have a lower probability of being exporters (e.g., Minetti and Zhu, 2011) and that credit-rationing reduces the predictive power of firm productivity for a firm's export status (e.g., Caggese and Cunat, 2013).

4.2.3 The Impact of Lower Trade Costs on Real Output

A fall in trade costs affects aggregate real output through three different channels, two negative and one positive. We now introduce and discuss these channels. Section 4.3 below will then focus on their relative strength and establish two analytical results (Propositions 3 and 4); Section 4.3 will also present findings from a quantitative exercise.

Here we start by stating how much capital price-constrained firms (i.e., import-competing entrepreneurs with $\omega_\tau^I < \omega$) invest in the intermediate-trade-costs equilibrium described by Proposition 2. Taking into account that $\rho = a/\tau$, equation (10') immediately implies

$$k(\omega)|_{\omega<\omega_\tau^I} = \frac{1}{1-\lambda\tau^2 q/a}\omega, \quad q \in \{a,b\}, \tag{18}$$

where $q = b$ if $\omega < \omega_\kappa^I$ (low-productivity firms) and $q = a$ otherwise (high-productivity firms).

With this in mind, we now turn to the first adverse channel by which a fall in trade costs affects Y/P. This channel is associated with the impact of trade costs on the minimum wealth level required to operate the high-productivity technology, ω_κ^I. Because $\omega_\kappa^I = \left(1-\lambda\tau^2\right)\kappa$ is negatively related to τ, a fall in trade costs increases the mass of firms using the low-productivity technology, $G(\omega_\kappa^I)$. This result is a consequence of the credit-market imperfection. As τ shrinks, the maximum price that can be demanded by the price-constrained firms decreases while the cost of borrowing ($\rho = a/\tau$) increases. As a result, mark-ups – and hence profit margins – shrink, implying that these firms face a reduction in the collateral they can put up. Less collateral, in turn, implies a lower borrowing capacity so that some additional firms become unable to meet the κ-threshold. In what follows, we call this effect *polarization effect* as it reinforces the (preexisting) polar structure of the economy, i.e., the coexistence of small low-productivity and large high-productivity firms.

While the polarization effect leads to a fall in unweighted average firm productivity, it does not necessarily imply a reduction in capital-weighted average productivity: Because preexisting low-productivity firms experience a decline in their ability to borrow as well, they are forced to invest less. The share of capital invested in low-productivity firms is given by

$$\beta = \int_0^{\omega_\kappa^I} k(\omega)|_{\omega<\omega_\tau^I}\, dG(\omega)/K = \frac{1}{1-\lambda\tau^2 b/a} \int_0^{(1-\lambda\tau^2)\kappa} \omega dG(\omega)/K,$$

where the second equal sign makes use of equation (18) and of $\omega_\kappa^I = \left(1-\lambda\tau^2\right)\kappa$. Clearly, the sign of the impact of lower trade costs on the above expression – and hence on capital-weighted average productivity – depends on the parameters of the model and on the mass of entrepreneurs at ω_{κ}^{I}. If the latter is sufficiently large, a gradual reduction in trade costs implies that a larger fraction of the capital stock is used in low-productivity firms. Put differently, in this case, the pro-competitive effects of trade impair, rather than improve, capital-weighted average firm productivity. The quantitative exercise in the following subsection shows that such a negative impact of a falling τ on capital-weighted average firm productivity can be observed over a broad range of trade costs. To summarize:

Lemma 5 (Polarization effect) *In the equilibrium described in Proposition 2, a fall in trade costs τ (i) increases the number of firms $G(\left(1-\lambda\tau^{2}\right)\kappa)$ using the low-productivity technology; (ii) may reduce capital-weighted average firm productivity.*

Proof. In text. ■

The second adverse channel, which we call *replacement effect*, is again related to the credit-market imperfection. As discussed above, a fall in τ forces the price-constrained firms – high- and low-productivity alike – to invest less, which can be seen from equation (18). As a result, the domestic output of goods produced by price-constrained firms falls, whereas the domestic demand for goods produced by those firms rises because of the lower limit price τ. The loss of output produced by price-constrained firms must be replaced with additional imports from abroad (which also cover any increase in demand);[14] at the same time, absorbing capital no longer employed by the price-constrained firms, large companies increase their output and send more goods abroad, thereby keeping trade balanced. These adjustments are a source of inefficiency as they may force the economy to spend more, rather than less, resources on transportation costs in response to a fall in τ. To summarize:

Lemma 6 (Replacement effect) *In the equilibrium described in Proposition 2, a fall in trade costs τ reduces the output by price-constrained firms. The resulting additional shortfall of domestic production relative to demand will be met by imports.*

Proof. In text. ■

On the other hand, a fall in τ exerts a positive effect on Y/P by reducing the dispersion of prices in the southern economy. The lower end of the price range is marked by $p(\widetilde{y})$, the price charged by firms that are not credit constrained. According to equation (17), $p(\widetilde{y}) = (1/\tau)(\sigma/(\sigma-1))$. The highest price is the limit price τ, charged by price-constrained firms.

[14] This replacement effect is reminiscent of a mechanism discussed in a paper by Brander and Krugman (1983). They show that the rivalry of oligopolistic firms can lead to "reciprocal dumping" (i.e., two-way trade in the same product) and hence to "wasteful" spending on transportation.

So a fall in τ reduces the ratio of the highest to the lowest price, $\tau^2(\sigma-1)/\sigma$, an implication that tends to induce individuals to consume a more balanced goods basket (equation 4).[15] As a result, the variation in the marginal utility of consumption across goods tends to fall and the welfare of the average individual (i.e., aggregate real output, Y/P) tends to rise. Note, however, that we cannot exclude that price dispersion increases locally: When τ falls, prices charged by credit-constrained firms will increase (as long as they are below the limit price τ). Yet, obviously, when the southern economy appraoches full integration, price dispersion must fall and eventually disppear altogether. To summarize:

Lemma 7 (Reduction in price dispersion) *In the equilibrium described in Proposition 2, a fall in trade costs τ reduces the ratio of the highest to the lowest price paid in the economy, thereby (eventually) narrowing down the variation in the marginal utility of consumption across goods.*

Proof. In text. ■

Finally, it is worthwhile to point out that a fall in trade costs does not only affect the level of the aggregate income but also the income distribution, which becomes more polarized. To see this, note that the nominal rate of return in unconstrained firms is a/τ, whereas the rate of return in price-constrained firms is given by $(1-\lambda)\tau b/(1-\lambda\tau^2(b/a))$ if the the low-productivity technology is used; and by $(1-\lambda)\tau a/(1-\lambda\tau^2)$ otherwise. Thus, lowering trade costs increases incomes in the higher parts of the distribution and diminishes those at the bottom. As a result, higher incomes gain disproportionally (which confirms a similar finding in the more parsimonious setting presented in Foellmi and Oechslin, 2010).

4.3 From Autarky to Full Integration

We now broaden our focus and explore how the economy is affected by the three channels when trade costs fall from prohibitive levels to zero. Using the general version of the model, we start by focusing on the impact on the aggregate real output at the point that separates the autarky equilibrium from the neighboring "trade equilibrium" ($\tau=\tau^{AT}$); and at the point where trade costs fall to zero ($\tau=1$). For the rest of the subsection, we then assume that initial capital endowments are distributed according to a Pareto distribution and rely on numerical analysis. This way, we also gain insights into the (relative) size of the different effects.

[15] Note that (R2), the central condition under which Proposition 2 is derived, implies $\tau^2(\sigma-1)/\sigma>1$.

4.3.1 Autarky and Full Integration

$\tau = \tau^{AT}$. Whether the two regions exchange goods in equilibrium is determined by trade costs, other things equal. If τ is so high that even firms with a zero capital endowment ($\omega = 0$) are able to set their constrained-optimal price, there is no trade between North and South. However, as soon as τ turns into a binding maximum price, trade emerges.

The critical threshold below which trade emerges can be calculated explicitly. Consider an autarky equilibrium in which the poorest entrepreneurs (i.e., those with $\omega = 0$) are forced to use the low-productivity technology.[16] The highest price charged in such an equilibrium is $p(\bar{y}(0))$, where $p(\cdot)$ is given by (5) and $\bar{y}(0)$ can be calculated using (10). Given this, we obtain $p(\bar{y}(0)) = \rho/(b\lambda)$. We further know that the rental rate of capital in a trade equilibrium equals a/τ. Thus, at the border between autarky and the neighboring trade equilibrium, we must have $p(\bar{y}(0)) = a/(b\lambda\tau)$. As a result, the critical τ-threshold is given by

$$\tau^{AT} \equiv (a/(b\lambda))^{1/2}.$$

The following proposition establishes how trade costs affect real output at this threshold.

Proposition 3 *Suppose that $\tau = \tau^{AT}$, and consider an equilibrium where entrepreneurs with a zero wealth endowment ($\omega = 0$) use the low-productivity technology. Then, a (marginal) reduction in trade costs, τ, leads to a fall in aggregate real output:*

$$\left.\frac{d(Y/P)}{d\tau}\right|_{\tau=\tau^{AT}} > 0.$$

Proof. See Appendix. ■

Credit market frictions have been shown to attenuate positive effects of trade liberalization (e.g., Peters and Schnitzer, 2015; Brooks and Dovis, 2018). Proposition 3 demonstrates that, in fact, there even exist circumstances in which trade liberalization reduces aggregagte real output. Note that output declines although some smaller firms rely on the low-productivity technology (implying that the supply of goods is particularly uneven). Proposition 3 holds analogously if all firms have access to the high-productivity technology under autarky (as can be shown using an approach similar to the one in the proof of Proposition 3).[17] The negative

[16] This is the case if $\omega_\kappa > 0$. From equation (8) we can conclude that $\omega_\kappa > 0$ is equivalent to $\kappa > (\lambda x)^\sigma a^{\sigma-1}$, where x is an endogenous variable defined in equation (9). From the proof of Proposition 1 we can conclude that x takes a finite value in equilibrium. So, other things equal, $\omega_\kappa > 0$ must hold if λ is sufficiently small. For completeness, we note that it is easy to check that the above condition and condition (11) are compatible as long as the credit market imperfection is relevant, i.e., as long as $\lambda < \sigma/(\sigma - 1)$.

[17] Note further that Proposition 3 does not depend on the assumption that the smallest initial capital endowment is zero (rather than positive) nor on the fact that we impose a continuous endowment distribution (rather than a discrete one). Detailed derivations are available from the authors on request.

impact of trade in the neighborhood of τ^{AT} is due to the fact that the fall in mark-ups forces the smallest firms to downsize substantially: The replacement effect has first-order consequences, while the fall in price dispersion is only a second-order effect.

$\tau = 1$. At the other end of the interesting spectrum of trade costs, the southern goods market is fully integrated into the northern one. Prices and marginal costs are equal to one, and we have $\rho = a$. Given this, only the high-productivity technology is used, while firm profits are equal to zero (implying indifference between running a firm and lending). According to (16), the initial capital endowment that just allows an entrepreneur to operate the high-productivity technology, ω_κ^I, is given by $\kappa(1 - \lambda) > 0$. So any agent with $\omega \geq \omega_\kappa^I$ may run a firm, and – given that the agent decides to do so – the size of her investment falls in the range $[\kappa, \omega(1 - \lambda)^{-1}]$, where the upper bound is a consequence of the credit market friction. Goods for which domestic supply falls short of demand (or goods that cannot be produced in the South at all) are imported from the North. Yet, since trade costs are zero, this does not lead to any inefficiency. Aggregate real output is thus at its maximum level: $Y/P = aK$.

Starting from this first-best situation, a marginal rise in trade costs must have a negative impact on the aggregate real output. Since a positive mass of goods must be imported, a rise in τ (from 1) means that the fraction of resources spent on trade costs, rather than on producing output, increases from zero to a positive level. Consequently, the first-best output can no longer be attained. We can therefore state the following result:

Proposition 4 *Suppose that $\tau = 1$, so that the aggregate real output takes its first-best level, aK. Then, a (marginal) increase in trade costs, τ, leads to a fall in aggregate real output:*

$$\left.\frac{d(Y/P)}{d\tau}\right|_{\tau=1} < 0.$$

Proof. In text. ∎

4.3.2 Partial Integration: A Quantitative Exercise

If τ is in between the two polar values τ^{AT} and 1, the consequences of falling trade costs depend on the distribution of initial capital endowments, $G(\omega)$, and on the choice of parameter values (see the discussion in Subsection 4.2.3). As for capital endowments, we assume from now on that they are distributed according to a Pareto distribution. In the literature on inequality, there is a long tradition of using the Pareto law to describe wealth or income distributions, in particular when it comes to the right tail (see, e.g., Atkinson et al., 2011). Our choice of parameter values is based on data from India, a country that went through an extensive trade liberalization episode in the 1990s (see, e.g., Topalova and Khandelwal, 2011).

The baseline parametrization is as follows. To come up with a value for the inverted Pareto coefficient, which is set equal to 1.81, we rely on Davies et al. (2011) who provide detailed wealth-distribution data for a number of countries, among them India.[18] Following Moll (2014), the parameter λ is chosen so that the maximum leverage ratio in absence of market power, $1/(1-\lambda)$, is 1.2 (Moll relies on data from Beck et al., 2000, to obtain an estimate for the Indian maximum leverage ratio). This gives us $\lambda = 0.17$. Under the baseline parametrization, a λ of 0.17 will imply a credit-to-GDP ratio of 0.19 in the autarky equilibrium, a value that – according to the World Development Indicators, WDI – is close to those observed in India in the 1980s (i.e., before the start of the liberalization process in the early 1990s). Our choice for the ratio of "physical productivities", a/b, is guided by Hsieh and Klenow (2009) who study the extent of factor misallocation in several countries, among them India. To discipline our choice of a/b, we rely on Hsieh and Klenow's Table I which provides information on the distribution of physical productivity (TFPQ). This information allows us to come up with estimates of productivity ratios.[19] As the productivity ratio is an important determinant of the size of the efficiency loss caused by credit market frictions, we take a conservative approach. Our baseline choice is $a/b = 1.50$. This ratio is conservative in the sense that it reflects productivity differentials between firms which are close to the median of the distribution: 1.33 and 1.77 correspond to the 55th-to-45th and 60th-to-40th percentile ratio, respectively, while 1.50 corresponds to the percentile ratio that is exactly in between. However, alongside the baseline simulation results, we will provide results based on 1.33 and 1.77, too.

The baseline value of κ is 0.8. This corresponds to an "intermediate" level: $\kappa = 0.8$ implies that, in equilibrium, (i) there exist constrained entrepreneurs that are forced to use the low-productivity technology for some levels of trade costs; (ii) all unconstrained entrepreneurs use the high-productivity technology (i.e., $\omega_\kappa^I < \widetilde{\omega}$ for all values of trade costs). Regarding the elasticity of substitution, we follow the literature (e.g., Hsieh and Klenow, 2009) and use $\sigma = 3$ for the baseline simulations. Finally, we normalize both K and a to unity. These normalizations imply that the first-best level of the aggregate real output is equal to unity, too. Table 2 shows

[18]For any arbitrary level ω^*, the inverted Pareto coefficient is the ratio of average capital of individuals with $\omega \geq \omega^*$ to ω^*. Using standard methods, we determine the inverted Pareto coefficient by using the top-5% and the top-1% wealth share (38.3% and 15.7%, respectively) listed in Table 5 of Davies et al. (2011).

[19]Hsieh and Klenow (2009) report the 75th-to-25th percentile ratio for various years. We use the number for 1987 (which is 4.71) to parameterize a Pareto distribution, which is then used to calculate different percentile ratios. Assuming that productivities follow a Pareto distribution is a usual approach in the literature.

the baseline simulation results, together with results that are based on the above-mentioned alternative values for the (a/b)-ratio. To assess the robustness of our baseline simulations, and to gain insights into the relative strength of the different effects, Tables 3 to 5 show simulation results that are based on alternative values of κ, σ, and λ, respectively.

Table 2 here

Columns (1), (3), and (5) of Table 2 show how aggregate real output adjusts in response to a gradual fall in trade costs from a prohibitive level ($\tau \geq \tau^{AT}$) to zero ($\tau = 1$). Under all three parametrizations considered, as τ decreases, Y/P first monotonically falls to a global minimum before it starts to approach its first-best level of 1. Relative to the autarky level, the maximum loss in terms of aggregate real output is about 5.5 percentage points if the (a/b)-ratio takes its baseline value of 1.50 (the corresponding numbers for the two alternative ratios are comparable). We consider this to be a significant effect, not least because we use a conservative (a/b)-ratio. It is further worthwhile to note that, for Y/P to return to its autarky level, τ must fall to a level of less than 1.05. This means that the two harmful pro-competitive effects – the polarization effect and the replacement effect – dominate the gains associated with a falling price dispersion (beneficial pro-competitive effect) over a broad range.

Columns (2), (4), and (6) of Table 2 indicate the share of capital invested in low-productivity firms, β. As discussed in Subsection 4.2.3, the impact of falling trade costs on β is ambiguous: The polarization effect increases the number of firms using the less productive technology, while the tightening of borrowing constraints reduces investment by the existing low-productivity firms. However, for all parametrizations considered, the picture is very similar: As τ falls, β increases until τ reaches a critical point below which the low-productivity firms go out of business and choose to become lenders instead. Table 2 indicates that this point is reached later if the productivity ratio takes a lower value (if $a/b = 1.50$, the critical point is at $\tau = 1.5^{1/2}$). In sum, relying on parameter values informed by Indian data, our quantitative exercise demonstrates that a gradual increase in competitive pressure (i.e., a gradual decrease in τ) may reduce, rather than improve, capital-weighted average firm productivity.

Table 3 here

In Table 3, we consider different values of κ (ranging from 60% to 90% of average capital holdings). The general pattern in the table is that, for a given value of τ, a higher level of κ is associated with a lower level of aggregate real output and a higher share of capital invested in low-productivity firms. This pattern reflects that the importance of credit constraints increases in the critical scale of investment. Table 3 can also be used to gauge the relative strength of the three different effects we identfiy in the theoretical model. First consider the simulations based on $\kappa = 0.6$. In this case, all entrepreneurs have access to the high-productivity technology irrespective of the value of τ; as a result, the polarization effect is absent. Moreover, if $\tau > 1.30$, the autarky equilibrium prevails, implying that the replacement effect is absent, too. So the difference between autarky aggregate real output (0.9970) and first-best aggregate real output (1) represents the pure price dispersion effect (i.e., the fact that prices and consumption levels are not equalized across varietes). As we can see, this effect is of minor quantitative importance. When τ passes the 1.30-threshold from above, Y/P starts to decline although price dispersion tends to fall. This is due to the negative replacement effect which, initially, outweighs the gains from a falling dispersion of prices. However, if $\tau < 1.5^{1/2} = 1.22$, the replacement effect is sufficiently weak so that a further fall in τ increases aggregate real output.[20]

Table 3 also illustrates how the two harmful pro-competitive effects may interact. Consider, for instance, the simulations based on $\kappa = 0.9$. When τ falls from 1.25 to 1.20, the harmful polarization effect disappears because all firms that would be forced to operate the low-productivity technology go out of business and choose to become lenders instead (i.e., the share of capital invested in low-productivity firms falls from 26.24% to 0%). However, aggregate real output hardly changes. The reason is that the harmful replacement effect gains in strength: The varieties that are no longer produced by the closed firms must now be imported from the North entirely – although trade costs are still relatively high. For the parametrization considered, it turns out that the strengthening of the replacement effect balances the disappearance of the polarization effect near-perfectly (the same holds for $\kappa = 0.9$).

Tables 4 and 5 here

In Tables 4 and 5, we look at different values of σ and λ, respectively. A larger σ implies that varieties are more easily substitutable. This affects aggregate real output through two different channels, one negative and one positive. On the one hand, a rise in σ reduces markups and thus profits; since profits serve as a "collateral", smaller firms are forced to downsize, and so the share of capital invested in low-productivity firms rises. On the other hand, a rise in σ means that any given dispersion in prices (and hence consumption levels) has smaller welfare consequences. The existence of countervailing effects explains why the simulation results for

[20] An indication of the strength of the replacement effect can also be gained by moving from left to right in any row of the table for which $\tau < 1.5^{1/2} = 1.22$ (as the polarization effect is absent and price dispersion hardly changes when τ is constant). Consider, for instance, the case $\tau = 1.20$: As κ rises from 0.6 to 0.9, the polarization effect reduces aggregate real output from 0.9717 to 0.8605.

Y/P are relatively stable when σ rises from its baseline value of 3 to 4 and then 5. By contrast, changes in the level of λ – Table 5 works with the values 0.15, 0.17, and 0.20 – have sizable quantitative implications. The reason is that smaller firms enjoy much better access to credit when λ rises. Consider, for instance, the autarky equilibrium (which prevails irrespective of the value of λ if τ is 1.45 or larger). While the share of capital invested in low-productivity firms exceeds 10% if $\lambda = 0.15$, this share is zero if $\lambda = 0.20$.

We finally link our simulation results to adjustments observed in India in the early 1990s. In 1991, the average output tariff in India was still very high. However, between 1991 and 1994, it fell by about one third (according to Topalova and Khandelwal, 2011, Table 1). With regard to this period, Hsieh and Klenow (2009) report two surprising facts. *First*, the ratio of actual aggregate output to "efficient" output fell from about 49% in 1991 to 44% in 1994, implying a decline in allocative efficiency.[21] *Second*, between 1991 and 1994, there was an increase in the standard deviation of physical productivities (TFPQ) across firms. Interpreting a fall in τ as a decline in tariffs, our simulations generate similar outcomes in qualitative terms. Starting from an initial tariff rate close to, but below, the autarky level, a substantial decline in tariffs – e.g., one of about one third, from $\tau = 1.40$ to $\tau = 1.25$ – reduces aggregate real output according to all three parametrizations considered in Table 2. As a result, in all three cases, the ratio of aggregate real output to first-best aggregate real output falls. Moreover, for the case $a/b = 1.50$, we observe that such a tariff cut increases the share of capital invested in low-productivity firms from 5% to about 9%. As a result, the capital-weighted standard deviation of physical productivity increases. So, while the surprising empirical pattern documented for India by Hsieh and Klenow (2009) is hard to replicate in standard heterogeneous-firms models, our simulations suggest that it may arise naturally in the present model.

4.4 Discussion of Alternative Assumptions

When deriving the implications of trade between the North and the South, a simplifying assumption so far has been that the two regions produce the same spectrum of goods. We now briefly discuss how robust the model's implications are to alternative assumptions regarding the northern goods spectrum. We consider two alternative modifications in turn.

[21] These two numbers can be calculated from the information provided in Hsieh and Klenow's (2009) Table IV. In their multiple-sector and multiple-distortions model, efficient output is attained if – due to the absence of any distortions – the revenue productivity (TFPR) is equalized across firms within each sector. In our one-sector model, efficient output (i.e., the output generated in absence of any credit market distortions) is equal to one under the current choice of parameters.

The first alternative assumption is that the range of goods produced in the South forms a subset of a broader set of goods produced in the North. In this case, since the utility function exhibits love for variety, the positive channel by which a fall in trade costs affects aggregate real output (reduction in price dispersion) is quantitatively stronger. In qualitative terms, however, a fall in trade costs has similar effects as in the baseline model. In particular, as τ shrinks, the maximum price that can be demanded by the price-constrained entrepreneurs decreases while the cost of borrowing ($\rho = a/\tau$) increases. Both effects tighten the financial constraints of smaller firms and hence raise the minimum level of initial capital required to operate the high-productivity technology. As a result, as is the case in the baseline model, the share of firms using the low-productivity technology will increase when trade costs fall.

Quite a distinct situation arises when North and South produce different goods (so that the northern spectrum complements the southern one) and northern firms, just as their southern counterparts, have some degree of monopoly power. In this polar case, a reduction in trade costs does not affect demand elasticities – and hence does not lead to more competitive pressure in the South. Moreover, all firms have the opportunity to export parts of their production. Consequently, for financially constrained southern firms, the pledgeable income will be larger than in the baseline setup (where southern demand becomes perfectly elastic if a price reaches τ). On the other hand, as is the case in the baseline setup, a fall in trade costs raises the value marginal product of capital and hence the cost of borrowing. The former effect (rise in pledgeable income) loosens borrowing constraints, while the latter one (higher borrowing costs) tightens them. One can show that the net effect on the borrowing capacity of credit-constrained firms is exactly zero.[22] As a result, if southern firms retain their monopoly power, the share of firms using the low-productivity technology remains unchanged when τ falls, as does the share of capital invested by low-productivity firms.

Note, however, that these results are only obtained in the polar case in which demand elasticities are completely unaffected by a reduction of trade costs. In an intermediate case, in which a fall in τ increased demand elasticities gradually (e.g., because northern goods are imperfect substitutes for southern ones), the pledgeable income would rise less sharply. As a result, the net effect of a fall in τ on the borrowing capacity of credit-constrained firms would no longer be zero but negative as in the baseline model. So, yet again, a reduction of trade costs would raise the share of firms using the low-productivity technology, thereby possibly reducing average firm productivity and the aggregate real output.

[22] Detailed derivations are available from the authors upon request.

5 Conclusion

We study the macroeconomic implications of trade liberalization in an economy that features three basic elements: Credit market frictions, technology choice, and some degree of monopoly power in the goods markets. In contrast to much of the recent literature, which primarily emphasizes beneficial pro-competitive effects of trade, we find that a partial integration into world markets may worsen the allocation of production factors and reduce overall output. The reason is that a partial integration lowers mark-ups and hence the borrowing capacity of the less affluent entrepreneurs. So, for small or medium-sized firms, lower trade barriers mean less access to external financing, a prediction we substantiate using a recent firm-level dataset covering seven Latin American countries.

In our model, a deterioration in the access to credit affects economic performance through two different channels. First, while not driven out of the market, some smaller firms are forced to switch to a less productive technology (polarization effect). Second, the loss in output generated by the smaller firms must be compensated through higher imports (replacement effect) – which requires the economy to spend more on trade-related costs. These changes in the use of technologies and firm sizes are also reflected in the income distribution: While the owners of smaller firms lose, the most affluent entrepreneurs win substantially – which implies that incomes are less equally distributed.

The result that in the present setup the aggregate output may fall in response to a gradual reduction of trade costs is an illustration of the theorem of the second best. The literature has shown that reducing trade barriers may lead to losses if the result is an even sharper deviation of the actual output distribution from the undistorted one (e.g., Bhagwati, 1971). We show that credit market frictions may be responsible for such harmful adjustments. Lower trade barriers tighten the borrowing constraints faced by smaller firms and force them to invest less, thereby increasing the extent of "under-production". On the other hand, absorbing capital no longer employed by the constrained small firms, large firms increase their output – which means even more "over-production" by these firms.

While we show that the pro-competitive effects of international trade may be harmful in economies characterized by significant financial frictions, our analysis does not suggest that such economies should stay away from trade liberalization. Such a conclusion would be inappropriate for at least three reasons. First, our model does not allow trade to provide benefits through channels other than a more balanced provision of goods. Second, we find that an opening of trade may be harmful only if it is incomplete. A reform that brings trade costs close to zero will always be beneficial. Third, even a modest reduction in trade barriers could be helpful if it were implemented together with complementary reforms.[23] Since the negative pro-competitive effects of a partial trade liberalization come from tighter credit constraints, the complementary measures should concentrate on the credit market. One option would be to improve credit contract enforcement. If the improvement were sufficiently strong, the borrowing constraints faced by small firms would ease even though mark-ups shrink.

A significant improvement in the quality of credit contract enforcement may be difficult to achieve, though. It would require substantial institutional reform (such as the introduction of India-style Debt Recovery Tribunals) and hence be very time-consuming or infeasible. There is, however, a less ambitious alternative. Since a firm's borrowing capacity is negatively related to the rental rate of capital, introducing a subsidized-credit scheme for constrained firms would have a very similar effect. The subsidy could be financed through an income tax which has upon introduction welfare costs of second order only (in the present framework it would not lead to any further distortions at all). It is finally worthwhile to note that our analysis, relying on a general equilibrium framework with technology choice, suggests that smaller firms should be the target of subsidized-credit schemes. The related trade and finance literature, which primarily emphasizes fixed costs of entering foreign markets, would rather suggest that such programs should be directed towards big export-oriented companies.

[23] A sizeable reduction might be infeasible because the remoteness of the place implies high trade costs even if tariffs are negligible; or the lack of a tax bureaucracy means that the state is forced to rely on trade taxes.

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APPENDIX: PROOFS

Proof of Proposition 1. (i) We focus first on the case $\lambda < (\sigma-1)/\sigma$ (credit rationing). In order to establish that there is a unique macroeconomic equilibrium, we proceed in two steps. We first show the existence of a unique equilibrium value of x. In a second step, we prove then that Y/P and ρ/P are uniquely pinned down.

To achieve the first step, observe that the equilibrium value of x must solve $K^D(x) = K$, where $K^D(x)$ is given by (14). Suppose now that x is exactly equal to the threshold given in (11). Then, $\widetilde{y}(x)/a$ is equal to κ whereas both $\overline{y}(\omega;x)/a$ (with $\omega \in [\omega_\kappa, \widetilde{\omega})$) and $\overline{y}(\omega;x)/b$ (with $\omega < \omega_\kappa$) are strictly smaller than κ. As a result, K^D must also be strictly smaller than κ. Moreover, since $\kappa < K$ due to (R1), we have $K^D < K$. Assume now that $x \to \infty$. Obviously, under these circumstances, we have $K^D \to \infty > K$. Finally, to show that there is a unique value that solves the equilibrium condition $K^D(x) = K$, we now establish that K^D increases monotonically as x rises from the threshold in (11) to infinity. Expressions (10) and (12) imply that both $\overline{y}(\omega;x)$ and $\widetilde{y}(x)$ are monotonically increasing in x. Moreover, the threshold ω_κ falls in x which reinforces the increase in capital demand since

$$\left[\frac{\overline{y}(\omega_\kappa^-)}{b} - \frac{\overline{y}(\omega_\kappa^+)}{a}\right] g(\omega_\kappa)\frac{d\omega_\kappa}{dx} \geq 0.$$

Thus, we have $K^D(x)/dx > 0$, and the proof of the first step is complete.

To show also that ρ/P (and hence Y/P) is uniquely pinned down, we make use of the CES price index. The first step is to find an expression for the price associated with an output level $\widetilde{y}$. To do so, we apply the expressions for x and $\widetilde{y}$ in (5) and get $p(\widetilde{y}) = (\rho/a)(\sigma/(\sigma-1))$. With this expression in mind, the definition of the CES price index implies

$$P^{1-\sigma} = \int_0^{\widetilde{\omega}} [p(\overline{y}(\omega))]^{1-\sigma}\, dG(\omega) + \left[\frac{\sigma}{\sigma-1}\frac{\rho}{a}\right]^{1-\sigma} [1-G(\widetilde{\omega})]. \tag{19}$$

Then, relying again on (5) to substitute for $p(\overline{y}(\omega))$, we eventually obtain

$$\left(\frac{\rho}{P}\right)^{\sigma-1} = \int_0^{\widetilde{\omega}(x)} x^{1-\sigma}\, [\overline{y}(\omega;x)]^{(\sigma-1)/\sigma}\, dG(\omega) + \left[\frac{\sigma}{\sigma-1}\frac{1}{a}\right]^{1-\sigma} [1-G(\widetilde{\omega}(x))],$$

which pins down the real rental rate of capital ρ/P as a function of x.

(ii) Assume now that $\lambda \geq (\sigma-1)/\sigma$ (no credit rationing). In this situation, all firms produce $\widetilde{y}$ and hence invest $\widetilde{y}/a$ capital units (recall $\kappa < K$). As a result, (gross-)capital demand is given by $\int_0^\infty (\widetilde{y}/a)\, dG(\omega) = (Y/P)a^{\sigma-1}(\rho/P)^{-\sigma}((\sigma-1)/\sigma)^\sigma$. Moreover, since all firms invest $\widetilde{y}/a$, we must have that $K = \widetilde{y}/a$ – which implies $Y/P = aK$ (equation 6). Hence, the equilibrium rental rate of capital is determined by $aKa^{\sigma-1}(\rho/P)^{-\sigma}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma} = K$,which results in

$$\frac{\rho}{P} = a\frac{\sigma-1}{\sigma}.$$

Proof of Proposition 2. To start the proof, we introduce a number of definitions. First, we define $z \equiv P^{\sigma-1}Y$ so that (i) $p(y)$ given in (5) reads $p(y) = z^{1/\sigma}y^{-1/\sigma}$; (ii) we have $x = (\tau/a)z^{1/\sigma}$. Second, it is convenient to introduce $\underline{z}$ which is the value of z that makes $p(a\kappa)$ equal to τ. Hence, we have $\underline{z} = (a\kappa)\tau^{\sigma}$. Thirdly, we write capital demand as a function of z:

$$\begin{aligned} K^D(z) &= \int_0^{\omega_\kappa^I} \frac{1-\tau^2 b/a}{1-\lambda\tau^2 b/a}\omega dG(\omega) + \int_{\omega_\kappa^I}^{\omega_\tau^I} \frac{1-\tau^2}{1-\lambda\tau^2}\omega dG(\omega) + \int_{\omega_\tau^I}^{\widetilde{\omega}} \frac{\overline{y}^I(\omega;z)}{a} dG(\omega) \\ &\quad + \frac{1}{a}z\tau^{\sigma}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}[1-G(\widetilde{\omega}_I)] + \frac{1}{a}z\tau^{2-\sigma}G(\omega_\tau^I). \end{aligned}$$

Finally, note that $\overline{y}^I(\omega;z)$ is increasing in z and that $\omega_\kappa^I = \omega_\tau^I$ if $z = \underline{z}$.

We now show that – if κ is sufficiently low – $K^D(z) = K$ uniquely pins down z. The first step is to observe that, as z rises from $\underline{z}$ to infinity, $K^D(z)$ monotonically increases (to calculate the derivative note that marginal changes in ω_τ^I and $\widetilde{\omega}$ leave K^D unaffected), where $\lim_{z\to\infty} K^D(z) = \infty$. The second step is to establish that $K^D(\underline{z}) < K$ if κ is sufficiently low. Since the first term in the above expression is negative and – at $z = \underline{z}$ – the second one is zero, we have

$$K^D(\underline{z}) < \int_{\omega_\tau^I}^{\widetilde{\omega}} \frac{\overline{y}^I(\omega;\underline{z})}{a} dG(\omega) + \frac{1}{a}\underline{z}\tau^{\sigma}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}[1-G(\widetilde{\omega})] + \frac{1}{a}\underline{z}\tau^{2-\sigma}G(\omega_\tau^I).$$

Moreover, using $\underline{z} = (a\kappa)\tau^{\sigma}$ and taking into account that $\overline{y}^I(\omega;z) \leq \widetilde{y} = \underline{z}\tau^{\sigma}\left((\sigma-1)/\sigma\right)^{\sigma}$ gives us

$$K^D(\underline{z}) < \kappa\left(\frac{\tau^2}{\sigma/(\sigma-1)}\right)^{\sigma}[1-G(\omega_\tau^I)] + \kappa\tau^2 G(\omega_\tau^I).$$

Note that the right-hand side (RHS) of the above expression depends only on exogenous parameters (and the distribution of ω). Thus, if $\kappa < K/\max\left\{\left(\tau^2(\sigma-1)/\sigma\right)^{\sigma}, \tau^2\right\}$, we have $K^D(\underline{z}) < K$. Moreover, since $K^D(z)$ monotonically increases in z (and is unbounded), there exists a unique z which satisfies $K^D(z) = K$.

As in the proof of Proposition 1, the final step is to show that Y/P is uniquely pinned down (given that there is a unique z). To do so, we exploit again the CES price index which – in this case – can be written as

$$P^{(1-\sigma)} = \tau^{1-\sigma}G(\omega_\tau^I) + \int_{\omega_\tau^I}^{\widetilde{\omega}} \left[p(\overline{y}^I(\omega;z))\right]^{1-\sigma} dG(\omega) + \left[\frac{\sigma}{\sigma-1}\frac{1}{\tau}\right]^{1-\sigma}[1-G(\widetilde{\omega})].$$

Note that $\overline{y}^I(\omega;z)$ as well as the thresholds ω_τ^I and $\widetilde{\omega}$ are functions of z (and the exogenous parameters of the model). As a result, P – and hence $Y/P = zP^{-\sigma}$ – are uniquely determined.

Proof of Proposition 3. To start with, consider an equilibrium where a positive mass of the poorest entrepreneurs uses the low-productivity technology. Moreover, suppose that a positive fraction of these low-productivity firms are price-constrained. Using an approach similar to the one chosen in Section 4.2, we can derive the credit market equilibrium condition that is relevant for this type of equilibrium:

$$\begin{aligned} K &= \int_0^{\omega_\tau^I} \frac{1-\tau^2 b/a}{1-\lambda\tau^2 b/a}\omega dG(\omega) + \int_{\omega_\tau^I}^{\omega_\kappa^I} \frac{\overline{y}^I(\omega)}{b} dG(\omega) + \int_{\omega_\kappa^I}^{\widetilde{\omega}} \frac{\overline{y}^I(\omega)}{a} dG(\omega) \\ &\quad + \frac{1}{a} Y P^{\sigma-1}\tau^\sigma \left(\frac{\sigma-1}{\sigma}\right)^\sigma [1-G(\widetilde{\omega})] + \frac{1}{a} Y P^{\sigma-1}\tau^{2-\sigma} G(\omega_\tau^I). \end{aligned}$$

In what follows, we will use the definition $v \equiv YP^{\sigma-1}\tau^\sigma$. Applying this definition, and using the fact that $\rho = a/\tau$, the function $\overline{y}^I(\omega)$ in the above equation is implicitly defined by

$$\overline{y}^I(\omega) = \begin{cases} b\omega + \lambda \left[\overline{y}^I(\omega)\right]^{\frac{\sigma-1}{\sigma}} v^{\frac{1}{\sigma}} b/a & : \quad \omega_\tau^I \le \omega < \omega_\kappa^I \\ a\omega + \lambda \left[\overline{y}^I(\omega)\right]^{\frac{\sigma-1}{\sigma}} v^{\frac{1}{\sigma}} & : \quad \omega_\tau^I < \omega_\kappa^I \le \omega \end{cases},$$

where the level of wealth at which the credit constraint becomes binding, ω_κ^I, is given by $\omega_\kappa^I = \kappa(1-\lambda(v/a\kappa)^{1/\sigma})$. The level of wealth at which the price constraint becomes relevant, ω_τ^I, is given by $\omega_\tau^I = P^{\sigma-1}Y\tau^{-\sigma}\left(b^{-1}-\lambda\tau/\rho\right)$. Using again $\rho = a/\tau$, we get $\omega_\tau^I = P^{\sigma-1}Y\tau^{-\sigma}\left(b^{-1}-\lambda\tau^2/a\right)$ which, in turn, can be rewritten as $\omega_\tau^I = v\tau^{-2\sigma}\left(b^{-1}-\lambda\tau^2/a\right)$. In this context, note further that $\widetilde{y} = v\left((\sigma-1)/\sigma\right)^\sigma$ and, as usual, $\widetilde{\omega} = \left(1-\lambda\sigma/(\sigma-1)\right)\widetilde{y}/a$. Finally, we can rewrite the above credit market equilibrium condition as

$$\begin{aligned} aK &= \int_0^{\omega_\tau^I} a\frac{1-\tau^2 b/a}{1-\lambda\tau^2 b/a}\omega dG(\omega) + \int_{\omega_\tau^I}^{\omega_\kappa^I} a\frac{\overline{y}^I(\omega)}{b} dG(\omega) + \int_{\omega_\kappa^I}^{\widetilde{\omega}} \overline{y}^I(\omega) dG(\omega) \\ &\quad + v\left(\frac{\sigma-1}{\sigma}\right)^\sigma [1-G(\widetilde{\omega})] + v\tau^{2(1-\sigma)} G(\omega_\tau^I). \end{aligned} \tag{20}$$

This is convenient as the endogenous variables enter expression (20) only through v. The same holds for the aggregate real output, Y/P (which is equivalent to welfare, U):

$$\begin{aligned} (Y/P)^{(\sigma-1)/\sigma} &= U^{(\sigma-1)/\sigma} = v^{(\sigma-1)/\sigma}\tau^{2(1-\sigma)} G(\omega_\tau^I) + \int_{\omega_\tau^I}^{\widetilde{\omega}} \overline{y}^I(\omega)^{(\sigma-1)/\sigma} dG(\omega) \\ &\quad + v^{(\sigma-1)/\sigma}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma-1} [1-G(\widetilde{\omega})]. \end{aligned}$$

The change in the aggregate real output (or welfare) in response to a change in trade costs can be decomposed into two parts. There is a direct as well as a general-equilibrium effect:

$$\frac{dU}{d\tau} = \frac{\partial U}{\partial \tau} + \frac{\partial U}{\partial v}\frac{dv}{d\tau}.$$

Taking into account that $\overline{y}^I(\omega_\tau^I) = v\tau^{-2\sigma}$, the two partial derivatives are given by

$$\frac{\partial U}{\partial \tau} = -2(\sigma-1)v^{(\sigma-1)/\sigma}\tau^{2(1-\sigma)-1}G(\omega_\tau^I) < 0$$

and

$$\begin{aligned}\frac{\partial U}{\partial v} \quad &= \quad \frac{\sigma-1}{\sigma}v^{-1/\sigma}\tau^{2(1-\sigma)}G(\omega_\tau^I) + \frac{\sigma-1}{\sigma}\int_{\omega_\tau^I}^{\widetilde{\omega}} \overline{y}^I(\omega)^{-1/\sigma}\frac{\partial \overline{y}^I(\omega)}{\partial v}dG(\omega) \\ &\quad + (b^{(\sigma-1)/\sigma} - a^{(\sigma-1)/\sigma})\kappa^{(\sigma-1)/\sigma}\frac{\partial \omega_\kappa^I}{\partial v} + v^{-1/\sigma}\left(\frac{\sigma-1}{\sigma}\right)^\sigma [1-G(\widetilde{\omega})] > 0,\end{aligned}$$

where the latter derivative is unambiguously positive since $\partial\overline{y}^I(\omega)/\partial v > 0$ and $\partial\omega_\kappa^I/\partial v < 0$. The derivative $dv/d\tau$, on the other hand, can be found by implicitly differentiating the credit market equilibrium condition (20):

$$\frac{dv}{d\tau} = -\frac{2(\lambda-1)\int_0^{\omega_\tau^I} \frac{b\tau}{(1-\lambda\tau^2 b/a)^2}\omega dG(\omega) + 2(1-\sigma)v\tau^{2(1-\sigma)-1}G(\omega_\tau^I)}{\int_{\omega_\tau^I}^{\omega_\kappa^I} \frac{a}{b}\frac{\partial}{\partial v}\overline{y}^I(\omega)dG(\omega) + \int_{\omega_\kappa^I}^{\widetilde{\omega}} \frac{\partial}{\partial v}\overline{y}^I(\omega)dG(\omega) + \left(\frac{\sigma-1}{\sigma}\right)^\sigma[1-G(\widetilde{\omega})] + \tau^{2(1-\sigma)}G(\omega_\tau^I)} > 0.$$

We now move on the final step of the proof which is to determine the sign of $dU/d\tau$ at $\tau = \tau^{AT}$. At this point, the constrained-optimal price of the poorest entrepreneurs (i.e, those with $\omega = 0$) is exactly τ – which implies $\omega_\tau^I = 0$. As a result, we immediately get $\partial U/\partial\tau|_{\omega_\tau^I=0} = 0$ and $\partial U/\partial v|_{\omega_\tau^I=0} > 0$. In order to find the sign of $dv/d\tau|_{\omega_\tau^I=0}$, note that

$$\lim_{\tau\to\tau^{AB}} \int_0^{\omega_{\tau I}} \frac{b\tau}{(1-\lambda\tau^2 b/a)^2}\omega dG(\omega) = -\frac{v}{4}\left(\frac{a}{b\lambda}\right)^{\sigma-1} g(\omega_\tau^I)\frac{\partial\omega_\tau^I}{\partial\tau} > 0$$

and hence $dv/d\tau|_{\omega_\tau^I=0} > 0$. As a result, we conclude that

$$\left.\frac{dU}{d\tau}\right|_{\omega_\tau^I=0} = \left.\frac{d(Y/P)}{d\tau}\right|_{\omega_\tau^I=0} > 0.$$

Proof of Lemma 1. The proof is most easily provided by a graphical argument. Consider the case $\omega < \omega_\kappa$. Whereas the left-hand side (LHS) of equation (10) is linear in $\overline{y}$ starting from zero, the RHS starts at ω and its slope reaches zero as $\overline{y}$ grows very large. Thus, $\overline{y}$ is uniquely determined. An increase in ω shifts up the RHS such that the new intersection of the LHS and the RHS lies to the right of the old one. The analogous argument holds true for $\omega \geq \omega_\kappa$. Finally, the definition of ω_κ implies that $\overline{y}(\omega_\kappa) = a\kappa > b\kappa > \lim_{\omega\to\omega_\kappa^-}\overline{y}(\omega)$. Hence, $\overline{y}(\omega)$ is strictly monotonic in ω.

Proof of Lemma 2. Suppose first $\lambda < (\sigma-1)/\sigma$ so that $\widetilde{\omega} > 0$. Under these circumstances, entrepreneurs with $\omega \in [\omega_\kappa, \widetilde{\omega})$ have access to the efficient technology but their maximum output, $\overline{y}(\omega)$, falls short of $\widetilde{y}$. But this means that, when producing $\overline{y}(\omega)$, the marginal revenue still exceeds marginal costs. Thus, producing the maximum quantity is indeed optimal. On the other hand, entrepreneurs with $\omega \geq \widetilde{\omega}$ will not go beyond $\widetilde{y}$ because, if they chose a higher level, the marginal revenue would be lower than the cost of borrowing (if $\omega < \widetilde{y}/a$) or the income from lending (if $\omega \geq \widetilde{y}/a$). The second part of the claim is obvious and does not require further elaboration.

Proof of Lemma 3. To establish the claim, we show that the marginal revenue at the output level $b\kappa$ is not smaller than the marginal cost associated with the less efficient technology, ρ/b. This implies that for all $y < b\kappa$ marginal revenues strictly exceed marginal costs so that all entrepreneurs with $\omega < \omega_\kappa$ strictly prefer the maximum firm output. The marginal revenue at $y = b\kappa$ is given by $((\sigma-1)/\sigma)P^{(\sigma-1)/\sigma}Y^{1/\sigma}(b\kappa)^{-1/\sigma}$, and so what we have to prove is

$$\begin{aligned} \frac{\sigma-1}{\sigma}P^{(\sigma-1)/\sigma}Y^{1/\sigma}(b\kappa)^{-1/\sigma} &\geq \frac{\rho}{b} \\ \frac{P^{(\sigma-1)/\sigma}Y^{1/\sigma}}{\rho} &\geq \frac{\sigma}{\sigma-1}\frac{1}{b}(b\kappa)^{1/\sigma}. \end{aligned} \tag{21}$$

In order to do so, we will establish a lower bound for the LHS of the second line in the above expression. Note that $((\sigma-1)/\sigma)P^{(\sigma-1)/\sigma}Y^{1/\sigma}\widetilde{y}^{-1/\sigma} = \rho/a$. Notice further that, in an equilibrium, we must have that $\widetilde{y}/a \geq K$ since there are no firms operating at a higher scale of investment. Thus, we have $((\sigma-1)/\sigma)P^{(\sigma-1)/\sigma}Y^{1/\sigma}(aK)^{-1/\sigma} \geq \rho/a$ or, equivalently,

$$\frac{P^{(\sigma-1)/\sigma}Y^{1/\sigma}}{\rho} \geq \frac{\sigma}{\sigma-1}\frac{1}{a}(aK)^{1/\sigma}.$$

It is now straightforward to check that, due to the parameter restriction (R1), $(1/a)(aK)^{1/\sigma} > (1/b)(b\kappa)^{1/\sigma}$. But this means that (21) must be satisfied.

Tables

***Table* 1** – Motivating evidence: tariff protection and access to finance

	Substantial tariff reduction	No substantial tariff reduction	Substantial tariff reduction	No substantial tariff reduction	Substantial tariff reduction	No substantial tariff reduction
	(1)	(2)	(3)	(4)	(5)	(6)
	All firms		Smaller firms (≤ 100 employees)		Larger firms (> 100 employees)	
Share of firms with *FIN_CONS* = 1 in 2006	0.080	0.123	0.083	0.129	0.071	0.1
Share of firms with *FIN_CONS* = 1 in 2010	0.123	0.113	0.132	0.125	0.095	0.057
Difference estimator (*ΔFIN_CONS*)	0.043	-0.010	0.049	-0.004	0.024	-0.043
	(0.200)	(0.654)	(0.215)	(0.904)	(0.697)	(0.350)
Number of observations	163	381	121	311	42	70
DiD estimator :						
- Country dummies included	0.111**		0.135***		0.006	
	(0.015)		(0.003)		(0.965)	
- Country and industry dummies included	0.125**		0.162**		0.034	
	(0.032)		(0.012)		(0.823)	
Number of observations	544		432		112	

Note: *p*-values in parentheses; *** and ** denote significance at the 1% and 5% level, respectively; the *p*-values are based on *t*-tests with unequal variances (difference estimator) or robust standard errors (difference-in-difference estimator). A substantial tariff reduction is a tariff cut of 0.5 percentage points or more. Tariffs fell by 4.0 percentage points on average—or 30%—in industries which experienced a substantial tariff reduction. The category "smaller firms" includes firms which the WBES classifies as either small (fewer than 20 employees) or medium-sized (fewer than 100, but at least 20, employees).

***Table* 2** – Quantitative exercise: baseline parametrization (a/b = 1.50) and alternative values of the (a/b)-ratio

	a/b = 1.33		a/b = 1.50		a/b = 1.77	
	(1)	(2)	(3)	(4)	(5)	(6)
Trade costs, τ	Y/P	β	Y/P	β	Y/P	β
1.00	1.0000	0.00	1.0000	0.00	1.0000	0.00
1.05	0.9677	0.00	0.9677	0.00	0.9677	0.00
1.10	0.9436	0.00	0.9436	0.00	0.9436	0.00
1.15	0.9279	0.00	0.9279	0.00	0.9279	0.00
1.20	0.9302	12.59	0.9215	0.00	0.9215	0.00
$1.50^{1/2}$	0.9337	10.83	0.9221	10.54	0.9221	0.00
1.25	0.9493	8.89	0.9392	8.64	0.9361	0.00
1.30	0.9716	5.77	0.9620	5.91	0.9531	0.00
1.35	0.9787	5.26	0.9693	5.39	0.9575	5.56
1.40	0.9823	5.05	0.9759	5.04	0.9642	5.20
1.45	0.9823	5.05	0.9769	5.00	0.9695	5.01

Note: Y/P and β refer to the aggregate real output and the share of capital invested in low-productivity firms, respectively. The table shows simulations for three different (a/b)-ratios, stated in the first row. The distribution of capital is assumed to be Pareto (with an inverted Pareto coefficient of 1.81). The remaining parameter values are as follows: λ = 0.17, σ = 3, κ = 0.8, and K = 1. The choice of parameter values is discussed in Subsection 4.3.2. The simulations were carried out in Mathematica; we programmed a routine which performs the numerical integration of an implicitly defined function.

***Table* 3** – Quantitative exercise: alternative values of κ

	κ = 0.6		κ = 0.7		κ = 0.8		κ = 0.9	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Trade costs, τ	*Y/P*	β	*Y/P*	β	*Y/P*	β	*Y/P*	β
1.00	1.0000	0.00	1.0000	0.00	1.0000	0.00	1.0000	0.00
1.05	0.9893	0.00	0.9853	0.00	0.9677	0.00	0.9544	0.00
1.10	0.9811	0.00	0.9798	0.00	0.9436	0.00	0.9160	0.00
1.15	0.9753	0.00	0.9753	0.00	0.9279	0.00	0.8846	0.00
1.20	0.9717	0.00	0.9717	0.00	0.9215	0.00	0.8605	0.00
$1.50^{1/2}$	0.9707	0.00	0.9707	0.00	0.9221	10.54	0.8501	26.24
1.25	0.9817	0.00	0.9817	0.00	0.9392	8.64	0.8547	25.83
1.30	0.9970	0.00	0.9970	0.00	0.9620	5.91	0.8699	25.02
1.35	0.9970	0.00	0.9970	0.00	0.9693	5.39	0.8868	24.18
1.40	0.9970	0.00	0.9970	0.00	0.9759	5.04	0.9035	23.39
1.45	0.9970	0.00	0.9970	0.00	0.9769	5.00	0.9061	23.30

Note: *Y/P* and β refer to the aggregate real output and the share of capital invested in low-productivity firms, respectively. The table shows simulations for four different levels of κ, stated in the first row. The distribution of capital is assumed to be Pareto (with an inverted Pareto coefficient of 1.81). The remaining parameter values are as follows: λ = 0.17, σ = 3, a/b = 1.5, and K = 1. The choice of parameter values is discussed in Subsection 4.3.2. The simulations were carried out in Mathematica; we programmed a routine which performs the numerical integration of an implicitly defined function.

***Table* 4 –** Quantitative exercise: alternative values of σ

	$\sigma = 3$		$\sigma = 4$		$\sigma = 5$	
	(1)	(2)	(3)	(4)	(5)	(6)
Trade costs, τ	Y/P	β	Y/P	β	Y/P	β
1.00	1.0000	0.00	1.0000	0.00	1.0000	0.00
1.05	0.9677	0.00	0.9677	0.00	0.9677	0.00
1.10	0.9436	0.00	0.9436	0.00	0.9436	0.00
1.15	0.9279	0.00	0.9279	0.00	0.9410	0.00
1.20	0.9215	0.00	0.9361	0.00	0.9393	0.00
$1.50^{1/2}$	0.9221	10.54	0.9362	12.45	0.9393	14.60
1.25	0.9392	8.64	0.9418	12.08	0.9417	14.46
1.30	0.9620	5.91	0.9518	11.47	0.9417	14.46
1.35	0.9693	5.39	0.9520	11.46	0.9417	14.46
1.40	0.9759	5.04	0.9520	11.46	0.9417	14.46
1.45	0.9769	5.00	0.9520	11.46	0.9417	14.46

Note: Y/P and β refer to the aggregate real output and the share of capital invested in low-productivity firms, respectively. The table shows simulations for three different levels of σ, stated in the first row. The distribution of capital is assumed to be Pareto (with an inverted Pareto coefficient of 1.81). The remaining parameter values are as follows: $\lambda = 0.17$, $\kappa = 0.8$, $a/b = 1.5$, and $K = 1$. The choice of parameter values is discussed in Subsection 4.3.2. The simulations were carried out in Mathematica; we programmed a routine which performs the numerical integration of an implicitly defined function.

***Table* 5 –** Quantitative exercise: alternative values of λ

	$\lambda = 0.15$		$\lambda = 0.17$		$\lambda = 0.2$	
	(1)	(2)	(3)	(4)	(5)	(6)
Trade costs, τ	*Y/P*	β	*Y/P*	β	*Y/P*	β
1.00	1.0000	0.00	1.0000	0.00	1.0000	0.00
1.05	0.9640	0.00	0.9677	0.00	0.9739	0.00
1.10	0.9353	0.00	0.9436	0.00	0.9579	0.00
1.15	0.9136	0.00	0.9279	0.00	0.9531	0.00
1.20	0.8994	0.00	0.9215	0.00	0.9614	0.00
$1.50^{1/2}$	0.8953	15.42	0.9221	10.54	0.9713	1.78
1.25	0.9083	13.97	0.9392	8.64	0.9913	0.00
1.30	0.9244	12.33	0.9620	5.91	0.9987	0.00
1.35	0.9357	11.57	0.9693	5.39	0.9987	0.00
1.40	0.9471	10.88	0.9759	5.04	0.9987	0.00
1.45	0.9528	10.57	0.9769	5.00	0.9987	0.00

Note: *Y/P* and β refer to the aggregate real output and the share of capital invested in low-productivity firms, respectively. The table shows simulations for three different levels of λ, stated in the first row. The distribution of capital is assumed to be Pareto (with an inverted Pareto coefficient of 1.81). The remaining parameter values are as follows: $\sigma = 3$, $\kappa = 0.8$, $a/b = 1.5$, and $K = 1$. The choice of parameter values is discussed in Subsection 4.3.2. The simulations were carried out in Mathematica; we programmed a routine which performs the numerical integration of an implicitly defined function.

Figures

***Figure* 1** – Maximum firm output

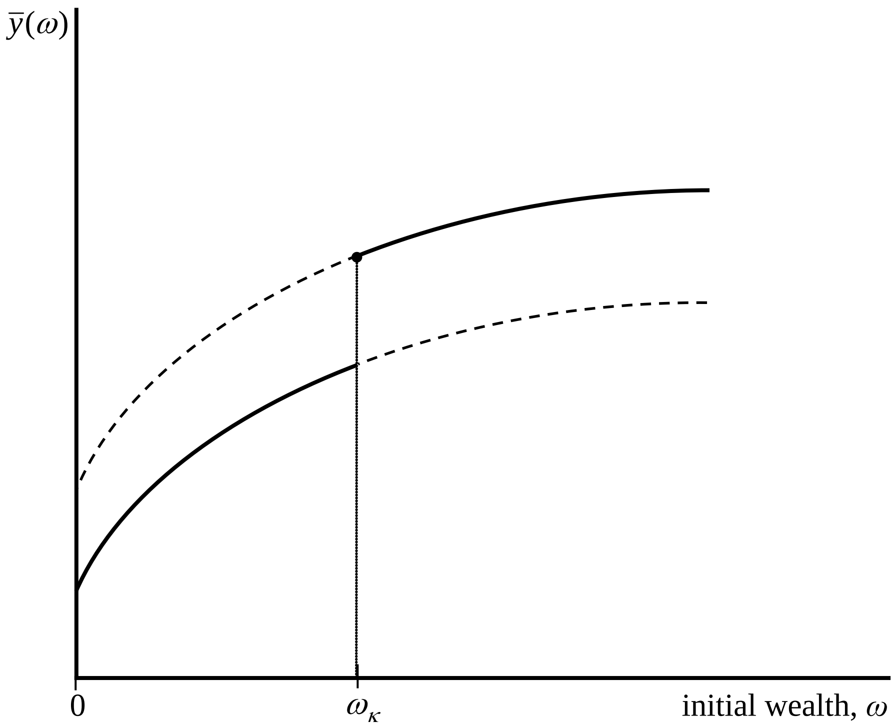

***Figure* 2** – Equilibrium firm outputs (assuming $\lambda < (\sigma - 1)/\sigma$)

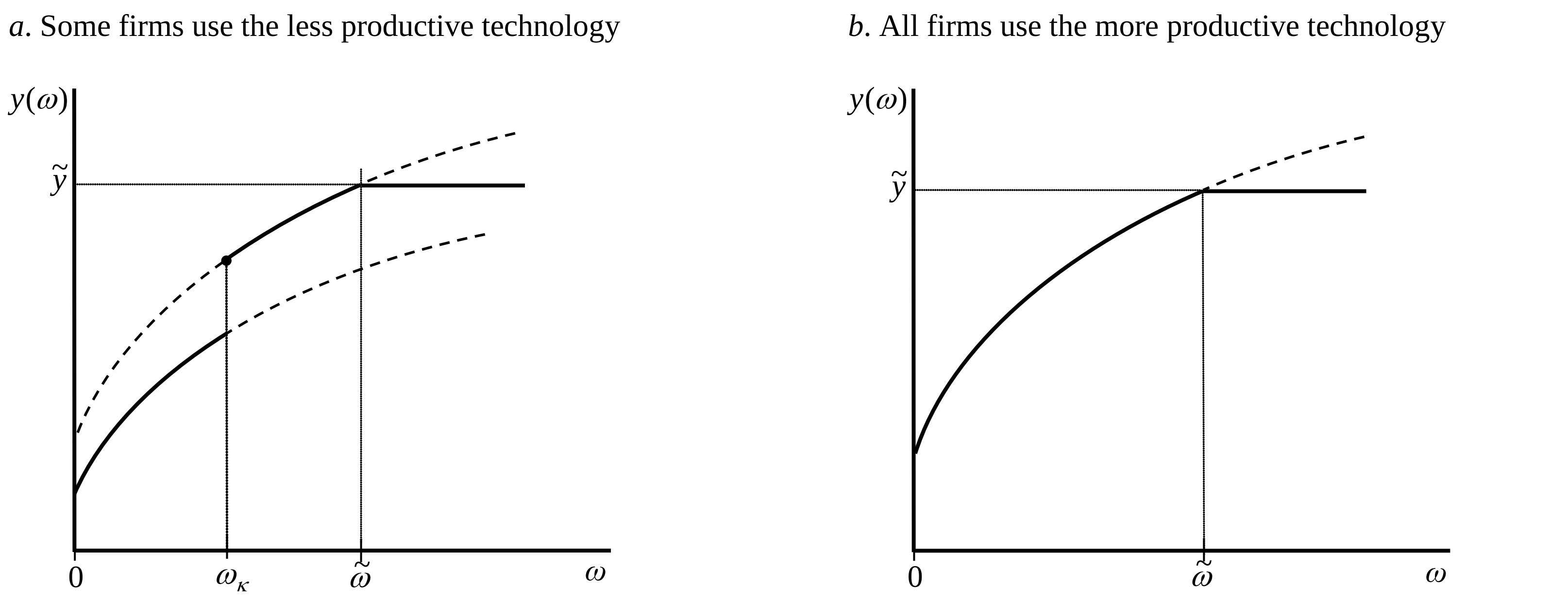

***Figure* 3** – Aggregate gross capital demand (assuming $\lambda < (\sigma - 1)/\sigma$)