Exporters, Credit Constraints, and Misallocation

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August 20, 2025

Abstract

How do financial frictions alter the gains from trade? I answer this question by combining a natural experiment in India with a quantitative model of credit constraints and international trade. Empirically, I find that loosening constraints raises the share of exports in total sales, implying that exports are inefficiently low in economies with financial frictions. However, I show theoretically that this inefficiency creates a new source of gains from trade via reductions in misallocation. I quantify the importance of this force by calibrating the model and find that it magnifies the standard gains from trade by 20%.

Introduction

A standard prescription for developing countries is to lower barriers to international trade, export goods in which they possess a comparative advantage, and thereby enjoy higher productivity and faster growth. However, a large literature, reviewed below, has documented that exporting is an activity particularly vulnerable to financial frictions. Can an economy facing significant financial frictions still benefit from international trade? Or should policymakers pursue trade liberalization only after reaching a certain level of financial development?

The ideal macro experiment one would use to answer these questions, in which countries are randomly subjected to varying degrees of financial development and openness to trade, is clearly infeasible. At the same time, micro evidence on the effects of financial frictions gives incomplete answers to such long-run, aggregate questions. I address these challenges by combining evidence from a natural experiment in India with a quantitative model of credit constraints, firm dynamics, and international trade. Empirically, I compare otherwise similar manufacturing firms that are exogenously subjected to different intensities of credit constraints, and find that looser constraints induce exporters to borrow more and export more intensely, with no effect on purely domestic

*Email: r.finlay@imperial.ac.uk. I thank my advisors, Michael Peters, Sam Kortum, and Lorenzo Caliendo. I also thank Costas Arkolakis, Giuseppe Moscarini, Ahyan Panjwani, Vitor Possebom, Jaehee Song, Trevor Williams, Hortense Fong, Simon Quinn, Adrien Matray, and seminar participants at Yale, UNC, Oxford, the Federal Reserve Board, Imperial College London, Stanford GSB, Oslo, and Columbia for their helpful comments, feedback, and suggestions.

producers. Motivated by this evidence, I build a model in which heterogeneous entrepreneurs accumulate assets over time and produce subject to credit constraints. Consistent with my empirical results, export sales in the model are more distorted by credit constraints than domestic sales. I show analytically that credit constraints create a new source of dynamic gains from trade: lower trade costs push exporters to save more and in the long run loosen their credit constraints, reducing misallocation. I calibrate a quantitative version of the model to the evidence from the natural experiment and find that these misallocation effects are substantial. I now discuss each aspect of the paper in more detail.

In the first part of the paper, I empirically measure the impact of credit constraints at the firm level, focusing on their effects on exporters. I do so by exploiting India's Priority Sector Lending (PSL) policy as a source of exogenous variation in the tightness of credit constraints. PSL incentivized banks to lend to eligible manufacturing firms, with eligibility determined by a cutoff rule: only firms with physical capital below 50 million rupees (roughly 1 million USD) were eligible. Using a regression discontinuity design (RDD), I show that eligible exporters borrowed about 35% more and increased the share of exports in total sales by just over 8 percentage points, while I find no effect of PSL on purely domestic firms. I infer that credit constraints are an important obstacle for a substantial fraction of exporters, at least close to the PSL cutoff, and in particular that credit constraints distort their export sales downwards.

I next build a model in which heterogeneous entrepreneurs produce and export subject to a working capital constraint that limits their ability to hire workers. They can meet their working capital needs either by accumulating internal funds over time or by borrowing. Consistent with the institutional details of bank lending in India, an entrepreneur's ability to borrow is in turn constrained by their sales. To keep the model analytically tractable, labor is the only factor of production, an entrepreneur's productivity is constant over time, and an entrepreneur's export status is exogenous. Crucially, I allow lenders to discriminate against export sales in their lending decisions. This friction creates a natural link between the tightness of credit constraints and the share of sales exported.

The interaction between financial frictions and international trade in the model is nuanced. Tighter credit constraints encourage firms to distort their export sales downwards and therefore make the economy less open. This force mechanically decreases the gains from trade, which I define as the effect of reductions in trade costs on total factor productivity (TFP). But I also show that another force is present. For an exporter, reductions in trade costs raise the marginal value of relaxing their borrowing constraint. This incentivizes exporters to gradually accumulate internal funds, relax their borrowing constraints, and in the long run export more. Since export sales were initially inefficiently low, this self-financed expansion in exports has a first order effect on aggregate TFP. As a result, compared to an equally open frictionless economy, the economy with financial frictions always gains *more* from trade.

To assess the quantitative importance of this mechanism, I enrich the model with idiosyncratic productivity shocks, physical capital subject to adjustment costs, and an endogenous export entry decision driven by sunk costs. These features allow me to create a tight connection between the quantitative model and the evidence from the PSL policy: in particular, they allow me to calibrate the model's key parameter, the extent to which export sales are penalized in lending decisions, by replicating PSL within the model and targeting the RDD estimates discussed above. The combination of the quantitative model with the empirical evidence reveals that credit constraints do indeed substantially distort exports. The average exporter sells just under 25% of their output abroad, whereas if credit constraints were removed this figure would rise to 32%.

With the calibrated model in hand, I am able to quantify the effect of financial frictions on the gains from trade. As in the analytical model, in the quantitative model frictions make the economy less open but also create the possibility of gains from reallocation over time. Considering both small reductions in trade costs as well as the larger shock of moving from autarky to the observed level of trade costs, I find that both forces play important roles. Overall, the gains from trade do decline slightly as financial frictions become more severe. However, this overall trend combines a steep decline in the standard gains from trade alongside rising gains from reallocation. Indeed, when benchmarked against the gains predicted by standard sufficient statistics approaches (Arkolakis, Costinot, and Rodríguez-Clare 2012), the gains from trade are about 20% higher for an economy at India's level of financial development. I also use the calibrated model to explore the effectiveness of export promotion policies. While the presence of credit constraints creates the potential for aggregate productivity gains from such interventions, in practice I find that the extent of heterogeneity within the set of exporting firms makes one-size-fits-all policies like a simple export sales subsidy relatively ineffective.

Overall, my results highlight the subtle effects of international trade in distorted economies, and in particular emphasize the importance of endogenous changes in misallocation in response to changes in trade costs. While less financially developed economies will generally be less open, they still stand to benefit from international trade because it can gradually mitigate the misallocation created by financial frictions

Related literature

This paper contributes to three broad literatures. First, an empirical literature measures the firm-level effects of financial frictions. Focusing on exporters, Zia (2008) studies the removal of subsidized export credit in Pakistan, Amiti and Weinstein (2011) and Paravisini et al. (2015) show that shocks to bank health are transmitted to export sales, and Matray et al. (2024) analyze the temporary shutdown of the Export-Import Bank of the United States. Taken together, these papers establish that export sales, which involve high upfront costs and long lags between production and payment, are particularly vulnerable to financial frictions. A related literature also analyzes the PSL policy that I study (Banerjee and Duflo 2014; Kapoor, Ranjan, and Raychaudhuri 2017). Of particular relevance is Rotemberg (2019), which develops an empirical methodology to estimate the general equilibrium effects of PSL. Relative to these papers, my focus is on heterogeneity in the policy's partial equilibrium effects across exporting and domestic firms and exported and domestic sales. I exploit these heterogeneous effects to calibrate a rich quantitative model capable of addressing a wide range of counterfactual questions beyond the PSL policy itself.

Second, a literature has incorporated financial frictions into models of international trade (Manova 2012; Chaney 2016; Kohn, Leibovici, and Szkup 2014; Brooks and Dovis 2020). Here the most relevant paper is Leibovici (2021). That paper builds a rich general equilibrium model of trade and credit constraints and calibrates it to match salient moments related to firm dynamics. Relative to Leibovici (2021), I make two important contributions. First, I develop an analytically tractable model that isolates the role of a particular mechanism: self-financing by exporters. As emphasized by Midrigan and Xu (2014) and Moll (2014) in different contexts, such self-financing plays an important role in shaping the effects of credit constraints. Second, I quantify the importance of credit constraints for exporters by directly targeting reduced form evidence from a natural experiment, rather than inferring constraints indirectly from cross-sectional moments. More broadly, Berthou et al. (2019) and Bai, Jin, and Lu (2024) study the gains from trade in models where misallocation is generated by exogenous wedges in the spirit of Hsieh and Klenow (2009). Misallocation in my model can always be represented in terms of such wedges. However, these wedges are endogenous and evolve over time in response to trade shocks.

Finally, this paper contributes to a growing literature that combines well-identified micro evidence on the effects of financial frictions with models in order to draw macro conclusions (Kaboski and Townsend 2011; Buera, Kaboski, and Shin 2021; Catherine et al. 2022; Bau and Matray 2023; Bøler, Moxnes, and Ulltveit-Moe 2023). I bring this approach to questions at the intersection of international trade, macroeconomics, and finance.

Outline

Section 1 uses India's PSL policy to estimate the effects of credit constraints on exporting firms and export sales. Section 2 analyzes a tractable model of credit constraints and exporting, and Section 3 calibrates a quantitative version of the model. Section 4 performs counterfactual experiments, focusing on how financial frictions alter the gains from trade. Finally Section 5 concludes.

1 Empirical Evidence on Credit Constrained Exporters

Quantifying the relationship between credit constraints and international trade requires, as a first step, exogenous variation in the tightness of those constraints.[1] I exploit differences across Indian manufacturing firms in eligibility for a directed credit policy, Priority Sector Lending (PSL), as a source of such variation. Using a regression discontinuity design (RDD), I find that exporters responded strongly to the policy by borrowing more and exporting more intensely. I do not detect any effects of PSL eligibility on purely domestic firms. I interpret my results as evidence that credit constraints are an important obstacle for a substantial fraction of exporters.

[1] I refer to a firm as credit constrained if it would like to borrow more at the going interest rate but cannot do so.

1.1 Context and Data

Priority Sector Lending

India's PSL policy was a directed credit policy administered by the Reserve Bank of India (RBI) that targeted the 'priority sector', which includes agriculture, transport, and small businesses.[2] The policy was first used to provide evidence on the importance of financial frictions by Banerjee and Duflo (2014). Since my focus is not on evaluating PSL *per se*, but instead on using the effects of PSL to measure the importance of credit constraints across different types of firms and sales, I keep my discussion of the policy here brief and provide a more detailed description in Appendix A.2. The key points are:

(i) *PSL incentivized banks to lend to eligible firms:* PSL obliged banks to allocate at least 40% of net credit to the priority sector or face financial penalties. Therefore, banks had a strong incentive to lend to firms in the priority sector, and priority sector firms enjoyed favorable access to financing. Banerjee and Duflo (2014) argue that observing an increase in borrowing among eligible firms alongside no change in borrowing costs is evidence that credit constraints must be binding for at least some eligible firms. In Appendix A.2 I verify that in my sample eligible firms did not borrow at significantly lower rates, and therefore interpret PSL as a policy that loosened credit constraints for eligible firms.

(ii) *Eligibility was determined by a cutoff rule:* I focus on manufacturing firms. Among these firms, lending to those with physical capital below a certain threshold counted towards a bank's priority sector quota.[3] Given my focus, it is important to note that eligibility was unrelated to a firm's export status and that PSL did not incentivize export credit specifically, a fact I document using the RBI's PSL guidance in Appendix A.2.

(iii) *The cutoff was at 50 million rupees (approximately 1 million USD) from 2007 onward:* The eligibility cutoff has moved around over time and until 2005 was set at 10 million rupees.[4] In 2005 a bill was introduced to raise the cutoff to 50 million rupees, and the new cutoff entered the RBI's PSL guidance at the start of 2007. In my analysis I therefore take 2004 as the base year and use this to split the sample into exporters and domestic firms. I then measure outcomes in the five years 2007-2011.[5]

Bank lending is important in India. In my data, described below, 82% of firms that report any borrowing at all report borrowing from a bank, and for these firms bank loans account for 63% of

[2]PSL continues to operate today, although with a very different structure.

[3]More precisely, PSL eligibility depends on 'gross plant and machinery', a (large) subset of physical capital. In my data, described below, I observe exactly this quantity on firms' balance sheets, but for brevity throughout this section will simply refer to it as capital.

[4]Banerjee and Duflo (2014) studied the effects of an increase in the cutoff from 6.5 million rupees to 30 million rupees in 1998, as well as a subsequent decrease in 2000. In principle, I could also study these earlier, lower cutoffs. In practice, sample size becomes an issue. Few firms at such low values of capital appear in my dataset (described below), even fewer export, and its coverage is less comprehensive in earlier years.

[5]India's financial year ends in March. I adopt the convention that year t refers to the financial year that ends in calendar year $t+1$. Thus 2004 was the final year before the new PSL cutoff was announced.

all borrowing. Bank lending is mainly used to meet firms' working capital needs (Banerjee and Duflo 2014). Therefore if PSL is effective, we would expect to see its effects in firms' purchases of variable inputs and sales, rather than in their investments in physical capital.

Data

I rely on the Prowess dataset, compiled by the Center for Monitoring the Indian Economy (CMIE). This is a panel of firms beginning in 1980 whose source is audited financial statements. In my main analysis I use information on the value of capital, total borrowing, bank borrowing, total sales, and export sales. Prowess is not representative of the universe of Indian firms. Instead, it focuses on larger firms, and among these firms it has fairly complete coverage.[6] Prowess does a good job of capturing firms affected by the PSL policy and is therefore ideal for my empirical exercise: in the year before the change in the cutoff was first announced, 2004, just under 40% of firms in Prowess had capital below 50 million rupees. Panel (a) of Figure 1 shows the distribution of log capital across firms in Prowess, separating them by export status. While exporters are generally larger, it is also clear that the data contains many firms of both types on either side of the cutoff.

Table 1 reports some salient features of the data for firms in 2004, separated by export status. Column (1) considers all firms and Column (2) focuses on the subset of firms close to the PSL cutoff. Exporters are well represented in Prowess. Overall just under half of firms export, although close to the cutoff that share drops to 39%. The high share of exporters reflects the selected nature of the Prowess sample. Row 3 shows that exporters are larger in terms of sales, but this difference is attenuated once I focus on firms close to the cutoff. Close to the cutoff, the median exporter sells a little less than twice as much as the median domestic firm. In rows 4 – 6 of Table 1 I

Table 1: Descriptive statistics

		(1) All firms		(2) Cutoff sample	
		(a) Domestic	*(b) Exporters*	*(a) Domestic*	*(b) Exporters*
1.	Number of firms	3172	2806	989	638
2.	... as % of total	53.06	46.93	60.79	39.21
3.	Median sales (millions of rupees)	2.905	15.12	2.964	5.711
4.	Ratio of bank loans to value added, median	0.500	0.434	0.458	0.396
5.	Sales growth rate, average past 2 years	0.017	0.063	0.020	0.054
6.	Fraction of firms 13 or younger	0.414	0.299	0.434	0.375

Notes: In Column (1), sample is all manufacturing firms in Prowess in 2004. In Column (2), sample is restricted to those with log plant machinery within less than 0.744 away from the 50 million rupee cutoff, i.e., roughly between 25 and 105 million rupees (0.744 is the median bandwidth used in Table 2). In both columns, exporters are those with positive export sales in 2004 while all other firms are domestic. See Appendix A.1 for more details.

[6]For example, firms in Prowess account for 60 − 70% of economic activity in the organized industrial sector and 75% of corporate taxes collected by the Government of India (De Loecker et al. 2016).

consider factors that might be informative about the importance of credit constraints. Row 4 shows that exporters borrow less relative to their value added, which I calculate as 40% of sales as in Midrigan and Xu (2014).[7] This difference could reflect either a lower supply of credit to exporting firms, or less demand: but given the greater financing needs associated with export sales (Manova 2012), the second explanation seems less likely. Row 5 shows that exporters, both overall and especially close to the cutoff, are generally fast growing firms, which also suggests a greater need for financing. In the final row, I consider age differences. Prowess only contains relatively coarse information on firm age, so here I report the fraction of firms 13 years old or younger. Exporters are generally older, although close to the cutoff this difference is smaller.

1.2 Estimation and Identification

The crucial feature of the PSL policy described above is that a firm's eligibility changes discretely as capital crosses the 50 million rupee cutoff. I therefore consider RDD specifications of the form,

$$\mathbb{E}\left[y_{it}|x_{it}\right] = f_y(x_{it}) + \beta_y \mathbb{I}\{x_{it} \leq k^*\}, \tag{1}$$

where i indexes firms and t indexes years. y_{it} is the outcome of interest — borrowing, sales, exports, and so on. The running variable x_{it} is log capital measured in year t. The constant k^* represents the 50 million rupee cutoff for PSL eligibility. The coefficient β_y is the parameter of interest and measures the effect of PSL eligibility on the outcome y for the firms close to the cutoff. As is standard in the RDD literature (Imbens and Lemieux 2008), I approximate the unknown function f_y with a local linear regression, so that estimating β_y reduces to the problem of estimating linear models on either side of the cutoff by weighted least squares, with the weights determined by bandwidth and kernel choices. I use a uniform kernel in my main specifications and choose bandwidths following Calonico, Cattaneo, and Titiunik (2014).

Identification concerns

How confident should we be in interpreting the estimated discontinuities β_y as the effects of PSL eligibility? The key threat to identification is sorting around the cutoff.[8] If firms choose their capital stocks with the goal of becoming or remaining eligible for PSL, and if deciding to sort around the cutoff in this way is correlated with other firm characteristics, then the RDD estimates would reflect both the effects of PSL and the influence of these characteristics. I address this concern in two ways: with manipulation testing, and with placebo checks.

First, if firms were sorting around the cutoff, we would expect to observe bunching in the density of firms close to the cutoff. In Appendix A.3 I check for bunching both visually and with

[7] Among firms in Prowess that report their purchases of intermediates and materials, the share of value added in sales is just over 37%.

[8] In the context of a differences-in-differences design, Rotemberg (2019) shows that general equilibrium responses may complicate identification of the firm-level effects of PSL. This is not a concern for the RDD strategy pursued here, as we would expect the effects of any equilibrium changes in prices to vary smoothly across the PSL cutoff.

formal statistical tests. For the period I use in my main analysis, 2007 – 2011, I find no evidence of any bunching. Interestingly, I do detect some evidence of bunching later, in 2012 – 2015. My interpretation is as follows: firms do value the access to credit that comes with PSL eligibility, but, because of important adjustment costs in physical capital (e.g., Cooper and Haltiwanger (2006)), any attempt to sort around the cutoff takes time and is unlikely to be an important influence on my results.

Second, the timing of the PSL policy suggests a natural set of placebo checks. Recall that the 50 million rupee cutoff first appeared in legislation in 2005. It would therefore be impossible for eligibility for PSL in, say, 2007 to have any direct effect on firms in any year prior to 2005. Any effects observed prior to 2005 would instead be suggestive of sorting around the cutoff. For example, if large firms tend to bunch behind the cutoff after the introduction of PSL, we would expect these firms to also be large even prior to 2005. In Appendix A.3 I conduct a battery of such placebo checks. I do not detect any significant effects of a firm's subsequent PSL eligibility on its pre-PSL borrowing, sales, or export share, confirming the message of the manipulation tests.

1.3 Results

Tables 2 and 3 report my main empirical results. In Table 2 all outcomes are measured in logs and can be interpreted as the (approximate) percentage difference between eligible and ineligible firms. Columns (1) and (2) show the effects of PSL on borrowing in the simplest possible specification, without any controls, splitting the sample into exporters and domestic firms. The effects of PSL are very different across the two sets of firms. Eligible exporters increase their borrowing by roughly 38%, while domestic firms do not respond at all. In Columns (3) and (4) I add industry and year fixed effects and control for log loans measured in the base year. The results are very similar to those in (1) and (2) but more precisely estimated, and the effect on exporters is now

Table 2: PSL effects on borrowing and sales

Outcome	(1) Loans	(2) Loans	(3) Loans	(4) Loans	(5) Bank loans	(6) Bank loans	(7) Sales	(8) Sales
RD estimate	0.379*	0.040	0.354**	0.013	0.422**	-0.044	0.074	0.002
	(0.211)	(0.123)	(0.164)	(0.116)	(0.199)	(0.152)	(0.133)	(0.110)
Sample	Exporters	Domestic	Exporters	Domestic	Exporters	Domestic	Exporters	Domestic
Fixed effects	✗	✗	✓	✓	✓	✓	✓	✓
Base year control	✗	✗	✓	✓	✓	✓	✓	✓
Observations	10,515	10,153	10,316	9,838	9,313	8,145	10,515	10,153
Bandwidth	0.930	1.227	0.653	0.867	0.642	0.678	0.684	0.803

Notes: Sample is all manufacturing firms in Prowess 2007 – 2011. Fixed effects are for years and industries. Base year control specifications include outcome variable measured in 2004 as a control. See Appendix A.1 for more details. RDD kernel is uniform with bandwidth chosen following Calonico, Cattaneo, and Titiunik (2014). Standard errors clustered at the firm level.

significant at the 5% level. The fact that the point estimates are not sensitive to the inclusion of base year controls is reassuring as it confirms the estimated discontinuities are not driven by pre-existing differences across firms. Panels (b) and (c) of Figure 1 visualize these two specifications. Although noisily measured, borrowing among exporters in Panel (b) is higher just to the left of the PSL cutoff and then drops discretely just to the right of the cutoff. No similar pattern is apparent among the domestic firms in Panel (c).

PSL worked by incentivizing banks in particular to lend to eligible firms. We would therefore expect its effects to be concentrated on bank lending. Column (5) shows that PSL eligibility did indeed have a large effect on exporter borrowing from banks, while I continue to find no effect on domestic firms in Column (6). In Columns (7) and (8) I turn to log sales. Although the point estimates here are consistent with a modest but positive effect on exporters and a zero effect on domestic firms, neither is statistically significant.

Motivated by the stark differences between exporters and domestic firms in Table 2, in Table 3 I turn to export-specific outcomes. In Columns (1) and (2) the sample is all exporting firms and the outcome is the share of exports in total sales, measured between 0 and 1. Column (1) does not include any controls while Column (2) adds fixed effects for industry and year and controls for export shares measured in the base year. Again, adding controls has little effect on the point estimates but improves precision. In particular, the estimate in Column (2) implies that PSL eligible exporters sold 8.6 percentage points more abroad than ineligible exporters. This estimate is significant at the 1% level. Given that the mean export share among exporters in Prowess is roughly 25%, it also represents an economically meaningful increase. Panel (d) of Figure 1 visualizes this result.

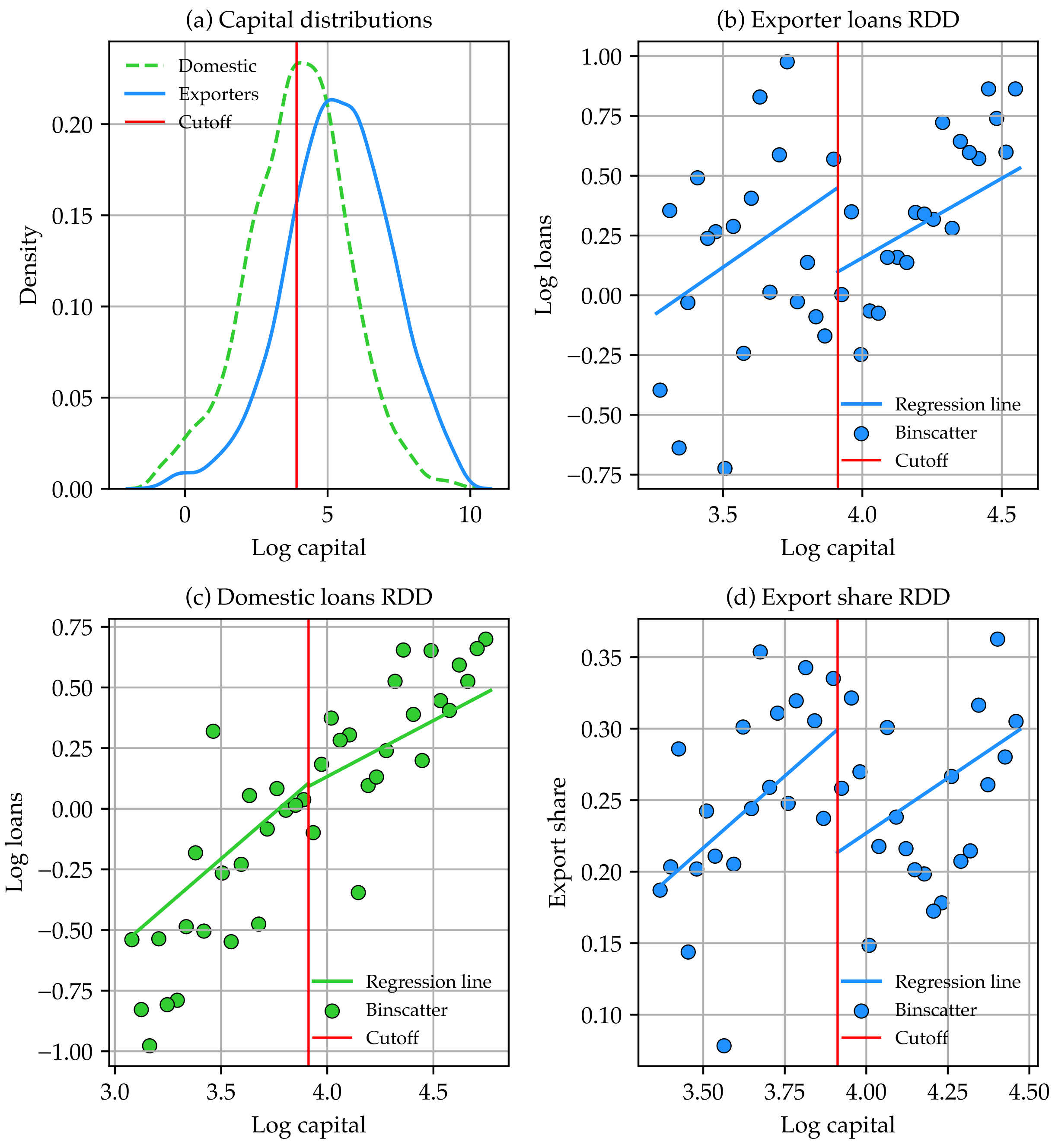
Two forces could have produced this increase in the export share: changes along the intensive margin by continuing exporters, and changes along the extensive margin by entering and exit-

Table 3: PSL effects on exporting

Outcome	(1) Export share	(2) Export share	(3) Export share	(4) Export status	(5) Export status
RD estimate	0.090* (0.053)	0.086*** (0.030)	0.058* (0.033)	0.103** (0.051)	0.012 (0.032)
Sample	Exporters	Exporters	Continuing exporters	Exporters	Domestic
Fixed effects	✗	✓	✓	✓	✓
Base year controls	✗	✓	✓	✓	✓
Observations	10,515	10,515	9,163	10,515	10,153
Bandwidth	0.636	0.559	0.466	0.684	0.735

Notes: Sample is all manufacturing firms in Prowess 2007 – 2011. Fixed effects are for years and industries. Base year control specifications include outcome variable measured in 2004 as a control. See Appendix A.1 for more details. RDD kernel is uniform with bandwidth chosen following Calonico, Cattaneo, and Titiunik (2014). Standard errors clustered at the firm level.

Figure 1: Regression discontinuity design plots



Notes: Panel (a) shows the density of capital in exporting (solid line) and domestic firms (dashed line) in Prowess in the base year. Panels (b) — (d) show binned scatterplots of different outcome variables close to the PSL cutoff of 50 million rupees. Solid lines show local linear regressions estimated on either side of the cutoff using a uniform kernel with bandwidths chosen following Calonico, Cattaneo, and Titiunik (2014). The discontinuities in (b) — (d) correspond to the point estimates in Columns (3) and (4) of Table 2 and Column (2) of Table 3. In each panel the vertical line shows the PSL cutoff.

ing exporters. In Column (3) of Table 3 I explore the first possibility by limiting the sample to continuing exporters, i.e., firm-year observations with positive export sales. I continue to find an economically significant effect of PSL eligibility, albeit measured less precisely.[9] In Column (4) I return to the sample of all exporters and use as the outcome a dummy equal to one if the firm exports at all in a given year. This specification therefore measures the effect of PSL eligibility on the probability that a firm that was exporting in the base year continues exporting. I find that eligible firms were 10 percentage points more likely to continue exporting, again a substantial effect given a baseline probability of continuing around 80% over the five years I use in estimation. For completeness, in Column (5) I turn to domestic firms and measure the effect of PSL eligibility on the probability that a firm starts exporting: the resulting point estimate is small and statistically insignificant. Together, Columns (3) and (4) of Table 3 suggest that both the intensive and extensive margins of exporting were affected by PSL. Some back-of-the-envelope calculations show that the intensive margin must be the main driver of the result in Column (2). To see this, assume that the firms that are induced by PSL to continue exporting have an average export share of 25%. Then the extensive margin would contribute $0.25 \times 0.103 \simeq 0.025$, or just under one-third of the point estimate in Column (2), leaving changes on the intensive margin to explain the remaining two-thirds.

Robustness and additional results

In Appendix A.4 I focus on three key results — the positive effect on exporter borrowing, the near-zero effect on domestic firm borrowing, and the positive effect on export intensity — and subject them to a range of robustness checks related to controls, timing, and the technical details of the RDD. Broadly, these changes do not have much effect on the magnitude or statistical significance of my results. I also address the concern that the differences between exporters and domestic firms reported in Table 2 may be driven by the different bandwidths used in estimation by including both exporters and domestic firms in a single RDD specification with a common bandwidth. The results are consistent with those in Table 2.

1.4 Discussion

My empirical results can be summarized in two points. First, PSL eligibility caused exporters to borrow more and export more intensely. Second, PSL eligibility did not have any effect on domestic firms.

I interpret the first result as evidence that export sales are particularly vulnerable to credit constraints. This finding is consistent with an existing literature that documents the sensitivity of exports to shocks to bank health (Amiti and Weinstein 2011; Paravisini et al. 2015) and to the removal of export credit institutions (Zia 2008; Matray et al. 2024). The literature has also suggested

[9] The figure in Column (3) likely underestimates the true intensive margin effects of PSL, if the marginal firms induced to continue exporting by PSL have relatively low export shares, as we would expect.

natural mechanisms that explain the effect of credit supply shocks on exports: because of the greater delays between production and payment involved in export sales, as well as the greater risk of default by importers, access to financing plays a more important role in facilitating exports than it does for domestic sales. Indeed, a textbook on international financial management describes trade financing as "the fundamental problem in international trade" (Bekaert and Hodrick (2012), as quoted in Amiti and Weinstein (2011)). In the remainder of the paper, I will combine the RDD estimates above with a model to go beyond such qualitative statements and quantify the importance of credit constraints for exports and international trade more broadly.

The second result is more subtle. A natural interpretation is that credit constraints are not binding for many domestic firms, at least close to the PSL cutoff. PSL eligibility, which loosens those constraints, therefore has little effect. But another interpretation is possible: credit constraints are in fact important for many domestic firms close to the cutoff, but banks chose to direct the increase in lending mandated by the PSL policy towards eligible exporters rather than eligible domestic firms. There are two arguments against this interpretation. First, nothing in the PSL policy itself encouraged lending to exporting firms or to facilitate export sales specifically. Indeed, as I document in Appendix A.2, the RBI's guidance explicitly stated that lending counted towards a bank's PSL quota if the recipient was below the cutoff irrespective of whether it was engaged in exporting or not. The second argument is empirical. As Table 1 showed, the data provides no reason to think banks have a preference for lending to exporters, other things equal. If anything, exporters seem slightly less able to borrow. This being the case, there is no reason to expect the expansion in lending caused by PSL to be biased towards exporters. Ultimately, however, it is impossible to be entirely certain that the zero effect on domestic firms reported in Table 2 truly represents an absence of credit constraints. I therefore avoid targeting these results in my calibration, and instead in Section 3 return to this question armed with the quantitative model.

2 A Theory of Credit Constrained Exporters

We have seen that looser credit constraints lead exporting firms to borrow more and export more intensely. What does this imply for the gains from trade in less developed countries, where financial frictions play an important role? To answer this question I now build a model. I start with a simple model that, despite featuring an endogenous distribution of assets across heterogeneous entrepreneurs, remains analytically tractable and allows me to provide new theoretical results in Subsection 2.2. I then incorporate a number of quantitative extensions in Subsection 2.3 with the aim of connecting the model to the evidence from Section 1.

2.1 Analytical Model

Time is continuous and denoted by t.[10] A unit mass of entrepreneurs produce using labor, accumulate internal funds over time, and derive utility from consumption. The model is set in partial equilibrium, i.e., the wage rate w and the real interest rate r are both exogenous. Given that the model represents the Indian manufacturing sector, which accounted for 17% of value added and a little over 10% of employment in the period I study, this seems a reasonable assumption (World Bank 2025b; Fan, Peters, and Zilibotti 2023).

Production and sales in the domestic market

I begin with an entrepreneur who sells domestically and does not export, and I denote the set of such firms by $\mathcal{D}$. The entrepreneur's productivity z is drawn from an exogenous distribution and fixed over time. Output y is produced using labor l with constant returns to scale, so that $y = zl$. Entrepreneurs are monopolistically competitive and face downward sloping demand curves,[11] with prices given by $p = y^{-\frac{1}{\sigma}}$. Thus an entrepreneur with productivity z who hires l workers generates sales s according to,

$$s = py = y^{\frac{\sigma-1}{\sigma}} = (zl)^{\frac{\sigma-1}{\sigma}}. \tag{2}$$

The only friction facing the entrepreneur is a working capital constraint: in order to hire workers, the entrepreneur must either have sufficient internal funds to cover the wage bill or else must borrow. Formally, employment is subject to the constraint,

$$wl \leq a + b, \tag{3}$$

where $a \geq 0$ represents internal funds accumulated by the entrepreneur — to be determined as part of their dynamic problem below — and $b \geq 0$ represents borrowing.

Borrowing is in turn subject to a constraint. The literature suggests a number of possible structures for the constraint, either backward looking (i.e., based on collateral) or forward looking (i.e., based on the value of the firm). In the context of working capital financing in India, however, it is natural to model the constraint as a fixed multiple of the entrepreneur's sales,

$$b \leq \lambda s, \tag{4}$$

where $\lambda \geq 0$ is a parameter that captures the tightness of borrowing constraints. Guidelines published by the Reserve Bank of India (RBI) recommend a lending rule of exactly this form, and Banerjee, Cole, and Duflo (2004) show that it provides a reasonable description of banks' lending

[10]Working in continuous time will make it easier to solve a quantitative version of the model in the presence of the PSL policy, which creates a discontinuity in entrepreneurs' payoffs.

[11]In general equilibrium these demand curves would be derived from constant elasticity of substitution preferences. Gopinath et al. (2017) uses an identical specification of demand in a partial equilibrium model of financial frictions.

decisions in practice.

Given these constraints, the profit maximization problem facing a domestic entrepreneur is,

$$\pi_D(z,a) = \max_l \quad (zl)^{\frac{\sigma-1}{\sigma}} - wl, \\ \text{s.t.} \quad wl \leq a + \lambda(zl)^{\frac{\sigma-1}{\sigma}}. \tag{5}$$

The constraint in (5) is likely to bind for highly productive entrepreneurs with low levels of internal funds. These entrepreneurs would like to operate at a large scale but do not possess, and cannot borrow, the funds to do so.

Exporting

For now an entrepreneur's export status is exogenous: a subset $\mathcal{X}$ of entrepreneurs are simply able to sell some of their output abroad. The production function is unchanged, and demand abroad is identical to demand at home except for an iceberg shipping cost τ. If an entrepreneur with productivity z employs l_X workers in the production of goods to be exported, the resulting export sales are,

$$s_X = p_X\left(\frac{zl_X}{\tau}\right) = \left(\frac{zl_X}{\tau}\right)^{\frac{\sigma-1}{\sigma}}, \tag{6}$$

while I denote the domestic employment and sales of an exporter by l_D and s_D,

$$s_D = p_D\left(zl_D\right) = \left(zl_D\right)^{\frac{\sigma-1}{\sigma}}. \tag{7}$$

Like domestic entrepreneurs, exporters face a working capital constraint and must pay for the labor they use in production either using internal funds or by borrowing. However, motivated by the evidence in Section 1 as well as broader evidence on the frictions involved in lending to exporters (Matray et al. 2024), I allow for the possibility that lenders might discriminate against export sales when choosing how much credit to extend to an entrepreneur. The borrowing constraint for an exporter is,

$$b \leq \lambda s_D + (\lambda - \theta)s_X, \tag{8}$$

where I refer to $0 \leq \theta \leq \lambda$ as the export penalty. If $\theta > 0$, then lenders are less willing to lend against export sales, and credit constraints will generally bind more tightly for exporters than domestic entrepreneurs. As we will see, θ will be the crucial parameter in allowing the model to match the effects of PSL documented in Section 1, and will have important implications for the relationship between financial frictions and trade more broadly.

Putting these different pieces together, the profit maximization problem facing an exporter is,

$$\pi_X(z,a) = \max_{l_D, l_X} \quad (zl_D)^{\frac{\sigma-1}{\sigma}} + \left(\frac{zl_X}{\tau}\right)^{\frac{\sigma-1}{\sigma}} - w(l_D + l_X)$$

$$w(l_D + l_X) \leq a + \lambda\,(zl_D)^{\frac{\sigma-1}{\sigma}} + (\lambda - \theta)\left(\frac{zl_X}{\tau}\right)^{\frac{\sigma-1}{\sigma}}. \tag{9}$$

As before, productive exporters low on internal funds will generally find themselves unable to produce at their desired scale. But now an additional force is present: because export sales appear with a penalty θ in the constraint in (9), constrained exporters will also tend to distort the composition of their sales across foreign and domestic markets.

The entrepreneur's dynamic problem

Over time entrepreneurs must decide how much to consume and how much to save. Formally, entrepreneurs — whether domestic or exporters — solve the optimal control problem,

$$\begin{aligned} v_i(z,a_0) = \max_{a(t),c(t)} \quad & \int_0^\infty \log c(t)\exp(-\rho t)dt, \\ \text{s.t.} \quad & \dot{a}(t) = ra(t) + \pi_i(z,a(t)) - c(t), \\ & a(0) = a_0, \quad a(t) \geq 0, \\ \text{for} \quad & i = D, X. \end{aligned} \tag{10}$$

Here $v_i(z,a_0)$ is the lifetime utility of a type i (i.e., domestic or exporting) entrepreneur with productivity z and an initial stock of assets a_0. Entrepreneurs have log utility and discount the future at rate ρ. The budget constraint is standard, and captures profits plus interest earned on internal funds. Finally, the entrepreneur cannot hold a negative quantity of internal funds, hence the constraint $a \geq 0$. Throughout I will assume $\rho > r$, as is typical in macro-development models (Buera, Kaboski, and Shin 2011; Midrigan and Xu 2014; Moll 2014; Gopinath et al. 2017). Without this assumption, borrowing constraints would become irrelevant in the long run, and indeed, if $\rho < r$, entrepreneurs would accumulate an infinite quantity of internal funds.

Notice that the dynamic problem above gives entrepreneurs the opportunity to gradually accumulate internal funds and self-finance their way out of credit constraints, in contrast to static models in which these constraints are exogenous (e.g Manova (2012)). This force will play an important role in shaping the effects of international trade in the presence of financial frictions.

Equilibrium

Wages w and interest rates r are exogenous. Given an initial distribution of internal funds, productivities, and export statuses, equilibrium in this model is: for each entrepreneur, a path for internal funds $a(t)$ that solves (10); and, given internal funds at each point in time, employment and production decisions that solve (5) for domestic entrepreneurs and (9) for exporters.

2.2 Analytical Results

Before analyzing the model, it will be helpful to introduce some notation. Within a given exporter, let e be the share of exports in terms of employment, and let x be the share of exports in terms of sales,

$$e = \left(\frac{l_X}{l_X + l_D}\right), \quad x = \left(\frac{s_X}{s_X + s_D}\right). \tag{11}$$

Also define,

$$E = \frac{\int_{\mathcal{X}} l_x}{\int_{\mathcal{X}}(l_X + l_D) + \int_{\mathcal{D}} l}, \quad X = \frac{\int_{\mathcal{X}} s_X}{\int_{\mathcal{X}}(s_X + s_D) + \int_{\mathcal{D}} s} \tag{12}$$

to be the shares of exports in total employment and total sales, aggregating over all entrepreneurs. In an efficient economy these shares will generally be identical, but in the current setting with distortions they may differ.

Result 1: The working capital constraint creates export and employment wedges.

To understand the effect of financial frictions in this economy, it is helpful to reformulate the constrained profit maximization problem facing exporters in (9).[12] I show in Appendix B.1 that the employment choices that solve this problem are equivalent to those that solve an unconstrained problem in which the entrepreneur chooses total employment l and the share of exports in total employment e, with the exporter's objective function distorted by an employment wedge t_L and an export wedge t_X,

$$\begin{aligned} &\max_{e,l} \quad \left((1-e)^{\frac{\sigma-1}{\sigma}} + (1-t_X)\left(\tau^{-1}e\right)^{\frac{\sigma-1}{\sigma}}\right)(zl)^{\frac{\sigma-1}{\sigma}} - (1+t_L)wl, \\ &t_X = \left(\frac{\mu}{1+\mu\lambda}\right)\theta, \quad t_L = \left(\frac{\mu}{1+\mu\lambda}\right)(1-\lambda). \end{aligned} \tag{13}$$

Here $\mu \geq 0$ is the Lagrange multiplier on the entrepreneur's working capital constraint, which will be strictly positive whenever the constraint binds. The wedges t_L and t_X capture the distortions created by this constraint. Naturally, a tighter constraint, corresponding to a larger μ, results in a higher labor and export wedges t_L and t_X, and ultimately lower employment and exports.

My primary interest is in the export wedge t_X. As long as the entrepreneur is constrained, and $\mu > 0$, the export wedge is positive whenever $\theta > 0$. Taking a first order condition of (13) yields the distorted export employment share,

$$e = \frac{(1-t_X)^\sigma \tau^{1-\sigma}}{1 + (1-t_X)^\sigma \tau^{1-\sigma}} < \frac{\tau^{1-\sigma}}{1+\tau^{1-\sigma}} = e^* \tag{14}$$

[12] Since domestic entrepreneurs are simply exporters facing infinite iceberg costs, analogous results for domestic entrepreneurs can be derived by setting $\tau = \infty$.

where e^* is the export share that an unconstrained exporter would choose. The share of exports in total sales, x, is also distorted downwards relative to the unconstrained optimum x^*. Intuitively, a constrained exporter restricts their export sales to economize on scarce working capital, and the extent to which they do so rises with the penalty θ that is attached to exporting. This intensive margin effect of credit constraints on exports is an important distinction between my model and the models in Brooks and Dovis (2020) and Leibovici (2021), which focus on distortions to the extensive margin decision to export, as well as distortions to firm size more broadly. While an export entry decision will also feature in the quantitative version of my model, the effects of PSL I found in Section 1 point to an important role for the intensive margin.

So far, I have simply reformulated the original profit maximization problem using the constraint multipliers μ. In general these multipliers are endogenous and vary across entrepreneurs depending on their productivities, stocks of internal funds, and export statuses. However, the steady state behavior of the model places tight restrictions on these multipliers, as Lemma 1 states.

Lemma 1. *In steady state the multipliers of all domestic entrepreneurs are all equal to a single value μ_D and the multipliers of all exporting entrepreneurs are all equal to a single value μ_X. These multipliers satisfy $\mu_X \geq \mu_D \geq 0$, and in particular if,*

$$\left(\frac{\sigma-1}{\sigma}\right) \leq \lambda < \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\sigma}{\sigma+(\rho-r)}\right) + \theta x(\rho-r), \tag{15}$$

where $x(\rho-r)$ is the export sales share that would be chosen by an entrepreneur facing a constraint multiplier equal to $\rho-r$, then $\mu_D = 0$ and $\mu_X = (\rho-r)$.

Proof. Follows from setting up the entrepreneur's dynamic problem as a Hamiltonian and taking the limit as $t \to \infty$. See Appendix B.2 for details. ∎

The intuition for Lemma 1 is as follows. Saving an additional unit of internal funds earns the entrepreneur a return of $\mu + r$, which they weigh up against their discount rate ρ. They then save or dissave until the two forces offset one another, implying $\mu + r = \rho$, or they hit the constraint $a \geq 0$, which turns out to pin down μ independently of z. In either case, within each group of entrepreneurs, the multipliers must converge to a single value. And because export sales are penalized in the borrowing constraint, the constraint multipliers are generally higher for exporters. The particular parametric restriction in (15) corresponds to the case in which borrowing is easy enough that domestic firms are always unconstrained, but export sales are penalized enough that in order to achieve their desired export sales share $x(\rho-r)$, exporters must do at least some self-financing.

Lemma 1 greatly simplifies the analysis of this economy because homogeneous constraint multipliers μ within each group imply homogeneous employment and export wedges t_L and t_X. Homogeneous wedges in turn imply we can think in terms of a representative domestic firm and a representative exporter.

Result 2: Looser borrowing constraints raise export shares.

I now use Lemma 1 to characterize the effects of a small positive shock to the parameter λ, which corresponds to a loosening of entrepreneurs' borrowing constraints. I think of this shock as the model analogue of the PSL policy studied in Section 1.

Theorem 1. *Suppose the economy is initially in its steady state and λ increases by some small $\mathcal{P} > 0$. If the parameter restriction (15) holds, then in the long run:*

(i) Domestic entrepreneurs are unaffected,

(ii) Borrowing and sales by exporters both increase,

(iii) Exporters sell a larger fraction of their output abroad.

In particular, all exporters increase their export sales shares by

$$\Delta x \simeq (\sigma - 1)x(1 - x)\left(\frac{\mu_X^2 \lambda}{1 + \mu_X(\lambda - \theta)}\right) \times \theta \times \mathcal{P}.$$

Proof. Follows from differentiating the expression for t_X in (13) with respect to λ, noting that by Lemma 1 the constraint multipliers μ can be held constant. ∎

Theorem 1 is useful for two reasons. First, it provides an intuitive comparative statics result. As financial frictions become are relaxed, the share of exports in total sales rises and the economy becomes more open. This will be an important force in determining how credit constraints shape the gains from trade. Second, it provides a concrete link between the model and the empirical evidence from Section 1. Points (i) – (iii) above show that the model is able to qualitatively reproduce the effects of PSL that I found empirically. Moreover, it tells us that the key result from Section 1 — the positive effect of PSL on the export sales share — is closely tied to the export penalty θ. When θ is large and export sales are strongly penalized in the borrowing constraint, entrepreneurs have a strong incentive to distort their export sales shares downwards, and loosening these constraints therefore has a large effect. This observation will be at the heart of my calibration strategy in Section 3. Of course, the shock in Theorem 1 is still only a stylized representation of the real PSL policy. The quantitative model, introduced below, will address this limitation.

Result 3: A new source of gains from trade.

We have seen that the model captures the idea that export sales are particularly vulnerable to credit constraints and is qualitatively consistent with the empirical evidence from Section 1. What does the model predict for the gains from trade? In my partial equilibrium environment a convenient outcome to focus on is aggregate total factor productivity (TFP). I denote this quantity by Z and in Appendix B.1 show that a natural definition is,

$$Z = \frac{S^{\frac{\sigma}{\sigma-1}}}{L} \tag{16}$$

where S represents aggregate sales and L represents aggregate employment. To focus tightly on the role of financial frictions in distorting exports, I now impose some parameter restrictions: in addition to (15), I also assume $\lambda = 1$ and $\theta = 1$. The first assumption implies that borrowing constraints are loose enough that domestic sales are undistorted and thus allows me to focus solely on the export wedges t_X. The second assumption implies entrepreneurs are completely unable to borrow against their export sales, and instead gives self-financing by exporters a central role.

Theorem 1 implies that in steady state TFP can be written in terms of a representative exporter and a representative domestic firm. After some algebra, I obtain,

$$Z = \frac{\left(Z_D^{\sigma-1} + \left(1 + \tau^{1-\sigma}(1-t_X)^{\sigma-1}\right) Z_X^{\sigma-1}\right)^{\frac{\sigma}{\sigma-1}}}{\left(Z_D^{\sigma-1} + \left(1 + \tau^{1-\sigma}(1-t_X)^{\sigma}\right) Z_X^{\sigma-1}\right)},$$

$$Z_D = \left(\int_{\mathcal{D}} z^{\sigma-1}\right)^{\frac{1}{\sigma-1}}, \quad Z_X = \left(\int_{\mathcal{X}} z^{\sigma-1}\right)^{\frac{1}{\sigma-1}} \tag{17}$$

Notice that only the export wedge t_X appears in (17), because the assumption that $\lambda = 1$ eliminates any labor wedges. Inspecting (17) reveals that, starting from $t_X = 0$, increases in the export wedge depress aggregate TFP by misallocating labor across export and domestic production within exporting firms.

To investigate the implications for the gains from trade, I start with a small reduction in trade costs τ. Theorem 2 characterizes the effects of such a reduction over time.

Theorem 2. *Suppose the economy is initially in its steady state and experiences a small reduction in trade costs, denoted $\mathcal{T} = -\Delta \log \tau > 0$. If the shock occurs at time $t = 0$, the resulting change in TFP at time t is,*

$$\Delta \log Z(t) = \underbrace{X\mathcal{T}}_{\text{Mechanical}} + \underbrace{(X - E)\,\Delta \log\left(\frac{E(t)}{1-E(t)}\right)}_{\text{Reallocation}}, \tag{18}$$

where $X - E > 0$. In particular in the short run ($t = 0$) we have,

$$\Delta \log Z(0) = X\mathcal{T}, \tag{19}$$

while in the long run ($t \to \infty$) we have,

$$\Delta \log Z(\infty) = X\mathcal{T} + (X - E)(\sigma - 1)\,\mathcal{T}. \tag{20}$$

Proof. See Appendix B.3. ■

Theorem 2 tells us that the gains from a small reduction in trade costs can be decomposed into two components in the spirit of Baqaee and Farhi (2020). The first component captures the mechanical effect of lower trade costs. In my model this mechanical effect takes a standard form (see e.g., Atkeson and Burstein (2010)) and does not vary over time. From Theorem 1, we would expect that as financial frictions become more severe and exporters cut the share of exports in total sales, this mechanical effect will tend to shrink.

The second term is more interesting. It captures the dynamic gains that arise as exporters reallocate labor towards export production. Since exports were initially inefficiently low, as captured by the gap between their share in sales X and their share in employment E, this reallocation creates a second source of productivity gains. To clarify the link between credit constraints and these gains from reallocation, in Appendix B.1 I show that (18) can equivalently be written,

$$\Delta \log Z(t) = X\mathcal{T} + (X - E)\left(\frac{A_X}{wEL}\right)\Delta \log A_X(t), \tag{21}$$

where A_X is the total stock of internal funds held by exporter. Together Theorem 2 and equation 21 reveal that self-financing plays a cental role in the gains from trade in the presence of credit constraints. In the short run a reduction in trade costs mechanically raises TFP but, since exporters are constrained, it is impossible for any reallocation towards export production to occur, hence the absence of any reallocation effect in (19). Over time, as (21) shows, exporters gradually accumulate internal funds, relax their borrowing constraints, reallocate employment towards exports, and ultimately further raise aggregate TFP.

So far I have focused on small changes in trade costs. What about the bigger question of how much this economy gains from international trade relative to autarky? My final theorem provides a sufficient statistics result in the style of Arkolakis, Costinot, and Rodríguez-Clare (2012), henceforth ACR.

Theorem 3. *Let Z_A and Z_T denote steady state TFP under autarky and at some baseline level of trade costs, respectively. Then,*

$$\log Z_T - \log Z_A = \left(\frac{1}{1-\sigma}\right)\log\left(1 - X\right) - \log\left(1 - t_X X\right), \tag{22}$$

where X is the share of exports in total sales in the baseline equilibrium, and t_X is the export wedge in the baseline equilibrium.

Proof. See Appendix B.4. ■

Theorem 3 tells us that even for large changes in trade costs, we can still decompose the resulting change in TFP into two components. The first term is familiar from ACR. That paper shows that exactly this expression describes the gains from trade across a broad class of models and thus that, in many cases, a model's microfoundations are irrelevant for the gains from trade conditional on the trade share X and the trade elasticity $(\sigma - 1)$.[13] The second term in (22) shows that this is not the case here: even conditional on the trade share, the model's microfoundations still matter. This term is positive whenever $t_X > 0$, and increases with t_X. That is, conditional on the observed

[13]In my model the long-run trade elasticity is indeed $(\sigma - 1)$.

trade share, the gains from trade are generally *larger* when exports are more severely distorted, reflecting the gains from reallocation in (20).

Together, Theorems 1 – 3 highlight the nuanced relationship between financial frictions and the gains from trade. Tighter credit constraints make the economy less open, and this force mechanically shrinks the standard gains from trade. At the same time, a new source of dynamic gains from trade appears in my model. When export sales are distorted downwards by credit constraints – consistent with the evidence in Section 1 – lower trade costs induce asset accumulation by exporters and a gradual expansion of export production that ultimately magnifies the standard gains from trade.

2.3 Quantitative Model

The analytical model highlights the key forces at work but lacks important features emphasized by the macro-development and export dynamics literatures. In order to make a connection with the evidence in Section 1 and to evaluate the quantitative importance of the mechanisms studied above, I now enrich the model.

Transitory productivity shocks

Transitory productivity shocks are a standard feature of macro-development models, and their volatility and persistence have important consequences for the effects of financial frictions (Midrigan and Xu 2014; Moll 2014). In the context of my model, the presence of transitory shocks will mean that the constraint multipliers μ do not converge to a single value as in Lemma 1 but instead to a stationary distribution. This will in turn give rise to a distribution of export wedges across entrepreneurs. Formally, I assume that an entrepreneur's productivity has two components,

$$z = \exp\left(z_P + z_T\right). \tag{23}$$

The permanent component z_P is exogenous and Normally distributed,

$$z_P \sim \mathcal{N}\left(0, \sigma_P\right), \tag{24}$$

while the transitory component z_T follows an Ornstein-Uhlenbeck process,[14]

$$dz_T = -\phi z_T dt + \sigma_T dW, \tag{25}$$

where W is a Brownian motion.

[14]This is the continuous time analogue of an AR(1) process, with the parameter ϕ determining the speed of mean-reversion.

Physical capital

A key goal for the quantitative model is to enable a tight mapping between the theory and the evidence on PSL from Section 1. Since PSL eligibility was a function of physical capital, explicitly modeling capital accumulation is critical. I also incorporate convex capital adjustment costs as in Gopinath et al. (2017). This, too, is critical for making sense of PSL within the model, as adjustment costs make it impossible for entrepreneurs to instantly jump behind the PSL cutoff as soon as the policy is introduced.

The production function is now,

$$y = zk^{\alpha}l^{1-\alpha}. \tag{26}$$

As above, labor is supplied elastically at an exogenous wage w but remains subject to the working capital constraint. Physical capital is owned by entrepreneurs and evolves according to,

$$\dot{k} = i - \delta k \tag{27}$$

where i is investment. If the entrepreneur invests i, they incur costs given by

$$C(i,k) = i + \left(\frac{\gamma}{2}\right)\left(\frac{i}{k}\right)^2 k. \tag{28}$$

The parameter $\gamma \geq 0$ governs the importance of capital adjustment costs and thus the sensitivity of investment decisions to shocks.

Export entry and exit

Alessandria, Arkolakis, and Ruhl (2021) outline a canonical model of export dynamics in which export entry and exit are driven by a combination of sunk and fixed costs. I attempt to capture the spirit of this model in a simplified way while adding heterogeneity in the sunk export entry cost.[15] This heterogeneity turns out to be crucial for generating a realistic amount of overlap in the size distributions of exporting and domestic firms, which in turn is important for thinking about the contrasting effects of PSL eligibility across these two types of firm.

Opportunities to start exporting arrive with domestic entrepreneurs at a Poisson rate η. Whenever an entrepreneur draws an export opportunity, they also draw a sunk export entry cost F from a lognormal distribution,

$$\log F \sim \mathcal{N}(\mu_F, \sigma_F). \tag{29}$$

[15]Directly using the structure of Alessandria, Arkolakis, and Ruhl (2021) in my setting does not pose a conceptual challenge but is computationally burdensome. In continuous time the fact the export entry and exit are always an option for the entrepreneur in that model results in a Hamilton-Jacobi-Bellman Variational Inequality (HBVI) rather than the simpler Hamilton-Jacobi-Bellman (HJB) equations (91) and (94). While Achdou et al. (2022) suggest a strategy for solving HJBVI equations by recasting them as linear complementarity problems, this method becomes slow in the context of my moderately large state space. Adding heterogeneity in the sunk cost of export entry to this model would only worsen the problem by creating an additional state variable.

The entrepreneur must choose between paying the export entry cost and starting to export, or remaining a purely domestic entrepreneur. If the entrepreneur chooses to start exporting, they continue to do so until they experience an exit shock and return to being a domestic entrepreneur. These exit shocks arrive at an exogenous rate χ.

Dynamic problem and equilibrium

The state of an entrepreneur consists of their permanent productivity z_P, their transitory productivity z_T, their stock of internal funds a, their stock of physical capital k, and their export status $x \in \{0,1\}$. Profits are defined exactly as in (5) and (9), except that production now uses physical capital. The dynamic problem facing entrepreneurs is to choose consumption c and investment i to maximize expected utility, subject to the laws of motion for internal funds and physical capital, as well as the exogenous productivity and export cost processes. In Appendix B.1 I express the dynamic problem facing each type of entrepreneur using Hamilton-Jacobi-Bellman (HJB) equations and detail my numerical solution procedure. Note that I continue to impose a non-negativity constraint on internal funds a, forcing entrepreneurs to fully self-finance investment in physical capital. While extreme, this assumption may not be too misleading for India, a relatively financially underdeveloped country. The payoff is that I am able to focus more closely on the short-term borrowing entrepreneurs undertake to meet their working capital needs, rather than combining both short- and long-term borrowing in a single model.

As above, the model is set in partial equilibrium and wages w and interest rates r are exogenous and constant over time. At each point in time, the state of the economy is given by the distribution of entrepreneurs over the various state variables. This joint distribution, denoted g, may vary over time. In particular, given some initial value, g solves the Kolmogorov Forward Equation (KFE) implied by the HJB equations in B.1. In the counterfactual experiments in Section 4 my focus will be on aggregate TFP. I adjust the definition above to account for the presence of physical capital in the quantitative model,

$$Z = \frac{S^{\frac{\sigma-1}{\sigma}}}{K^{\alpha} L^{1-\alpha}}, \tag{30}$$

where K denotes the aggregate capital stock.

3 Calibration

This section calibrates the parameters of the quantitative model and assesses its empirical performance. Subsection 3.1 outlines my calibration strategy and Subsection 3.2 reports the results. Subsection 3.3 studies the model's predictions for a range of untargeted moments. Finally, Subsection 3.4 uses the calibrated model to revisit the RDD estimates of the effects of PSL from Section 1.

3.1 Calibration Strategy

I begin by externally calibrating the seven parameters and prices shown in Panel (a) of Table 4. The first four parameters, $(\alpha, \sigma, \delta, \rho)$, are set to standard values from the literature. Lacking a natural target for the arrival rate of export entry opportunities, I set $\eta = 1$. This choice ensures that my model mimics discrete time models where the decision to start exporting is made once per period. To pin down the real interest rate r, I calculate the average nominal interest rate reported by firms in Prowess (10.27%) and subtract inflation (9.30% in India between 2007 and 2011 (World Bank 2025a)). The resulting real interest rate, 0.97%, is low but similar to the value used Buera, Kaboski, and Shin (2021), who also calibrate a model of financial frictions in India and set the real interest rate equal to -0.17%. Finally, I normalize wages to one without loss of generality.

I calibrate the remaining parameters by targeting the effects of the PSL policy reported in Section 1 as well as salient features of the firm size distribution and firm dynamics taken from Prowess. I discuss each of these aspects of the calibration in detail below.[16]

PSL in the model

The role of PSL in my calibration strategy builds on Theorem 1, which showed that the effect of a looser borrowing constraint on the share of exports in total sales is closely tied to the export penalty parameter θ, with larger values of θ mapping to larger effects. Intuitively, therefore, we can use the effects of PSL eligibility on the export share to identify θ.

Exploiting this argument requires an analogue of the PSL policy within the model. In the model, an entrepreneur is eligible for PSL at time t if their capital stock at time t is below a cutoff k^*. The parameter λ, which captures banks' willingness to lend, now depends on an entrepreneur's capital stock via their PSL eligibility,

$$\lambda(k) = \begin{cases} \overline{\lambda} + \mathcal{P} & \text{if} \quad k \leq k^*, \\ \overline{\lambda} & \text{if} \quad k > k^*. \end{cases} \tag{31}$$

The introduction of PSL thus loosens the borrowing constraints of eligible entrepreneurs without affecting ineligible entrepreneurs. Here $\mathcal{P}$, which I will refer to as the PSL scale parameter, is the analogue of the shock to λ studied in Theorem 1. I will calibrate $\mathcal{P}$ alongside the other model parameters.

To implement the PSL policy, I assume that the model is initially in its steady state without PSL. Then at $t = 0$, PSL is introduced. The cutoff k^* is located at the 35th percentile of the steady state capital distribution, matching its position relative to firms in Prowess in PSL's first year, 2007. The introduction of PSL is unforeseen by entrepreneurs, but once the policy is in place they expect it persist indefinitely and account for it in their dynamic decision making. Entrepreneurs below the cutoff immediately become eligible while those above the cutoff do not, and over time

[16] Note that in general all the calibrated parameter values depend on all the moments discussed below, so that references to the identification of a particular parameter using a particular moment are purely heuristic.

an entrepreneur's eligibility will change as they adjust their capital stock. I simulate a large panel of entrepreneurs starting at $t = 0$ and follow them for five years, as in the empirical analysis in Section 1, and estimate RDD specifications that parallel those from Section 1. The particular results I target in my calibration are the effects of PSL eligibility on exporter borrowing (Column (4) of Table 2) and on the export share of continuing exporters (Column (3) of Table 3). These two estimates are reproduced in the first two rows of Table 5.

Additional targets from Prowess

The distribution of productivity across entrepreneurs is governed by the parameters $(\sigma_P, \sigma_T, \phi)$, which are identified by the moments from the sales distribution reported in rows 3 – 5 of Table 5. Following Midrigan and Xu (2014), I target the standard deviation of log sales and the standard deviation of changes in log sales to pin down the standard deviations of the permanent and transitory components of productivity, σ_P and σ_T. In the spirit of Gopinath et al. (2017), to pin down the mean-reversion parameter ϕ I run the following regression,

$$\log\left(sales_{it}\right) = a_i + b_t + \hat{\beta}\log\left(sales_{it-1}\right) + \epsilon_{it}, \tag{32}$$

where i indexes firms and t indexes years. Here a_i and b_t are firm and year fixed effects, respectively. Row 5 reports $\hat{\beta} = 0.443$ (s.e. $= 0.017$). I simulate a large sample of firms from the model, run the same regression, and require the model analogue of $\hat{\beta}$ to match its counterpart in the data.

The capital adjustment cost parameter γ determines the sensitivity of investment with respect to transitory productivity shocks. To identify this parameter, I again borrow from Gopinath et al. (2017) and run the following regression,

$$\Delta\log(capital_{it}) = c_t + \hat{\zeta}\Delta\log(sales_{it}) + \epsilon_{it}. \tag{33}$$

Here c_t is a year fixed effect. The idea behind (33) is that sales growth proxies for transitory productivity shocks and so the coefficient $\hat{\zeta}$ is informative about the sensitivity of capital to productivity shocks, and so in turn is informative about γ. Row 6 reports $\hat{\zeta} = 0.094$ (s.e. $= 0.008$). I simulate a large sample of firms from the model and run the same regression, and pin down γ by requiring the model-implied regression coefficient matches its counterpart in the data.

Export sales and transitions in the model are governed by the parameters $(\tau, \mu_F, \sigma_F, \chi)$. The iceberg cost τ is pinned down by the share of sales sold abroad conditional on exporting (row 7). The average cost of export entry μ_F is naturally tied to the share of firms that export (row 8). The dispersion of these costs is governed by σ_F and determines the extent to which the exporter and non-exporter size distributions overlap. In the context of my calibration strategy, a natural statistic that summarizes this overlap is the share of exporters below the PSL cutoff (row 9). Finally the exogenous exit rate χ is closely tied to the persistence of exporting (row 10).

The final parameter to pin down is $\overline{\lambda}$, which determines the tightness of the borrowing constraint for entrepreneurs ineligible for PSL. I identify this parameter by targeting the ratio of total borrowing to total sales.[17] The only subtlety is that in calculating aggregate borrowing in Prowess I restrict attention to bank loans rather than considering all borrowing. The constraints (3) and (8) represent short-term borrowing intended to meet an entrepreneur's working capital needs. Consistent with the discussion of the role of bank lending in Banerjee and Duflo (2014), I identify such short-term borrowing in the model with bank lending in the data.

3.2 Results

Panel (b) of Table 4 reports the internally calibrated parameters and Panel (a) of Table 5 compares the values of the targeted moments in the calibrated model and the data. With 11 parameters targeting 11 moments, the model matches the data closely.

The key parameter in the model is θ, the penalty associated with export sales in the borrowing constraint. My calibration finds $\theta = 0.471$, implying that while an additional 100 rupees of do-

Table 4: Calibrated parameters

	Parameter	**Description**	**Value**
	(a) Externally calibrated		
1.	α	Capital share	0.300
2.	σ	Demand elasticity	6.667
3.	δ	Depreciation rate	0.070
4.	ρ	Discount rate	0.130
5.	η	Export entry opportunity arrival rate	1.000
6.	r	Real interest rate (%)	0.970
7.	w	Wage	1.000
	(b) Internally calibrated		
8.	θ	Export penalty	0.471
9.	$\mathcal{P}$	PSL scale	0.184
10.	σ_P	Standard deviation of productivity (permanent)	0.331
11.	σ_T	Standard deviation of productivity (transitory)	0.217
12.	ϕ	Persistence of productivity (transitory)	0.508
13.	γ	Capital adjustment costs	2.100
14.	μ_F	Mean export entry cost	2.726
15.	σ_F	Standard deviation of export entry cost	5.138
16.	χ	Export exit rate	0.081
17.	τ	Iceberg cost	1.126
18.	$\overline{\lambda}$	Borrowing constraint	0.526

Notes: Demand elasticity σ chosen to imply returns to scale $(\sigma - 1)\sigma^{-1}$ equal to 0.85 as in Midrigan and Xu (2014). Discount rate ρ taken from Gopinath et al. (2017). Parameters in Panel (b) chosen to minimize squared distance between model and data moments reported in Panel (a) of Table 5.

[17] To match the concept of sales in the model, which are purely value added, I multiply sales in the data by a value added share of 40% as in Section 1. I apply the same scaling to the moments in rows 15 and 16 of Table 5.

mestic sales relaxes an entrepreneur's borrowing constraint by 52.6 rupees ($= \overline{\lambda}$), the equivalent figure for export sales is just 5.5 rupees ($= (\overline{\lambda} - \theta)$). Figure 2 illustrates the role of this parameter. In Panel (a) I hold all other parameters constant and vary θ between 0 and 0.50. On the y-axis I plot the resulting effect of PSL eligibility on the export share, as measured by the model RDD. Consistent with the intuition from Theorem 1, there is a clear positive relationship between θ and the effect of PSL. My calibration implies a large value for θ exactly because in Section 1 I found a large effect of PSL on the export share. In Panel (b) I plot the resulting distribution of export wedges t_X across entrepreneurs in the steady state of the calibrated model. Recall from Section 2 that a positive value for t_X is like a tax that distorts an entrepreneur's export sales downward. In the calibrated model this wedge varies across entrepreneurs depending on their productivities, capital stocks, and stocks of internal funds: the average wedge is 0.0560, while an unfortunate entrepreneur at the 90th percentile of the wedge distribution faces a wedge equal to 0.101 and just over 10% of exporters have a zero wedge and are therefore unconstrained. The result of these wedges is that export sales are inefficiently low. The average exporter sells just under 25% of their

Table 5: Model and data moments

	Moment	**Data**	**Model**
	(a) Targeted		
1.	PSL effect on exporter borrowing	0.354	0.354
2.	PSL effect on export share	0.058	0.058
3.	Standard deviation of log sales	1.874	1.870
4.	Standard deviation of log sales growth	0.459	0.458
5.	Regression coefficient $\hat{\beta}$ in (32)	0.443	0.442
6.	Regression coefficient $\hat{\zeta}$ in (33)	0.094	0.094
7.	Share of firms exporting	0.479	0.480
8.	Share of exports in total sales	0.248	0.248
9.	Share of exporters eligible for PSL	0.263	0.265
10.	Persistence of export status	0.928	0.928
11.	Aggregate borrowing - sales ratio	0.426	0.426
	(b) Untargeted		
12.	Exporter size premium, log sales	1.613	1.439
13.	Exporter size premium, log employment	1.608	1.402
14.	Exporter size premium, log capital	1.358	1.432
15.	Borrowing - sales ratio, domestic firms	0.612	0.498
16.	Borrowing - sales ratio, exporters	0.391	0.398
17.	Export intensity in first year of exporting	0.091	0.094
18.	Export intensity change over first four years exporting	0.067	0.141

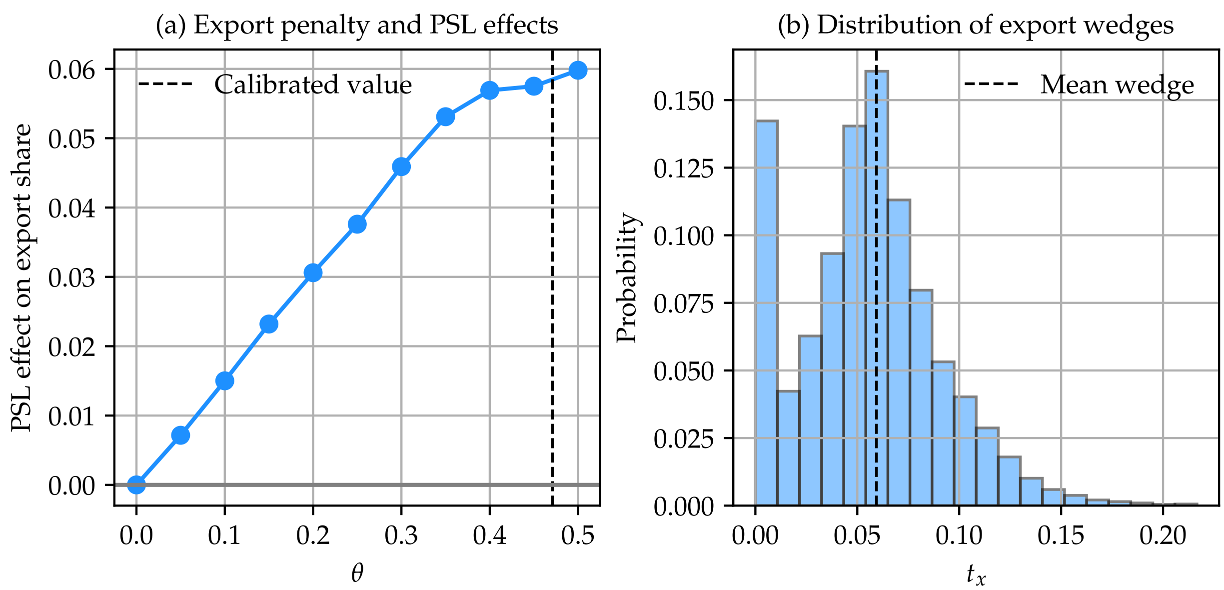
Notes: Values in Data column calculated using manufacturing firms in Prowess. Exporter size premia in rows 12 – 14 obtained from a regression including year and industry fixed effects. For more details see Appendix A.1. Values in Model column taken from steady state of model with parameters as in Table 4.

output abroad in the model's steady state, but if all wedges were removed this number would rise to 32%..

The results for the remaining parameters are as expected and I keep my discussion brief. Both components of productivity are important, with the transitory component volatile but not very persistent, in line with the literature (Midrigan and Xu 2014; Gopinath et al. 2017). The calibrated value for capital adjustment costs, γ, is not too far from, but somewhat lower than, comparable estimates in Gopinath et al. (2017) and Winberry (2021). The export entry cost F is, on average, large, but because potential exporters tend to wait for a favorable draw, the actual costs paid by new exporters are smaller: the entry cost paid by a new exporter amounts to 28% of their first-year export revenues on average.

Finally, the calibrated value of $\overline{\lambda}$ implies that purely domestic entrepreneurs are able to borrow a little under 53% of the value of their sales to meet their working capital needs. We can compare this figure to the RBI's guidelines as described in Banerjee, Cole, and Duflo (2004). The RBI recommends that banks meet no more than 80% of a firm's working capital needs, with the rest coming from internal funds. The RBI in turn recommends that banks estimate a firm's working capital needs to be 25% of turnover, i.e., sales. Putting these numbers together, the RBI recommends that banks lend firms at most 20% of their sales. However, note that sales in my model are purely value added, while sales in the data at least partly reflect intermediate inputs. Assuming a value added share of 40%, the RBI's recommended borrowing constraint is 50% of value added, reassuringly similar to the figure of 53% implied by my calibration.

Figure 2: Calibration results



Notes: Panel (a) varies the export penalty parameter θ between 0 and 0.5 and re-runs the model RDD, holding other parameters constant. Panel (b) shows a histogram of the export wedges t_X implied by the calibrated model's steady state.

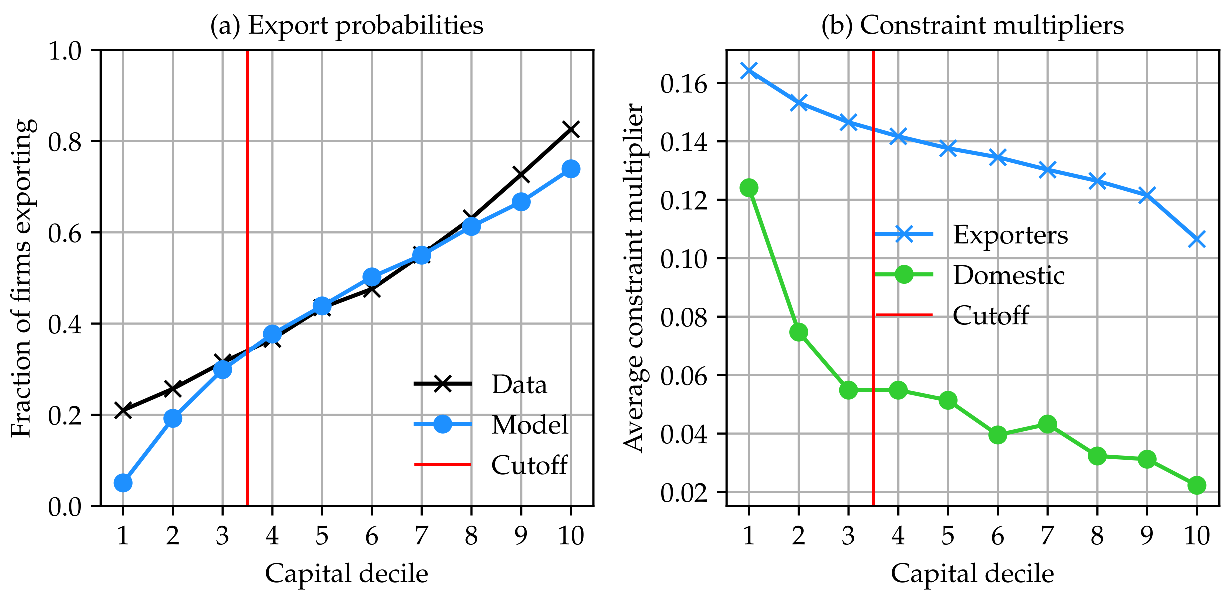
3.3 Validation

The model matches the target moments in Panel (a) of Table 5 well, but with 11 parameters targeting 11 moments this is hardly surprising. I therefore evaluate the model by assessing its fit on a number of untargeted moments from Prowess, reported in Panel (b) of Table 5.

Around the world, exporters are much larger than purely domestic firms (Bernard, Jensen, et al. 2007). This is also true for the Indian manufacturing firms in Prowess. Rows 12 – 14 of Table 5 report exporter premia — the difference in average log size between exporters and domestic firms, controlling for year and industry fixed effects — for different measures of size. My calibration does not directly target any measures of the exporter premium, but nevertheless comes close to matching these moments. More broadly, Panel (a) of Figure 3 plots the probability a firm exports as a function of its size in terms of capital stock deciles in model and data. My calibration targets the overall share of exporters, as well as the share below the PSL cutoff, but Figure 3 shows that the model also does a good job of matching the data throughout the capital distribution, except perhaps among the very smallest firms.

A key feature of my model is the penalty associated with export sales in the borrowing constraint. A natural prediction is that we should therefore observe exporters borrowing less, relative to their sales, than domestic firms. Rows 15 and 16 of Table 5 report aggregate borrowing-sales ratios, separating firms by export status. Consistent with the model, exporters in the data borrow less than domestic firms given their sales. If anything, given the large gap in borrowing between

Figure 3: Firm characteristics by capital decile



Notes: Panel (a) shows the probability a firm exports by deciles of the capital distribution in the data (crosses) and in the calibrated model's steady state (dots). Panel (b) shows averages of the Lagrange multiplier μ on entrepreneurs' borrowing constraints by capital decile, again taken from the calibrated model's steady state, separated into exporters (crosses) and domestic entrepreneurs (dots). In both panels the vertical line shows the PSL cutoff.

exporters and domestic firms in the data, the model does not penalize export sales enough.

Finally, the dynamics of new exporters can be informative about the presence of financial frictions (Kohn, Leibovici, and Szkup 2014). In rows 17 and 18 of Table 5 I focus on the average export sales share of new exporters and the change in this share over the first four years of an export spell for continuing exporters. Exporters in India start off exporting relatively little, just 9% of total sales relative to an average across all exporters around 25%.[18] Their export share then grows slowly over time, increasing by just over 6 percentage points in the first four years. The model replicates this pattern qualitatively: exporters in the model start with an export intensity just over 9%, and this number grows by 14 percentage points over the first four years of an export spell as they accumulate internal funds and loosen their borrowing constraints. Relative to the data, in the model export shares grow too quickly, suggesting that other forces besides credit constraints contribute to the dynamics of new exporters: examples would be gradual investments to reduce export costs (Alessandria, Choi, and Ruhl 2021) and search and learning (Eaton et al. 2021).

3.4 Revisiting PSL

To close this section, I return to the PSL policy studied in Section 1 armed with the calibrated model and pose two questions. First, what does the model say about the near-zero effects I found for purely domestic firms? And second, what does the model reveal about the usefulness of PSL as a natural experiment?

My calibration strategy did not target any effects of PSL on domestic firms. I now estimate these effects in the model using RDD specifications that parallel those I ran in Section 1. I obtain point estimates of 0.098 and 0.050 for the effects of PSL on log borrowing and log sales, respectively. These numbers are not significantly different from the effects I found in Section 1 (0.013 and 0.00). The implication is that the near-zero effects I found should not be surprising: they are in fact not far from the predictions of the model of firm dynamics and financial frictions I have calibrated here. This is not because credit constraints do not matter for domestic firms at all. Panel (b) of Figure 3 plots the average constraint multiplier μ by deciles of the capital distribution, separating entrepreneurs by their export status. At the bottom of the size distribution multipliers are large for all firms. 100 additional rupees of internal funds would generate 12 rupees of profit for a domestic entrepreneur and 16 rupees of profit for an exporter. But, as Panel (b) shows, as domestic entrepreneurs grow larger constraints quickly become irrelevant while they remain an important obstacle even for large exporters.

Now I turn to the second question. While certainly informative, the PSL policy is not a perfect experiment. As well as the direct effect of loosening borrowing constraints, PSL also gave firms an incentive to sort around the eligibility cutoff. This is a potential source of bias in my empirical estimates, although the bunching and placebo checks reported in Section 1 do lessen this concern.

[18] Bernard, Bøler, et al. (2017) point out that partial-year effects exaggerate the extent to which new exporters start small. Since I obtain the model moments by simulating the trajectory of firms over very small time increments and then aggregating up to an annual frequency, the same partial-year effects are present in the model and the comparison between model and data is still informative.

More broadly, the structure of PSL means it is not obvious how far my findings generalize to other settings. Because I explicitly model the PSL cutoff and entrepreneurs' decisions to sort around it, these issues do not pose a challenge for my calibration strategy. Instead, I am able to use the calibrated model to assess how closely the effects of PSL mimic those I would obtain from a 'perfect' experiment. I implement such a perfect experiment in the model as follows: I draw a large random sample of entrepreneurs with capital stocks equal to k^* from the model's steady state (without PSL) and once-and-for-all loosen their borrowing constraints by the same amount $\mathcal{P}$ that I calibrated above. I then follow these treated entrepreneurs over five years and compare their outcomes to those of untreated entrepreneurs who started at the same point in the capital distribution. Focusing on the outcomes in the first two rows of Table 5, I find that treated exporters in the model increase their borrowing by 0.398 log points, and conditional on continuing to export increase their export shares by 4.2 percentage points. These effects are reassuringly similar to those produced by the real PSL policy.[19] The implication is that, seen through the lens of the model, PSL is a reasonably good approximation to the perfect experiment.

4 Exporters, Credit Constraints, and Misallocation

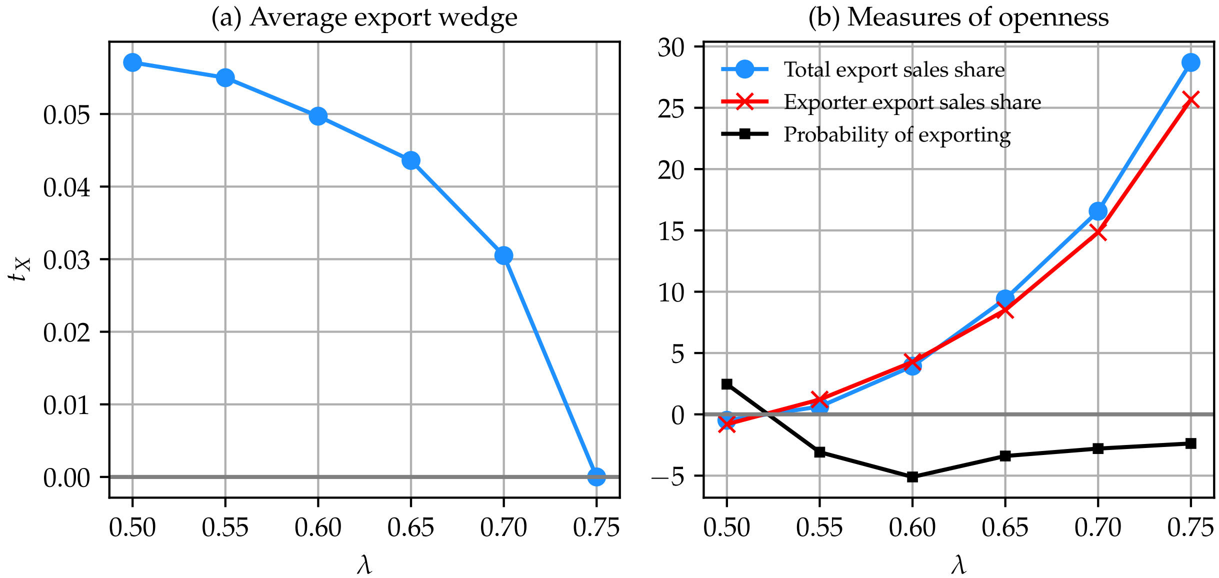
With the calibrated model in hand, I now quantify the relationship between credit constraints and the gains from trade and also ask how a policymaker might respond to these distortions. Throughout, as in Section 2, my focus will be on aggregate TFP, defined as in (30).

4.1 Financial Development and Openness

Does financial development make the economy more open to international trade? To answer this question I vary the parameter λ, which determines the tightness of borrowing constraints, and compare the resulting steady states of the model. I vary λ between 0.500, just below the calibrated value of 0.525, and 0.750, at which point credit constraints cease to bind for all entrepreneurs. Panel (a) of Figure 4 plots the resulting export wedges t_X as a function of λ while Panel (b) shows the effects on different measures of openness. Given the empirical results in Section 1 and the theoretical results in Section 2, it is not surprising that looser borrowing constraints lessen the distortions facing export sales and ultimately result in greater openness. The effects are quantitatively large: the share of exports in total sales rises from 0.178 at $\lambda = 0.525$ to 0.230 at $\lambda = 0.750$, as the solid line in Panel (b) shows. This increase is mainly explained by changes along the intensive margin, shown by the dashed line in Panel (b). In contrast, the relationship between financial development and the share of entrepreneurs exporting, shown by the dotted line in Panel (b), is

[19] Relative to the PSL policy, the effect on borrowing is slightly larger (0.398 vs 0.354) and the effect on export intensity is slightly smaller (4.2 percentage points vs 5.8). This is because the perfect experiment, without the cutoff, allows firms to direct some of the new slack in their borrowing constraints towards investment in physical capital. This leads to higher borrowing and leaves less slack available for expanding export sales. When eligibility instead depends on the cutoff, eligible firms close to the cutoff are dissuaded from such investment because increases in capital would cause them to lose eligibility.

Figure 4: Financial Development and Openness



Notes: Both panels vary the borrowing constraint parameter λ between 0.50 and 0.75. The line in Panel (a) shows the average export wedges in the resulting steady steady states of the model. Panel (b) shows the resulting share of exports in total sales (dots), the average share of exports in the sales of exporters (crosses), and the fraction of firms exporting (squares).

weak and even non-monotone. The explanation for this pattern is that as λ rises domestic entrepreneurs rely more on borrowing and shrink their stocks of internal funds. When they draw an opportunity to start exporting, some domestic entrepreneurs are then unable to pay the sunk entry cost out of their internal funds.

Financial development also has important effects on other macro aggregates in the model. As λ rises and credit constraints are relaxed, sales, employment and capital all rise. Compared to $\lambda = 0.525$, at $\lambda = 0.750$, employment is 25% higher, capital is 14% higher, and total sales are 19% higher. Moving to $\lambda = 0.750$ also raises aggregate TFP, but only by 0.38%. Of course, the effects of financial development on aggregate TFP have been extensively studied elsewhere (Buera, Kaboski, and Shin 2011; Midrigan and Xu 2014; Moll 2014). In the context of my paper, the more interesting question is what financial frictions imply for the gains from international trade. It is to this question I now turn.

4.2 The Gains from Trade

Above we have seen that credit constraints generally make the economy less open in terms of the share of total sales exported. A natural conclusion would be that credit constraints should therefore reduce the gains from trade. However, from Theorem 2 we also know that credit constraints create a new source of gains from trade through reallocation. I now use the calibrated model to quantify these opposing forces. In the spirit of the analytical model, I start by analyzing the effects of a small reduction in trade costs, then turn to larger shocks.

The gains from a small shock

Consider a small reduction in trade costs $\mathcal{T} = -\Delta \log \tau > 0$. As in Theorem 2, I decompose the resulting change in TFP into two components,

$$\Delta \log Z = \underbrace{\Delta \log Z_M}_{\text{Mechanical Effect}} + \underbrace{\Delta \log Z_R}_{\text{Reallocation}}, \tag{34}$$

where the mechanical effect is defined as the effect of a change in trade costs holding all the decisions of entrepreneurs — employment, investment, export entry, and so on — fixed, and the reallocation effect captures additional gains or losses from allowing entrepreneurs to adjust along these margins. Just as in the analytical model, the mechanical effect can be calculated by hand,

$$\Delta \log Z_M = X\mathcal{T} \tag{35}$$

where X is the share of exports in total sales. In the quantitative model I cannot calculate the reallocation effect by hand, as in Theorem 2, but instead I infer it from (34) as a residual.

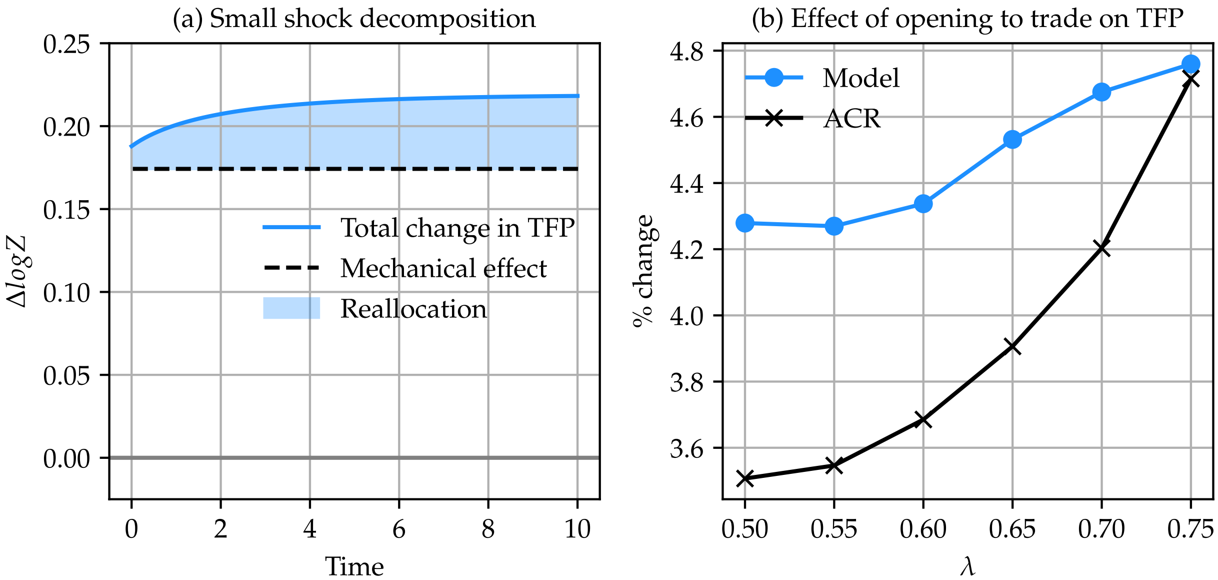
Panel (a) of Figure 5 implements this decomposition by shocking the model with a 0.1% reduction in trade costs. The solid line shows the total effect of this change on TFP over 10 years, normalized by $\mathcal{T}$, while the dotted line shows the mechanical effect. The shaded area shows the contribution of reallocation to the overall change in TFP. In line with the intuition from Theorem 2, the importance of reallocation grows over time. In the long run the reallocation effect is 21.1% as large as the mechanical effect of lower trade costs.

In the analytical model, in which export entry was exogenous and credit constraints were the only distortion, this reallocation effect could be completely attributed to financial frictions. The quantitative model, however, features an endogenous export decision and capital adjustment costs, as well as a non-negativity constraint on internal funds that will generally distort the allocation of physical capital. In principle these aspects of the model could also contribute to the gains from reallocation seen in Panel (a). To isolate the role of credit constraints specifically, I repeat the same shock to trade costs in an economy with $\lambda = \infty$, so that credit constraints never bind. Focusing on the long run, in this economy the mechanical effect of the shock is larger than in the baseline economy ($0.230\mathcal{T}$ vs $0.178\mathcal{T}$) but the reallocation effect shrinks ($0.014\mathcal{T}$ vs $0.038\mathcal{T}$). In particular, measured as a fraction of the mechanical effect, reallocation now accounts for only 6% of the gains from the reduction in trade costs.

The gains from a large shock

I now turn to a more economically interesting question: starting from autarky, how much does the economy gain from moving to the observed level of trade costs? I conduct the following

Figure 5: The gains from trade



Notes: In Panel (a), the solid line shows the total change in TFP caused by a small reduction in trade costs, the dashed line shows the mechanical effect of this shock, and the difference between them is the reallocation effect defined by (34). Panel (b) varies λ between 0.50 and 0.75. The line with crosses plots the resulting gains from trade, defined as the percentage difference between autarky TFP and TFP at the baseline level of trade costs. The line with dots shows the gains implied by (36).

experiment. I first solve for the steady state of the model under autarky, i.e., with $\tau = \infty$. I then open the economy to international trade by setting τ equal to its value in Table 4. In the long run employment, capital, and total sales rise by 17%, 19%, and 19%, respectively, and aggregate TFP rises by 4.28%. The transition dynamics of all of these variables are shown in Appendix Figure 7.

Is this effect on TFP large or small? Theorem 3 suggests using the ACR formula below as a benchmark,

$$\Delta \log Z_{ACR} = \left(\frac{1}{1-\sigma}\right) \log(1 - X). \tag{36}$$

Even in the quantitative model, if capital and labor are efficiently allocated across firms then (36) exactly describes the gains from trade. Plugging the baseline export sales share, 0.178, and the value for σ in Table 4 into (36) yields gains from trade of 3.53%. The long run gains from trade are therefore about 21% larger in the quantitative model than they would be in a frictionless economy with the same trade share.

It is important to be precise about the interpretation of this number. The implication is not that the gains from trade are necessarily higher in the economy with credit constraints compared to an otherwise identical economy without those constraints. Notice that (36) conditions on the share of exports in total sales, X, which we have seen itself depends on the severity of financial frictions. The correct interpretation is therefore that *for a given level of openness, as captured by the export sales share X, the economy with frictions gains more from trade*. Put another way, an econometrician who observed only the export share and erroneously assumed it to have been generated by a frictionless economy would underestimate the gains from trade in this economy.

To clarify the role of credit constraints in this result, I repeat the same experiment over a range of values of λ and plot the results in Panel (b) of Figure 5. The line with crosses shows the changes in TFP implied by the model, while the line with dots shows those implied by the ACR formula. There are two important takeaways. First, when λ is sufficiently large, the gains from trade implied by the model are almost identical to those implied by the ACR formula. The differences between the two lines at lower values of λ therefore reflect the role of credit constraints. Second, while the ACR formula predicts that the gains from trade should fall steeply as λ declines, the model reveals a much shallower (and even non-monotone) relationship. This is exactly because reductions in the standard gains from trade — those captured by the ACR formula — are being offset by the reallocative gains illustrated in Panel (a).

My quantitative results so far show that the relationship between financial frictions and international trade is nuanced. Figure 4 shows that as credit constraints are tightened, the economy becomes less open. But, as Panel (a) of Figure 5 shows, credit constraints also create the possibility of dynamic gains from reallocation towards export production. Overall, Panel (b) of Figure 5 shows that when these two forces are combined, the gains from trade do decline somewhat as credit constraints are tightened, but they are still higher than one would predict based on the sufficient statistics approach of ACR. In other words, less financially developed countries actually stand to gain *more* from international trade than we would have expected, thanks to the gains from reallocation.

4.3 Export Promotion Policies

Export promotion policies – subsidies directed towards export sales and exporting firms – are a ubiquitous policy tool. For example, Itskhoki and Moll (2019) document their widespread use in East Asia's 'miracle economies'. My model provides a natural laboratory in which to study their effects.

From the analytical model of Section 2 we know that export sales are distorted downwards because of the penalty associated with exports in the borrowing constraint, θ. Additionally, since exporters are typically more constrained than domestic firms, total employment in exporting firms is also generally distorted downwards. Natural policy instruments to tackle these distortions would be an export sales subsidy, denoted ν_X, and an exporter employment subsidy, denoted ν_L.[20] In Appendix B.7, I use the analytical model to study the effectiveness of a simple export promotion policy consisting of an export sales subsidy ν_X and an exporter employment subsidy ν_L. I find that, in the long run, these two instruments can completely eliminate the distortions created by credit constraints and restore TFP to its first-best level. As might be expected from

[20] Throughout I assume these subsidies are funded by a proportional tax on the consumption of entrepreneurs. In my context this is a convenient assumption because, thanks to the assumption of log utility, it does not distort any entrepreneurs' decisions.

earlier results, self-financing by exporters plays a crucial role. These subsidies raise TFP by raising the constraint multiplier of exporters, inducing them to gradually accumulate internal funds and undo their borrowing constraints. This result is reminiscent of the optimal policy in Itskhoki and Moll (2019), but whereas policy in their model tries to induce higher aggregate saving, in mine the goal is to target a particularly constrained subset of entrepreneurs, namely exporters.

Next I turn to the quantitative model, and focus on the export sales subsidy ν_X in isolation.[21] It turns out that the effects of a small subsidy are proportional to the reallocation effect in (34). From Panel (a) of Figure 5, we know this is positive and thus that, even in the quantitative model, an export sales subsidy must be able to raise TFP. To quantify the potential gains, I search for the value of ν_X which maximizes steady state TFP. The optimal subsidy is $\nu_X = 0.0613$, and this subsidy raises steady state TFP by 0.13%. These gains are nontrivial but quantitatively modest. To put them in context, I conduct a simple wedge accounting exercise in which the export wedges t_X are set to zero for all firms while holding all labor and capital wedges constant. Eliminating this distortion raises TFP by 0.77%. The optimal export subsidy thus achieves only about $0.13/0.77 \simeq$ 17% of the gains we might have hoped for.

Why is the export sales subsidy relatively ineffective? The key reason is that it is a blunt instrument that gives the same incentives to very different entrepreneurs. In the analytical model this is not an issue because, from Lemma 1, the model behaves as if there is a representative exporter with a single export wedge. Recall from Panel (b) of Figure 2 that this is certainly not the case in the quantitative model: export wedges vary widely across entrepreneurs. While the subsidy ν_x can shift the average export wedge, it does nothing to resolve this dispersion. To see this, let us return to the wedge accounting exercise above and consider the effects of simply reducing all export wedges by the amount of the optimal subsidy, 0.0613, without eliminating dispersion across exporters. The result is an increase in aggregate TFP of just 0.08%, compared to 0.77% from eliminating wedges entirely.

Methodologically, these results illustrate the importance of going beyond the tractable representative exporter framework of Section 2. Substantively, they suggest that the gains from simple export promotion policies like those considered here may be limited. On the other hand, they do highlight the potential of more targeted policies. Carefully thinking through how a policymaker might target the most constrained exporters lies beyond the scope of this paper but is an interesting challenge for future research.

5 Conclusion

My main findings can be summarized in three points. Empirically, I have provided evidence from India's Priority Sector Lending policy showing that exports are particularly vulnerable to credit constraints: a shock that allowed exporters to borrow about 35% more caused them to in-

[21] I have also considered policies which combine exporter sales and employment subsidies. The results are very similar to those obtained using the sales subsidy alone.

crease the share of exports in total sales from just under 25% to just over 33%. Theoretically, I have shown that when export sales are distorted by credit constraints in this way, new gains from trade emerge. Lower trade costs induce exporters to accumulate internal funds, relax their credit constraints, expand exports, and ultimately resolve misallocation. Finally, I quantified the importance of this mechanism by calibrating a model of trade, firm dynamics, and financial frictions to the evidence from Priority Sector Lending. The gains from reallocation towards constrained exporters magnify the standard gains from trade by about one-fifth. Rather than having less to gain from deepening international integration, less developed economies with important financial frictions actually stand to gain more than one would expect given their baseline level of openness.

Throughout, my approach has been to develop a tight connection between estimates of the effects of credit constraints from a natural experiment at the micro level with a rich quantitative model capable of speaking to macro questions. This approach has a number of strengths. First, the credibility of my empirical estimates hinges on relatively transparent identifying assumptions rather than the details of the particular model I propose. Second, the addition of the model allows me to critically evaluate the usefulness of the natural experiment by comparing it to an idealized randomized control trial performed within the model. And third, with the model in hand I am able to connect the empirical evidence to broader questions like the gains from international trade and the potential of export promotion policies.

Looking ahead, an exciting avenue for future research is to more deeply explore the connections between trade and industrial policies, especially as they relate to credit constraints. Existing policies around the world already seem to acknowledge the presence of distortions in this area alongside the potential for important aggregate gains. To give just one example, Matray et al. (2024) describe export credit agencies as "the predominant tool of industrial policy." My results highlight that the endogenous decisions of exporters to loosen (or tighten) their borrowing constraints over time, as well as the substantial heterogeneity within the set of exporters, will be critical in determining the success or failure of such policies.

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A Empirical Appendix

A.1 Data

I use data from the Prowess dataset compiled by CMIE. Specifically, I consider firms in the 'manufacturing superset', as defined by CMIE. This includes all firms which have ever been classified as manufacturing firms by Prowess. To ensure that my sample consists of firms that are still in manufacturing, I drop any firm-year observations in which a firm does not report selling any manufacturing products. I am able to do so because Prowess includes information on the specific products produced by a firm. Prowess groups firms into industries based on India's National Industrial Classification (NIC). When constructing industry fixed effects I use four-digit codes and 150 distinct industries appear in my data. India's financial year ends in March, and I refer to the financial statements ending in March of calendar year $t + 1$ as data from year t. Firms differ in the time span their financial statements cover: although most report information covering 12 months, a few report information for shorter timespans. Where this is the case, I rescale the flow variables (wage bills, sales, and exports) to a yearly frequency.

In the RDD specifications in Section 1, I take 2004 to be the base year, and limit the sample to firms with non-missing and strictly positive sales in this year. I define exporters as firms with non-missing and strictly positive export sales and define all other firms to be domestic. I then only include firm-year observations between 2007 and 2011 in my RDD sample if they have non-missing and strictly positive values for sales, wage bills, borrowing, and gross plant and machinery, the running variable in the RDD.

In the calibration exercise in Section 3, I do not limit the sample to firms with non-missing and strictly positive sales in the base year, but I do drop firm-year observations with missing or zero values for sales, wage bills, or gross plant and machinery. I calculate the target moments using data from 2005-2011. I choose to use the slightly longer sample (i.e., the entire period after the change in the PSL cutoff was announced) because the coefficient on lagged sales in (32) is biased downward in short panels when a firm fixed effect is included in the regression. To minimize the influence of outliers in the calibration targets, when I calculate standard deviations in Rows 3 and 4 of Table 5 I drop the largest 1% of observations in absolute value. I perform the same drop when calculating the corresponding moments generated by the model.

A.2 Priority Sector Lending Details

In this section I supplement the description of Priority Sector Lending (PSL) provided in the main text. To do so I draw on Banerjee and Duflo (2014) and Rotemberg (2019), as well as the guidelines issued by the Reserve Bank of India (RBI), who administered PSL.[22] PSL was (and, with some changes, remains today) a directed credit policy which mandated Indian banks to allocate a specific fraction of their lending to the *priority sector*. The priority sector was defined to include

[22] I rely on the 'Master Circulars' on priority sector lending issued each year in June or July by the RBI, downloaded from the RBI's website at `https://rbi.org.in/Scripts/BS_ViewMasterCirculardetails.aspx`

agriculture and the *weaker sections* (a collection of categories including small farmers, the urban poor, and certain minorities), as well as relatively small enterprises in manufacturing and services. At times, as discussed below, export credit was also included in the priority sector.

Outline

In the period I study, PSL mandated that all banks allocate at least 40% of net credit to the priority sector, as defined above. Banerjee and Duflo (2014) study the lending decisions of one large bank in detail and document that the bank's priority sector lending share was generally close to 40%, implying that the quota was a binding constraint on the bank's lending decisions. Banks that failed to meet the quota were obliged to lend money to government agencies at very low rates of interest (Banerjee and Duflo 2014); thus, banks had a strong financial incentive to lend to priority sector firms.

Eligibility

I focus on manufacturing enterprises. As Banerjee and Duflo (2014) document, the eligibility requirements for this group have changed over time. Up to 2005, membership of the priority sector was restricted to *small scale industries*, defined as manufacturing enterprises with plant and machinery (at original cost, i.e., gross) below 10 million rupees. In principle, this lower eligibility threshold could be exploited in an RDD in exactly the same way as the higher threshold used in the main text. In practice, however, Prowess' coverage of such small firms is minimal, especially for the earlier years when this threshold was applied, so I do not pursue this strategy.

In May 2005 the government introduced the Small and Medium Enterprises Development Bill in the Lok Sabha (the lower house of India's parliament), and this bill was passed as the Micro, Small and Medium Enterprise Development Act in June 2006. This Act broadened membership of the priority sector to include the new category of *micro and small enterprises* (MSEs), defined as enterprises with gross plant and machinery below 50 million rupees. The Act also defined *medium enterprises* as those with gross plant and machinery between 50 and 100 million rupees, but these enterprises were not included in the priority sector. The RBI first used the new definition in its directive to banks on PSL issued in April 2007 (RBI 2007). Given that India's financial year ends in March, I define 2004 (i.e., financial statements running from April 2004 up to March 2005) as the final pre-policy-change year and use data from this year to define a firm's export status and construct base year controls. I take 2007 (i.e., financial statements running from April 2007 up to March 2008) as the first post-policy-change year, and start measuring the effects of PSL in this year.

These PSL eligibility criteria continued to be used unchanged until July 2012, when the rules around export credit were changed (RBI 2012). Although, as discussed below, this change is not critically important for my estimation strategy, being five years after the introduction of the new cutoff it provides a natural endpoint. I therefore use 2011 (i.e., financial statements running from April 2011 up to March 2012) as the final year in my main specifications. A more substantial change occurred in April 2015, when (i), the definition of the priority sector was expanded to include medium enterprises, i.e., those with plant and machinery below 100 million rupees; and (ii), enterprises were allowed to retain their priority sector status for three years after growing beyond this threshold (RBI 2015b). The second of these changes makes an RDD strategy impossible after 2015 and makes 2014 (i.e., the financial year ending March 2015) a natural endpoint for my robustness checks.

A final issue is the distinction between 'enterprises' and 'firms.' Prowess is a firm-level dataset, whereas the PSL eligibility criteria were applied at the level of enterprises, i.e., plants or establishments, although Rotemberg (2019) states that there was some confusion on this point in the implementation of the policy. If all firms close to the cutoff are single-plant firms, then clearly this is not an issue; and since the firms I consider are relatively small, it is likely that most of them are indeed single-plant firms. But in general this mismatch in definitions means the estimates in Section 1 are a lower bound on the true effects of PSL eligibility, because some of the firms close to the cutoff may be multi-plant firms for whom PSL eligibility does not change discretely as capital crosses the cutoff.

Eligibility and exporting

Given my focus on differential effects of PSL eligibility across exporting and domestic firms, a natural question is whether the PSL policy itself distinguished between these two sets of firms. The answer is no. The RBI's guidelines do not mention a firm's export status as part of the eligibility criteria for PSL. Indeed, the 2010 Master Circular (RBI 2010), quoted below, made this explicit:

> *Loans granted by commercial banks to micro and small enterprises (MSE) (manufacturing and services) are eligible for classification under priority sector, provided such enterprises satisfy the definition of MSE sector as contained in MSMED Act, 2006, irrespective of whether the borrowing entity is engaged in export or otherwise.*

The RBI's guidelines do mention export credit. Up to and including 2011, they simply state that lending for export credit did not *per se* count towards domestic banks' PSL targets (RBI 2011). Foreign banks were subject to slightly different rules, and export credit did form part of the PSL target for these banks (RBI 2011). After 2012 lending for export credit was counted towards a domestic bank's PSL target up to a certain limit (RBI 2012). Crucially, however, both before 2012 and after, for both foreign and domestic banks, whether or not export credit counted towards a bank's PSL target was independent of the size of the recipient of the export credit. So, while the policy may have encouraged lending towards exporting firms in general, it did not do so differentially for firms above and below the threshold that forms the basis of the RDD in the main text. This implies it is not a concern for my identification strategy.

Finally, in April 2015 the government did introduce an *interest equalization scheme* which subsidized export credit for enterprises below the eligibility threshold (RBI 2015a). This policy would present a challenge for my identification strategy, but, given the other changes in the PSL policy that occurred at the same time, I anyway do not analyze any data beyond 2015.

Other programs

Firms eligible for PSL were also eligible for a number of other programs run by the Ministry for Micro, Small, and Medium Enterprises (MSME). In practice the vast majority (70%) of MSME's budget was devoted to credit guarantee and support schemes (Rotemberg 2019). We would expect these credit guarantees to have effects similar to those of PSL, and since my goal is not to measure the effects of PSL *per se*, but rather to use eligibility as a source of exogenous variation in credit supply, the presence of such credit guarantee schemes does not present a problem. MSME also provided entrepreneurs with access to training programs, which would be expected to raise firm productivity. Rotemberg (2019) finds that eligibility had a negligible effect on firm productivity, suggesting such training programs were unimportant. I therefore follow Banerjee and Duflo (2014) and interpret PSL eligibility as a shock to firms' access to credit.

Effect on borrowing costs

Banks had a strong incentive to increase the flow of credit to priority sector firms. In principle, they had two means of doing so. First, banks could lower the price of credit, i.e., the interest rate, for these firms. Second, if a substantial number of priority sector firms were at binding credit constraints, then banks could also increase their lending to these firms by loosening those constraints without any changes in the interest rate. Which of these is true is important for the interpretation of my results, since only in the second case can we take the estimates in Section 1 as an indication that credit constraints are important for many exporters.

A priori I do not expect to see much movement in interest rates: the rates charged by banks in India are regulated and cannot be more than 4% above the prime lending rate (Banerjee and Duflo 2014). Analyzing earlier changes in the eligibility rules, Banerjee and Duflo (2014) found that newly eligible firms did not receive lower interest rates. I investigate the same question in my sample using RDD specifications that parallel those in Table 2, using as the outcome firms' borrowing costs as a percentage of their liabilities. For exporters I estimate a PSL effect of -0.562 with a standard error of 0.937 without fixed effects or controls, and -0.680 with a standard error of 0.958 once year and industry fixed effects and a control for base year interest rates are included. For domestic firms I estimate a PSL effect of 0.419 with a standard error of 0.619 without fixed effects or controls, and 0.613 with a standard error of 0.809 once year and industry fixed effects and a control for base year interest rates are included.

None of these estimates are statistically significant, but the point estimates for exporters do suggest interest rates for eligible firms may have been a little more than half a percentage point lower. However, existing estimates of the semi-elasticity of loan demand with respect to interest rates lie between -1 and -3 (Bassett et al. 2014; Joaquim, Doornik, Ornelas, et al. 2019; Altavilla, Boucinha, and Bouscasse 2022). These semi-elasticities suggest that the decline in borrowing costs for eligible exporters reported above can account for at most a $(-0.680) \times (-3) \simeq 2\%$ increase in borrowing. From these calculations, it seems unlikely that changes in borrowing costs can explain the large increases in borrowing among exporters reported in Table 2. I instead interpret these increases as evidence that credit constraints are binding for a substantial fraction of exporters close to the PSL cutoff.

A.3 Manipulation and Placebo Testing

Manipulation Tests

Recall from Section 1 that the key threat to identification in my RDD is sorting around the PSL cutoff. If some firms sort around the cutoff, and the decision to sort in this way is correlated with firm characteristics (e.g., size, export intensity), then this would tend to bias my RDD estimates. To investigate this possibility I check for bunching in the density of capital close to the PSL cutoff.

I begin by looking for visual evidence of bunching. Panels (a) – (c) of Figure 6 show histograms of log capital close to the PSL cutoff for all firms, exporters, and domestic firms, respectively, in 2004, which I used as the base year in Section 1. Panels (d) – (f) show the same histograms using data from 2007-2011, the years I used in my main RDD specifications. Finally Panels (g) – (i) show the same histograms using data from 2012-2014. There is no obvious sign of bunching in 2004, although the histograms also look fairly noisy. Similarly in 2007-2011 all three histograms appear smooth around the PSL cutoff. For exporters 2012-2014, in Panel (h), there may be some

Table 6: Manipulation test statistics by year

Year	(1) All Firms	(2) Exporters	(3) Domestic
(a) Pre-estimation years			
2004	-0.645	-1.183	0.034
2005	0.596	0.206	0.808
2006	-0.210	1.695*	-0.911
(b) Years used in estimation			
2007	1.756*	2.336**	0.744
2008	1.497	0.120	1.449
2009	0.375	-0.725	0.802
2010	0.513	-0.444	0.894
2011	-0.875	-1.246	0.604
(c) Post-estimation years			
2012	0.215	-0.657	0.856
2013	-0.783	-1.675*	-0.010
2014	-0.785	-2.497**	0.270

Notes: Each row shows the manipulation test statistic of Cattaneo, Jansson, and Ma (2020) using log capital measured in a different year. Positive values indicate a jump upwards in the density of log capital at the PSL cutoff and are not indicative of manipulation. Negative values indicate a jump downwards in the density of log capital at the PSL cutoff and are indicative of manipulation. Exporters and domestic firms defined using sales in 2004, as in Section 1.

suggestion of bunching — a jump in the density of capital just to the left of the cutoff and a hole just to the right. Again, however, the noise in the histograms makes it hard to be certain.

I next consider formal statistical tests for bunching. Cattaneo, Jansson, and Ma (2020) provide a test of the null hypothesis of no discontinuity in the density of the running variable — here log capital — and I report the resulting t-statistics year-by-year for each group of firms between 2004 and 2015 in Table 6. Note that a *positive* value for the test statistic indicates a jump *up* in the density of capital at the PSL cutoff, while a *negative* value indicates a jump *down*. Therefore only negative values of the test statistic are suggestive of sorting to gain eligibility for PSL. Prior to the years used in estimation the test statistics alternate in sign and are marginally significant but positive for exporters. In 2007 the test statistic is significant at the 5% level for exporters but again positive and therefore not concerning. Apart from this observation the test statistics in the period used in estimation are statistically insignificant and do not suggest any sorting around the cutoff.

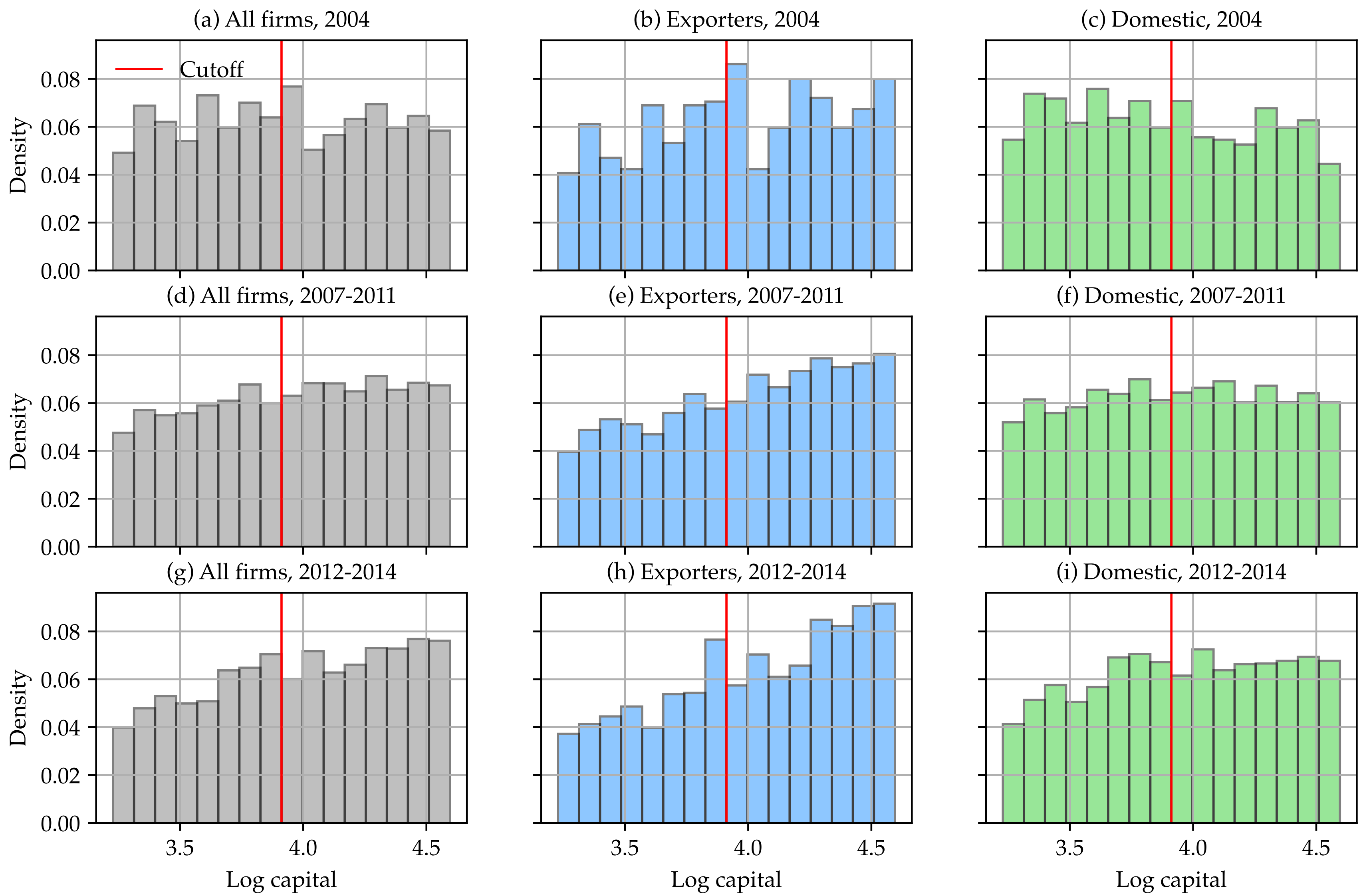
In 2012-2014, however, the test statistics for exporters are consistently negative and sometimes statistically significant, consistent with sorting around the cutoff. This pattern should not come as a surprise: the results in Section 1 suggest that exporters in particular do benefit from PSL, so we would expect them to distort their choices of capital with the aim of becoming or remaining eligible. The fact that this pattern only appears gradually over time is again not surprising given the stickiness of physical capital. The fact that manipulation is a possibility does mean we should interpret the results in Section 1 with some caution. On the other hand, the fact that this manipulation only appears in the long run, rather than in the period used for estimation, is reassuring.

Placebos

The identifying assumption in the RDD specifications in Section 1 is that the only difference between eligible and ineligible firms close to the cutoff is indeed PSL eligibility. A natural placebo check is then to look at firm outcomes measured *before* the introduction of PSL: if, in 2004, firms just to the left of the cutoff in, say, 2007 were borrowing more than those just to the right of the cutoff, then it would seem probable that the identifying assumption does not hold. If, on the other hand, significant differences between eligible and ineligible firms emerge only after the introduction of PSL, then sorting around the cutoff is less likely.

I implement this idea in Table 7. Each column considers a different outcome or sample of firms, and each row uses log capital from a different year between 2007 and 2011 — the years I used in estimation in Section 1 — as the running variable. I measure outcomes over four years between 2001 and 2004, bearing in mind that the new PSL cutoff was first announced in 2005. Column (1) reports results for borrowing by exporters, Column (2) for borrowing by domestic firms, Column (3) for sales by exporters, Column (4) for sales by domestic firms, and Column (5) for the export sales share of exporters. None of the results in Table 7 are statistically significant, and while some individual point estimates are large they generally alternate in sign as the year used for the running variable changes. Overall, the results in Table 7 do not suggest significant differences between eligible and ineligible firms close to the cutoff prior to the introduction of PSL.

Figure 6: Visual checks for manipulation



Notes: Each panel shows the density of log capital near the PSL cutoff for different subsets of firms in Prowess and in different years. The top row shows this density the year before the PSL cutoff was announced, the second row shows this density in the years I used for estimation in Section 1, and the third row shows this density in three post-estimation years. In all panels the vertical line shows the PSL cutoff.

Table 7: Placebo Checks

Running variable year	(1)	(2)	(3)	(4)	(5)
2007	0.207	-0.161	-0.048	0.284	0.051
	(0.238)	(0.142)	(0.186)	(0.161)	(0.043)
2008	-0.068	-0.015	0.199	0.030	0.039
	(0.234)	(0.158)	(0.172)	(0.160)	(0.046)
2009	0.195	0.041	0.250	-0.057	-0.003
	(0.249)	(0.148)	(0.208)	(0.167)	(0.056)
2010	0.218	0.065	-0.052	-0.119	-0.001
	(0.252)	(0.130)	(0.217)	(0.134)	(0.057)
2011	-0.090	0.197	0.166	0.091	0.062
	(0.302)	(0.246)	(0.235)	(0.238)	(0.053)
Outcome	Loans	Loans	Sales	Sales	Export share
Sample	Exporters	Domestic	Exporters	Domestic	Exporters

Notes: Sample is all manufacturing firms in Prowess 2001 – 2004. All specifications include fixed effects are for years and industries as in Section 1. Each estimate shows the estimated discontinuity at the PSL cutoff for a given outcome variable (loans, sales, export share) and a given group of firms (exporters or domestic). Each row uses a different year in 2007 – 2011 as the running variable and outcomes are always measured 2001 – 2004. Standard errors clustered at the firm level.

A.4 Robustness of Main Results

I focus on three main results: the effect of PSL on borrowing by exporters, the effect of PSL on borrowing by domestic firms, and the effect of PSL on the export share of exporters. My baseline estimates of these effects are in Columns (3) and (4) of Table 2 and Column (2) of Table 3, and I reproduce these baseline estimates in Column (1) of Table 8 below. The remaining columns of Table 8 subject these results to a range of robustness checks.

I begin by considering the role of controls. The baseline results include year and industry fixed effects and control for values of the outcome variable measured in 2004. Recall that the results in Columns (1) and (2) of Table 2 and in Column (1) of Table 3 already report specifications with no controls at all. Column (2) of Table 8 shows results with base year controls but without fixed effects, whereas Column (3) shows results with fixed effects but without base year controls. Varying the controls does not qualitatively change my results, although the effects on exporters without fixed effects but with the base year control in Column (2) are smaller and generally statistically insignificant. I next turn to the period over which outcomes are measured. The baseline specification uses five years following the implementation of PSL, 2007 — 2011. Column (4) drops the first year, Column (5) drops the final year, and Column (6) extends the sample to 2014, when the PSL eligibility criteria were changed. In (4) and (5) the results are qualitatively similar to the baseline specifications, although with some variation in statistical significance. The point estimates for exporter loans and the export share are somewhat smaller in (6), although this should not be too surprising: relatively few firms that were exporting in the base year, 2004, would still be exporting

Table 8: Robustness of main results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Exporter loans	0.355^{**} (0.164)	0.192 (0.161)	0.419^{**} (0.185)	0.369^{*} (0.189)	0.311^{**} (0.152)	0.276^{*} (0.161)	0.289^{**} (0.147)	0.123 (0.177)	0.290^{**} (0.144)	0.254 (0.185)	0.308^{*} (0.186)	0.387^{**} (0.166)	0.367^{**} (0.183)
Domestic loans	0.013 (0.116)	0.088 (0.117)	0.009 (0.126)	-0.003 (0.121)	0.006 (0.120)	0.018 (0.127)	0.002 (0.099)	-0.079 (0.137)	-0.006 (0.102)	0.033 (0.146)	-0.002 (0.129)	0.015 (0.112)	-0.004 (0.135)
Export share	0.086^{***} (0.030)	0.052 (0.032)	0.083^{*} (0.049)	0.099^{***} (0.034)	0.041 (0.030)	0.043^{*} (0.026)	0.042 (0.028)	0.075^{**} (0.034)	0.080^{***} (0.028)	0.104^{***} (0.038)	0.094^{***} (0.033)	0.084^{***} (0.032)	0.111^{***} (0.037)
Note	Baseline	No fixed effects	No lagged controls	Drop 2007	Drop 2011	To 2014	Wide bw.	Narrow bw.	Triangular kernel	Local quadratic	Bias corrected	Donut (1%)	Donut (5%)

Notes: Baseline sample is manufacturing firms in Prowess 2007 – 2011. Each column reports RDD estimates of the effect of PSL eligibility on three different outcomes: borrowing by exporters, borrowing by domestic firms, and the export sales share of exporters. (1) shows baseline results matching those in Section 1, Tables 2 and 3; (2) drops year and industry fixed effects; (3) drops the outcome variable measured in 2004 as a control; (4) only uses data from 2008-2011; (5) only uses data from 2007-2010; (6) uses data from 2007-2014; (7) increases the bandwidth by 50% relative to the baseline; (8) decreases the bandwidth by 50% relative to the baseline; (9) uses a triangular kernel in estimating the local linear regression; (10) uses a local quadratic regression as opposed to a local linear regression; (11) drops the 1% of the sample (within the baseline bandwidth) closest to the cutoff; (12) drops the 5% of the sample (within the baseline bandwidth) closest to the cutoff; and (13) reports the robust, bias-corrected estimates suggested by Calonico, Cattaneo, and Titiunik (2014).

a decade later.

Columns (7) — (11) check the importance of technical details of the RDD: Column (7) increases the bandwidths used in the local linear regressions by 50% relative to the baseline, (8) decreases these bandwidths by 50%, (9) uses a triangular kernel to weight observations rather than a uniform kernel, and (10) replaces the local linear regression with a local quadratic regression. Using a very wide bandwidth shrinks the export share result significantly, while using a very narrow bandwidth does the same to the exporter borrowing result; but apart from these instances, the details of the RDD do not matter much for my results. In Column (11) I investigate the effects of the bias-correction suggested by Calonico, Cattaneo, and Titiunik (2014), who point out that if one uses the MSE-optimal bandwidth choice that is standard in the RDD literature the resulting point estimates are generally inconsistent. The bias-corrected estimates in Column (11) are similar to my baseline estimates, although somewhat less precise.

The final two columns of Table 8 perform the 'doughnut hole' checks suggested by Imbens and Lemieux (2008). In Column (12) I drop the 1% of the sample (within the baseline bandwidth) closest to the PSL cutoff, while in Column (13) I drop 5% of the sample. The idea here is that these are the observations most susceptible to manipulation of capital; large changes when these observations are excluded would suggest sorting around the cutoff is playing an important role in my results. Fortunately none of the results turn out to be sensitive to dropping these observations.

Table 9 considers a different question. Notice that the contrasting effects of PSL eligibility on borrowing across exporters and domestic firms reported in Table 2 come from separate RDD specifications with different bandwidths. A natural concern is that the different results for the two

Table 9: PSL effects on borrowing, combined sample

Outcome	(1) Loans	(2) Loans	(3) Loans	(4) Loans
Main effect	0.129 (0.090)	0.063 (0.095)	0.055 (0.095)	0.055 (0.109)
PSL x exporter interaction		0.196** (0.095)	0.219** (0.164)	0.210 (0.189)
PSL x exporter interaction	✗	✓	✓	✓
Intercept x exporter interaction	✗	✗	✓	✓
Slope x exporter interaction	✗	✗	✗	✓
Sample	All firms	All firms	All firms	All firms
Fixed effects	✓	✓	✓	✓
Base year control	✓	✓	✓	✓
Observations	5,836	5,836	5,836	5,836
Bandwidth	0.936	0.936	0.936	0.936

Notes: Sample is all manufacturing firms in Prowess 2007 – 2011. Fixed effects are for years and industries. RDD kernel is uniform with bandwidth chosen following Calonico, Cattaneo, and Titiunik (2014) and held fixed across Columns (1) – (4). Standard errors clustered at the firm level.

groups of firms might reflect these different bandwidths. To address this concern, I now consider specifications which combine all firms using a single bandwidth. Specifically, I first run a standard RDD specification using all firms and record the MSE-optimal bandwidth. The results are shown in Column (1) of Table 9. The estimated effect of PSL is relatively small and statistically insignificant, and the bandwidth chosen is 0.936. In Column (2) I continue to use the same bandwidth but now interact PSL eligibility with a dummy equal to one if a firm is an exporter. The point estimate on this exporter interaction is significant at the 5% level and implies that the effect of PSL on exporter borrowing was about 20 percentage points larger than its effect on domestic firm borrowing. Columns (3) and (4) consider more flexible specifications, in which first the intercept in the regression and then also the slope coefficients with respect to capital on either side of the PSL cutoff are allowed to vary with export status. These changes have little effect on the point estimate on the exporter interaction, although in Column (4), the most flexible specification, it is no longer significant. I conclude that the different effects of PSL on exporters versus domestic firms are not an artifact of the separate RDD specifications used in Table 2.

B Theoretical Appendix

B.1 Derivations of Expressions in Section 2

Derivation of (13)

The profit maximization problem facing an exporter is,

$$\begin{aligned}\pi_X(z,a) = \max_{l_D, l_X} \quad & (zl_D)^{\frac{\sigma-1}{\sigma}} + \left(\frac{zl_X}{\tau}\right)^{\frac{\sigma-1}{\sigma}} - w(l_D + l_X) \\ \text{s.t.} \quad & w(l_D + l_X) \leq a + \lambda\,(zl_D)^{\frac{\sigma-1}{\sigma}} + (\lambda - \theta)\left(\frac{zl_X}{\tau}\right)^{\frac{\sigma-1}{\sigma}}. \end{aligned} \tag{37}$$

Defining e as the share of l_X in total employment $l = l_X + l_D$ gives

$$\begin{aligned}\pi_X(z,a) = \max_{e,l} \quad & \left((1-e)^{\frac{\sigma-1}{\sigma}} + \left(\frac{e}{\tau}\right)^{\frac{\sigma-1}{\sigma}}\right)(zl)^{\frac{\sigma-1}{\sigma}} - wl \\ \text{s.t.} \quad & wl \leq a + \left(\lambda(1-e)^{\frac{\sigma-1}{\sigma}} + (\lambda-\theta)\left(\frac{e}{\tau}\right)^{\frac{\sigma-1}{\sigma}}\right)(zl)^{\frac{\sigma-1}{\sigma}}. \end{aligned} \tag{38}$$

Write the problem above as a Lagrangian with a multiplier μ on the borrowing constraint.

$$\begin{aligned}\mathcal{L} = \max_{e,l} & \left((1-e)^{\frac{\sigma-1}{\sigma}} + \left(\frac{e}{\tau}\right)^{\frac{\sigma-1}{\sigma}}\right)(zl)^{\frac{\sigma-1}{\sigma}} - wl \\ & - \mu\left(wl - a - \left(\lambda(1-e)^{\frac{\sigma-1}{\sigma}} + (\lambda-\theta)\left(\frac{e}{\tau}\right)^{\frac{\sigma-1}{\sigma}}\right)(zl)^{\frac{\sigma-1}{\sigma}}\right). \end{aligned} \tag{39}$$

Rearranging slightly yields,

$$\mathcal{L} = (1+\mu\lambda)\left(\max_{e,l} \quad \left\{\left((1-e)^{\frac{\sigma-1}{\sigma}} + (1-t_X)\left(\frac{e}{\tau}\right)^{\frac{\sigma-1}{\sigma}}\right)(zl)^{\frac{\sigma-1}{\sigma}} - (1+t_L)\, wl\right\}\right) + \mu a, \tag{40}$$

where t_X and t_L are defined as in (13). Finally note that the multiplication by $(1+\mu\lambda)$ and the addition of μa are both irrelevant for the optimal choices of e and l. Dropping these terms yields (13), as desired.

Definition of TFP in (16)

In the analytical model I define aggregate TFP as

$$Z = \frac{S^{\frac{\sigma}{\sigma-1}}}{L}. \tag{41}$$

Notice that sales have been scaled by a power of $\frac{\sigma}{\sigma-1}$, which is nonstandard. I could alternatively have defined TFP as

$$\tilde{Z} = \frac{S}{L^{\frac{\sigma-1}{\sigma}}}, \tag{42}$$

which clarifies that, because as firms sell more they drive down prices, my partial equilibrium model effectively features decreasing returns to scale in the aggregate. The definition of TFP with the scaling by $\frac{\sigma}{\sigma-1}$ is slightly more convenient. In the absence of any distortions, it implies a standard expression for aggregate TFP

$$Z = \left(\int_{\mathcal{D}} z^{\sigma-1} + \left(1+\tau^{1-\sigma}\right)\int_{\mathcal{X}} z^{\sigma-1}\right)^{\frac{1}{\sigma-1}}. \tag{43}$$

Furthermore, using this definition of TFP results in more familiar expressions. With this definition, the mechanical effect of small trade shocks in (18) is identical to the corresponding expression in Atkeson and Burstein (2010), and the first term in the expression for the gains from trade in (22) is identical to the formula for the gains from trade in Arkolakis, Costinot, and Rodríguez-Clare (2012). Nonetheless, the choice between $\tilde{Z}$ and Z is not critical since, in logs, they are proportional to one another. In particular the key results from the quantitative model, which quantify the importance of reallocation relative to the mechanical gains from trade, are completely unchanged.

Derivation of (17)

Aggregate TFP is defined as

$$Z = \frac{S^{\frac{\sigma}{\sigma-1}}}{L} \tag{44}$$

Start with aggregate employment. With $\lambda = 1$ employment by domestic entrepreneurs is undistorted. After some algebra, total employment by these entrepreneurs is

$$L_D \equiv \int_{\mathcal{D}} l = \int_{\mathcal{D}} \left(\frac{\sigma-1}{\sigma}\right)^{\sigma} w^{-\sigma} z^{\sigma-1} = \left(\frac{\sigma-1}{\sigma}\right)^{\sigma} w^{-\sigma} Z_D^{\sigma-1}. \tag{45}$$

Employment by exporters is distorted. In particular, the first order condition for employment implies,

$$l = \left(\frac{\sigma-1}{\sigma}\right)^{\sigma} w^{-\sigma} z^{\sigma-1} \left(1 + \tau^{1-\sigma}(1-t_X)^{\sigma}\right) z^{\sigma-1}, \tag{46}$$

where I have used the first order condition for e to eliminate this variable. Since the export wedges t_X are homogeneous across exporters in the steady state, we can aggregate to obtain

$$L_X \equiv \int_{\mathcal{X}} (l_X + l_D) = \left(\frac{\sigma-1}{\sigma}\right)^{\sigma} w^{-\sigma} \left(1 + \tau^{1-\sigma}(1-t_X)^{\sigma}\right) Z_X^{\sigma-1}. \tag{47}$$

Total employment is thus

$$L = \left(\frac{\sigma-1}{\sigma}\right)^{\sigma} w^{-\sigma} \left(Z_D^{\sigma-1} + Z_X^{\sigma-1} + \tau^{1-\sigma}(1-t_X)^{\sigma} Z_X^{\sigma-1}\right). \tag{48}$$

Following the same steps for total sales yields,

$$S = \left(\frac{\sigma-1}{\sigma}\right)^{\sigma-1} w^{1-\sigma} \left(Z_D^{\sigma-1} + Z_X^{\sigma-1} + \tau^{1-\sigma}(1-t_X)^{\sigma-1} Z_X^{\sigma-1}\right). \tag{49}$$

Taking S to the power of $\left(\frac{\sigma}{\sigma-1}\right)$ and dividing by L gives (17), as desired.

Derivation of (21)

To obtain (21), notice that when $\lambda = \theta = 1$ the borrowing constraint for exporters can be written,

$$wl_X \leq a + \pi_D^*(z), \tag{50}$$

where $\pi_D^*(z)$ denotes the undistorted domestic profits of an entrepreneur with productivity z. We know that in the initial steady state this holds with equality. Log differentiating around the initial steady state yields

$$\Delta \log l_X = \left(\frac{a}{wl_X}\right) \Delta \log a. \tag{51}$$

Since in the proof of Theorem 2 we have established that, within exporters, all variables follow the same trajectories up to a rescaling by z, we can aggregate to write

$$\Delta \log(EL) = \left(\frac{A_X}{wEL}\right) \Delta \log A_X, \tag{52}$$

where A_X denotes the total internal funds held by exporters and I have used the fact that,

$$EL = \int_{\mathcal{X}} l_X. \tag{53}$$

Now, notice that $(1-E)L$ is labor employed in domestic production by both exporters and domestic firms. When $\lambda = \theta = 1$ this quantity is unaffected by shocks to τ. Therefore

$$\Delta \log(1-E)L = 0 \implies \Delta \log(1-E) + \Delta \log L = 0 \implies \Delta \log L = -\Delta \log(1-E)$$
$$\implies \Delta \log EL = \Delta \log E - \Delta \log(1-E) = \Delta \log\left(\frac{E}{1-E}\right) \tag{54}$$

Thus we have

$$\Delta \log\left(\frac{E}{1-E}\right) = \left(\frac{A_X}{wEL}\right)\Delta \log A_X. \tag{55}$$

Plugging this into (18) gives (21).

B.2 Proof of Lemma 1

I break the proof into several steps.

1. In the long run entrepreneurs converge to either an interior steady state or a boundary steady state.

Dropping the exporter and domestic subscripts for the moment, the problem facing an entrepreneur with a given level of productivity z is,

$$\begin{aligned} \max_c \quad & \int_0^\infty \log(c)\exp(-\rho t)dt \\ \text{s.t.} \quad & \dot{a} = y(a,z) - c, \\ & a \geq 0, \end{aligned} \tag{56}$$

where $y(a,z) = \pi(a,z) + ra$. Income $y(a,z)$ is always strictly positive and strictly increasing in a. Inspection also shows that, for both exporters and domestic firms, $y(a,z)$ is strictly concave up to some $a^*(z)$ at which the entrepreneur is no longer constrained and thereafter affine. Standard arguments imply that: (i) the entrepreneur's stock of funds converges to a steady state $\bar{a}(z)$ in the long run; (ii) if this steady state has $\bar{a}(z) > 0$, it is unique and must have $y_1(\bar{a}(z),z) = \rho$; and (iii), if this steady state instead has $\bar{a}(z) = 0$ then it must be that $y_1(\bar{a}(z),z) < \rho$. I refer to the first possibility as an interior steady state and the second as a boundary steady state.

2. Within a group of entrepreneurs (exporters or domestic) the constraint multipliers evaluated at zero internal funds are independent of productivity.

This statement is true for both exporters and domestic firms. Below I prove it for exporters. The result for domestic entrepreneurs then immediately follows by setting $\tau = \infty$. First, let us write the static profit maximization problem facing an exporter as,

$$\max_{e,l} \quad A(e)\,(zl)^{\frac{\sigma-1}{\sigma}} - wl - \mu(wl - a - B(e)\,(zl)^{\frac{\sigma-1}{\sigma}}),$$
$$A(e) = (1-e)^{\frac{\sigma-1}{\sigma}} + \left(\frac{e}{\tau}\right)^{\frac{\sigma-1}{\sigma}}$$
$$B(e) = \lambda(1-e)^{\frac{\sigma-1}{\sigma}} + (\lambda-\theta)\left(\frac{e}{\tau}\right)^{\frac{\sigma-1}{\sigma}} \tag{57}$$

where I am using $A(e)$ and $B(e)$ purely for notational convenience. This has the following optimality and feasibility conditions,

$$0 = A'(e)\,(zl)^{\frac{\sigma-1}{\sigma}} + B'(e)\mu\,(zl)^{\frac{\sigma-1}{\sigma}}, \tag{58}$$
$$0 = A(e)\frac{d}{dl}\left((zl)^{\frac{\sigma-1}{\sigma}}\right) - w(1+\mu) + \mu B(e)\frac{d}{dl}\left((zl)^{\frac{\sigma-1}{\sigma}}\right) \tag{59}$$
$$wl \leq a + B(e)\,(zl)^{\frac{\sigma-1}{\sigma}}, \tag{60}$$

where if the final inequality is strict we must have $\mu = 0$, and otherwise $\mu \geq 0$. Our goal is to show that at $a = 0$, μ does not depend on z. First I show that whether $\mu > 0$ or $\mu = 0$ is independent of z. To see this, suppose $\mu = 0$. After some algebra, I obtain

$$\mu = 0 \iff \lambda \geq \left(\frac{\sigma-1}{\sigma}\right) + \theta x^*, \tag{61}$$

where x^* is the undistorted share of exports in total sales. None of these terms depend on z, and thus if μ is zero for any entrepreneur, it must be zero for all entrepreneurs, as desired. Next, consider $\mu > 0$. Substituting the binding borrowing constraint with $a = 0$ into the two optimality conditions above and rearranging yields,

$$0 = A'(e) + \mu B'(e), \tag{62}$$
$$0 = \left(\frac{A(e)}{B(e)}\right)\left(\frac{\sigma-1}{\sigma}\right) - (1+\mu) + \mu\left(\frac{\sigma-1}{\sigma}\right), \tag{63}$$

which does not depend on z. Thus μ and x are independent of z whenever $a = 0$.

3. All entrepreneurs within a group converge to the same steady state constraint multiplier.

I continue to suppress the subscripts for exporters and domestic entrepreneurs. First note that from the Lagrangian (40) above, we have $y_1(a,z) = \pi_1(a,z) + r = \mu(a,z) + r$ where $\mu(a,z)$ is the constraint multiplier of an entrepreneur with internal funds a and productivity z. Therefore from the results directly above, we know that for any entrepreneur either: (i) the constraint multiplier μ converges to $\rho - r$; or (ii) internal funds a converge to 0 and the constraint multiplier μ converges to a value less than $\rho - r$. Suppose, in order to obtain a contradiction, that there is some entrepreneur with productivity z_0 for whom internal funds converge to 0 and whose constraint multiplier converges to $\mu(0, z_0) < \rho - r$, while there is another with productivity z_1 for whom the constraint multiplier converges to $\mu(\bar{a}(z_1), z_1) = \rho - r$. Above we established that $\mu(0, z_0) = \mu(0, z_1)$. Thus $\rho - r = \mu(\bar{a}(z_1), z_1) \leq \mu(0, z_1) = \mu(0, z_0) < \rho - r$, where the first inequality follows from the concavity of the profit function. This is clearly a contradiction. So it must be that all entrepreneurs within a group (exporters or domestic) converge to the same steady state constraint multiplier.

4. The steady state to which exporters converge is always weakly more constrained.

Let us now use the notation $\mu_D(a, z)$ and $\mu_X(a, z)$ to denote the constraint multipliers of domestic and exporting entrepreneurs, respectively. And let μ_D and μ_X denote the steady state values that these constraint multipliers converge to: we have established above that these are independent of z. Inspection shows that $\mu_D(a, z) \leq \mu_X(a, z)$ for all a and z. Now suppose, to obtain a contradiction, that $\mu_X < \mu_D$. We can immediately rule out the possibility that both are at interior steady states, for then both steady state multipliers would be equal to $\rho - r$. Then either (i) domestic entrepreneurs converge to an interior steady state and exporters do not, or (ii) both types converge to boundary steady states. If (i), then we must have $\mu_D = \mu_D(\bar{a}(z), z) \leq \mu_D(0, z) \leq \mu_X(0, z) = \mu_X$, where z is an arbitrary productivity level. This contradicts our premise that $\mu_D > \mu_X$. If (ii), then we must have $\mu_D = \mu_D(0, z) \leq \mu_X(0, z) = \mu_X$, where z is an arbitrary productivity level. This contradicts our premise that $\mu_D > \mu_X$. So neither (i) nor (ii) can be true, and we must therefore always have $\mu_X \geq \mu_D$.

5. If $\lambda \geq \left(\frac{\sigma-1}{\sigma}\right)$ then $\mu_D = 0$.

In the absence of any distortions, a domestic entrepreneur would like to choose a level of employment such that,

$$\left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{s}{l}\right) = w. \tag{64}$$

The borrowing constraint would then read,

$$wl = \left(\frac{\sigma - 1}{\sigma}\right) s \leq a + \lambda s. \tag{65}$$

As long as $\lambda \geq \left(\frac{\sigma-1}{\sigma}\right)$, this holds for any $a \geq 0$. Thus domestic entrepreneurs can always achieve the unconstrained profit-maximizing level of employment, the borrowing constraint never binds, and $\mu_D = 0$.

6. If $\lambda < \left(\frac{\sigma-1}{\sigma}\right)\left(\frac{\sigma}{\sigma+(\rho-r)}\right) + \theta x(\rho - r)$ then $\mu_X = (\rho - r)$.

Suppose in order to obtain a contradiction that $\mu_X \neq (\rho - r)$. Then it must be that $\mu_X < \rho - r$ and the internal funds of entrepreneurs must be zero in steady state. Substituting the borrowing constraint of exporters into the first order condition for labor yields,

$$\mu_X = \left(\frac{1}{\lambda - \theta e(\mu_X)}\right)(\sigma - 1) - \sigma, \tag{66}$$

where $x(\mu_X)$ is the export sales share, which is itself a function of the constraint multiplier μ_X. Now, $x(\mu_X)$ is decreasing in μ_X, and $\mu_X < \rho - r$, and so,

$$x(\mu_X) \geq x(\rho - r). \tag{67}$$

Inspection of μ_X shows it is increasing in the export sales share. Therefore,

$$\mu_X = \left(\frac{1}{\lambda - \theta x(\mu_X)}\right)(\sigma - 1) - \sigma \geq \left(\frac{1}{\lambda - \theta x(\rho - r)}\right)(\sigma - 1) - \sigma. \tag{68}$$

Rearranging yields,

$$\lambda \geq \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\sigma}{\sigma + \mu_X}\right) + \theta x(\rho - r). \tag{69}$$

The right-hand side of this inequality is decreasing in μ_X, and $\mu_X < \rho - r$, so

$$\lambda \geq \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\sigma}{\sigma + \mu_X}\right) + \theta x(\rho - r) > \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{\sigma}{\sigma + (\rho - r)}\right) + \theta x(\rho - r), \tag{70}$$

which contradicts our assumption. So we must have $\mu_X = \rho - r$. This completes the proof.

B.3 Proof of Theorem 2

I break the proof into several steps.

1. The trajectories of assets and consumption over time between steady states are invariant to z after an appropriate rescaling.

First, note that profits always satisfy $\pi_i(a, z) = z^{\sigma-1}\pi_i(1, az^{1-\sigma})$ for $i = X, D$. To see this for domestic entrepreneurs, write,

$$\begin{aligned}
\pi_D(a, z) &= \max_{l}\{(zl)^{\frac{\sigma-1}{\sigma}} - wl\} \quad \text{s.t.} \quad wl \leq a + \lambda\,(zl)^{\frac{\sigma-1}{\sigma}} \\
&= z^{\sigma-1}\max_{\tilde{l}}\{\tilde{l}^{\frac{\sigma-1}{\sigma}} - w\tilde{l}\} \quad \text{s.t.} \quad w\tilde{l} \leq az^{1-\sigma} + \lambda\tilde{l}^{\frac{\sigma-1}{\sigma}} \\
&= z^{\sigma-1}\pi_D(az^{1-\sigma}, 1)
\end{aligned} \tag{71}$$

An identical sequence of steps establishes the same result for exporters. Now, turn to the dynamic problem of the entrepreneur. We have,

$$\begin{aligned} v_i(a_0, z) = \max_{c(t)} \quad & \int_0^\infty \log c(t) \exp(-\rho t) dt, \\ \text{s.t.} \quad & \dot{a}(t) = ra(t) + \pi_i(z, a(t)) - c(t), \\ & a(0) = a_0, \quad a(t) \geq 0, \\ \text{for} \quad & i = D, X. \end{aligned} \tag{72}$$

Define

$$\tilde{c} = cz^{1-\sigma}, \tilde{a} = az^{1-\sigma}. \tag{73}$$

The problem becomes

$$\begin{aligned} v_i(a_0, z) = \max_{\tilde{c}(t)} \quad & \int_0^\infty \log \tilde{c}(t) \exp(-\rho t) dt + (\sigma - 1) \log z, \\ \text{s.t.} \quad & \dot{\tilde{a}}(t) = r\tilde{a}(t) + \pi_i(\tilde{a}(t), 1) - \tilde{c}(t), \\ & \tilde{a}(0) = a_0 z^{1-\sigma}, \quad \tilde{a}(t) \geq 0, \\ \text{for} \quad & i = D, X, \end{aligned} \tag{74}$$

where I have exploited the homogeneity of profits above to eliminate z from the budget constraint. Notice that while z appears additively in the objective function of the entrepreneur, it is irrelevant for their choices of $\tilde{a}$ and $\tilde{c}$. Instead the only place z matters is in the initial condition on assets. Now, assume that the initial condition comes from a steady state. From Lemma 1, we know that in any steady state the constraint multipliers μ are equalized within a group of entrepreneurs. A little algebra shows that this implies $a = \bar{a}_i z^{\sigma-1}$ for $i = X, D$. Then z drops entirely out of the (transformed) dynamic problem facing the entrepreneur, implying the optimal trajectories for $\tilde{a}$ and $\tilde{c}$ are independent of z. Finally, consider the constraint multipliers of an entrepreneur of type i along the transition path. We have

$$\mu_i(a, z) = \frac{d}{da}\pi_i(a, z) = z^{\sigma-1}\frac{d}{da}\pi_i(az^{1-\sigma}, 1) = \pi'_{i1}(\tilde{a}_i, 1). \tag{75}$$

Since $\tilde{a}_i$ follows the same trajectory for all entrepreneurs of type i, the constraint multipliers $\mu_i(a, z)$ also follow the same trajectory for all entrepreneurs of type i. This observation allows me to aggregate within exporters and within domestic entrepreneurs along the transition path between steady states.

2. Derivation of (18)

To obtain (18), we must write TFP as a function of τ and e. To do so, note that from the argument above, the constraint multipliers μ are identical within the set of exporters all along the transition path. This implies that export shares e are also identical along the transition path. Then we can write,

$$(1-t_X) = \left(\frac{e}{1-e}\right)^{\frac{1}{\sigma}} \tau^{\frac{\sigma-1}{\sigma}}. \tag{76}$$

Total employment is then

$$L \propto \left(Z_D^{\sigma-1} + Z_X^{\sigma-1} + \left(\frac{e}{1-e}\right) Z_X^{\sigma-1}\right), \tag{77}$$

while total sales are

$$S \propto \left(Z_D^{\sigma-1} + Z_X^{\sigma-1} + \tau^{\frac{1-\sigma}{\sigma}} \left(\frac{e}{1-e}\right)^{\frac{\sigma-1}{\sigma}} Z_X^{\sigma-1}\right). \tag{78}$$

Finally, some algebra shows that the share of exports in total employment is given by,

$$\frac{E}{1-E} = \left(\frac{e}{1-e}\right)\left(\frac{Z_X^{\sigma-1}}{Z_X^{\sigma-1} + Z_D^{\sigma-1}}\right). \tag{79}$$

This is helpful because Z_X and Z_D are exogenous, and so,

$$\frac{d\log\left(\frac{E}{1-E}\right)}{d\log\tau} = \frac{d\log\left(\frac{e}{1-e}\right)}{d\log\tau}. \tag{80}$$

To obtain the decomposition in (18), write,

$$\frac{d\log Z}{d\log\tau} = \frac{\partial\log Z}{\partial\log\tau} + \frac{\partial\log Z}{\partial\log\left(\frac{e}{1-e}\right)}\frac{d\log\left(\frac{e}{1-e}\right)}{d\log\tau} = \frac{\partial\log Z}{\partial\log\tau} + \frac{\partial\log Z}{\partial\log\left(\frac{E}{1-E}\right)}\frac{d\log\left(\frac{E}{1-E}\right)}{d\log\tau}. \tag{81}$$

The first term is the mechanical effect while the second is the reallocation effect. Let us first obtain the mechanical effect, noting that τ does not appear directly in L,

$$\frac{\partial\log Z}{\partial\log\tau} = \left(\frac{\sigma}{\sigma-1}\right)\frac{\partial\log S}{\partial\log\tau} = -\left(\frac{(\tau e)^{\frac{1-\sigma}{\sigma}}(1-e)^{\frac{\sigma-1}{\sigma}} Z_X^{\sigma-1}}{S}\right) = -X. \tag{82}$$

To obtain the reallocation effect, differentiate TFP with respect to $\log\frac{e}{1-e}$,

$$\frac{\partial\log Z}{\partial\log\left(\frac{e}{1-e}\right)} = \left(\frac{\sigma}{\sigma-1}\right)\frac{\partial\log S}{\partial\log\left(\frac{e}{1-e}\right)} - \frac{\partial\log L}{\partial\log\left(\frac{e}{1-e}\right)} = -(X-E). \tag{83}$$

Combining the partial derivatives above and using the definition of $\mathcal{T}$ yields (18).

3. Derivation of (19) *and* (20)

To obtain (19), note that with $\lambda = \theta = 1$ the borrowing constraint of an exporter can be written

$$wl_X \leq a + \pi_D^*(z), \tag{84}$$

Now, from Lemma 1 we know that in steady state this constraint holds with equality. We also know that a shock to τ does not change $\pi_D^*(z)$, nor does it change internal funds a at $t = 0$. Therefore we know that l_X does not change for any exporter. Since

$$e \equiv \frac{l_X}{l_X + l_D}, \tag{85}$$

and we know that a shock to τ does not affect l_D, we can conclude that e does not change at $t = 0$. Then from the argument above E also does not change at $t = 0$. So the reallocation term in (18) is zero, giving (19).

To obtain (20), notice that in the long run we must reach a new steady state. Since the shock to τ is assumed to be small, the inequality (15) continues to hold and in the new steady state we must still have

$$\mu_X = \rho - r \implies \frac{d\mu_X}{d\log\tau} = 0 \implies \frac{d(1-t_X)}{d\log\tau} = 0. \tag{86}$$

The observation that export wedges are constant in the long run in turn implies,

$$\frac{d\log\left(\frac{E}{1-E}\right)}{d\log\tau} = \frac{d\log\left(\frac{e}{1-e}\right)}{d\log\tau} = (1-\sigma). \tag{87}$$

Plugging this in to (18) gives (20).

B.4 Proof of Theorem 3

Start with the expression for TFP in terms of wedges,

$$Z_T = \frac{\left(Z_D^{\sigma-1} + Z_X^{\sigma-1} + \tau^{1-\sigma}(1-t_X)^{\sigma-1}Z_X^{\sigma-1}\right)^{\frac{\sigma}{\sigma-1}}}{Z_D^{\sigma-1} + Z_X^{\sigma-1} + \tau^{1-\sigma}(1-t_X)^{\sigma}Z_X^{\sigma-1}}. \tag{88}$$

Setting $\tau = \infty$ gives TFP under autarky

$$Z_A = \left(Z_D^{\sigma-1} + Z_X^{\sigma-1}\right)^{\frac{1}{\sigma-1}}. \tag{89}$$

Taking the ratio of these yields,

$$\frac{Z_T}{Z_A} = \frac{\left(1 + \frac{\tau^{1-\sigma}(1-t_X)^{\sigma-1}Z_X^{\sigma-1}}{Z_X^{\sigma-1}+Z_D^{\sigma-1}}\right)^{\frac{\sigma}{\sigma-1}}}{1 + \frac{\tau^{1-\sigma}(1-t_X)^{\sigma}}{Z_X^{\sigma-1}+Z_D^{\sigma-1}}} = \frac{\left(1+\frac{X}{1-X}\right)^{\frac{\sigma}{\sigma-1}}}{1+(1-t_X)\left(\frac{X}{1-X}\right)} = (1-X)^{\frac{1}{1-\sigma}}\left(1-Xt_X\right)^{-1}. \tag{90}$$

Taking logs yields the result.

B.5 Additional Model Details

Hamilton-Jacobi-Bellman Equations

For convenience, I will define $\omega = (z_P, z_T, a, k)$ and denote the profits of domestic and exporting entrepreneurs by $\pi_D(\omega)$ and $\pi_X(\omega)$, respectively. For domestic entrepreneurs,

$$\begin{aligned} \rho v_D(\omega) = \max_{c,i} \quad & \left\{ \log(c) + \dot{a}\left(\frac{\partial v_D}{\partial a}\right) + \dot{k}\left(\frac{\partial v_D}{\partial k}\right) - \phi z_T \left(\frac{\partial v_D}{\partial z_T}\right) + \left(\frac{\sigma_T^2}{2}\right)\left(\frac{\partial^2 v_D}{\partial z_T^2}\right) \right. \\ & \left. + \eta \left(\mathbb{E}[\max\{v_X(\omega'), v_D(\omega)\}]\right) \right\} \\ \text{s.t.} \quad & \dot{a} = \pi_D(\omega) + ra - c - C(i,k) \\ & \dot{k} = i - \delta k, \end{aligned} \tag{91}$$

where ω' denotes the entrepreneur's state after paying the export entry cost, i.e.,

$$\omega' = (z_P, z_T, a - F, k), \tag{92}$$

and the entrepreneur's choices should satisfy the state constraints:

$$a \geq 0, \quad k \geq 0. \tag{93}$$

The problem facing an exporting entrepreneur is almost identical and given by,

$$\begin{aligned} \rho v_X(\omega) = \max_{c,i} \quad & \left\{ \log(c) + \dot{a}\left(\frac{\partial v_X}{\partial a}\right) + \dot{k}\left(\frac{\partial v_X}{\partial k}\right) - \phi z_T \left(\frac{\partial v_X}{\partial z_T}\right) + \left(\frac{\sigma_T^2}{2}\right)\left(\frac{\partial^2 v_X}{\partial z_T^2}\right) \right. \\ & \left. + \chi \left(v_D(\omega) - v_X(\omega)\right) \right\} \\ \text{s.t.} \quad & \dot{a} = \pi_X(\omega) + ra - c - C(i,k) \\ & \dot{k} = i - \delta k, \end{aligned} \tag{94}$$

again subject to the state constraints (93).

Kolmogorov Forward Equations

I will denote the distribution of type $j \in \{D, X\}$ entrepreneurs at time t by $g_j(\omega, t)$. To express the Kolmogorov Forward Equations (KFEs) compactly, define:

$$\begin{aligned} \mathcal{A}_j g_j(\omega, t) = & -\frac{\partial}{\partial a}\left(\mu_{a,j}(\omega)\, g_j(\omega, t)\right) - \frac{\partial}{\partial k}\left(\mu_{k,j}(\omega)\, g_j(\omega, t)\right) \\ & + \phi \frac{\partial}{\partial z_T}\left(z_T\, g_j(\omega, t)\right) + \left(\frac{\sigma_T^2}{2}\right) \frac{\partial^2 g_j(\omega, t)}{\partial z_T^2}, \end{aligned} \tag{95}$$

where, for $j \in \{D, X\}$,

$$\mu_{a,j}(\omega) = \pi_j(\omega) + ra - c_j(\omega) - C\big(i_j(\omega), k\big), \tag{96}$$

$$\mu_{k,j}(\omega) = i_j(\omega) - \delta k. \tag{97}$$

Then the KFEs for g_D and g_X are:

$$\dot{g}_D(\omega, t) = \mathcal{A}_D\, g_D(\omega, t) + \chi\, g_X(\omega, t) - \eta\, m(\omega)\, g_D(\omega, t), \tag{98}$$

$$\dot{g}_X(\omega, t) = \mathcal{A}_X\, g_X(\omega, t) - \chi\, g_X(\omega, t) + \eta\, m(\tilde{\omega})\, g_D(\tilde{\omega}, t), \tag{99}$$

where,

$$\tilde{\omega} = (z_P, z_T, a + F, k), \tag{100}$$

and the export entry decision rule is,

$$m(\omega) = \mathbf{1}\left\{a \geq F \ \text{ and } \ v_X(z_P, z_T, a - F, k) \geq v_D(z_P, z_T, a, k)\right\}. \tag{101}$$

Numerical solution

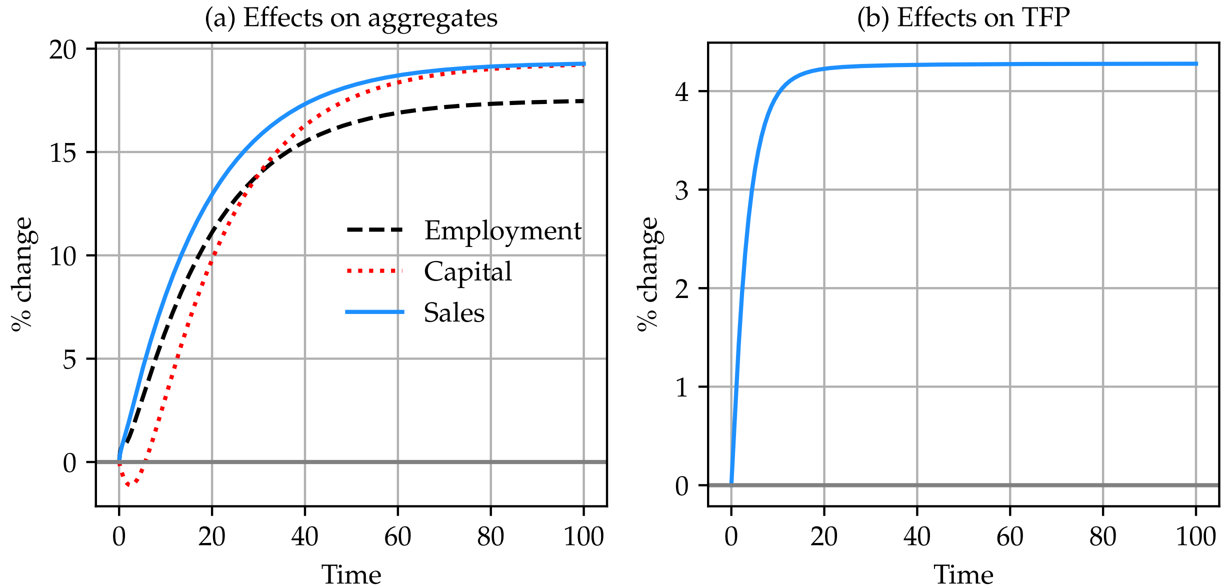
I solve for the value functions v_D and v_X using the finite difference method from Achdou et al. (2022), augmented with the nested drift algorithm of Sabet and Schneider (2025) to deal with the presence of two endogenous state variables. I use a grid with 7 evenly spaced points on $[-1.0, 1.0]$ for z_T and 7 evenly spaced points on $[-0.6, 0.6]$ for z_P. I use a log-spaced grid for physical capital with 200 evenly spaced points between -8 and $+5$, both in logs. To deal with internal funds, I first define $\tilde{a} = ak^{-1}$ and reformulate the model using this $\tilde{a}$ as a state variable in place of a. I then discretize $\tilde{a}$ on an evenly spaced grid with 30 points between 0 and 1. Finally I discretize the export entry cost shock F on a log grid with 11 evenly spaced points between $\mu_F - 2\sigma_F$ and $\mu_F + 2\sigma_F$.

In calibrating the model I must solve it twice: once without the PSL policy and again with the PSL policy. I first solve it without the PSL policy, then solve the KFE for the steady state distributions g_D and g_X. I then place the PSL cutoff k^* at the 35th percentile of the resulting physical capital distribution and define new profit functions $\tilde{\pi}_D(\omega)$ and $\tilde{\pi}_X(\omega)$ using the definition of $\lambda(k)$ in (31). This definition does imply that the entrepreneur's profits may jump down discontinuously as k crosses the cutoff k^*, but as Achdou et al. (2022) point out, such discontinuities are not an issue when using their finite difference solution method. Having defined the new profit functions in this way, I solve the resulting HJB equations for new value functions $\tilde{v}_D$ and $\tilde{v}_X$.

B.6 Transition dynamics after opening to trade

In Section 4 I reported the long run effects of moving from autarky, with $\tau = \infty$, to the baseline level of trade costs, with $\tau = 1.126$ as in Table 4. In Figure 7 I show the transition between these

Figure 7: Transition dynamics after opening to trade



Notes: Both panels show percentage changes caused by moving from autarky to the baseline level of trade costs over time, as implied by the calibrated model. Panel (a) shows aggregate sales (solid), aggregate physical capital (dotted), and aggregate employment (dashed). Panel (b) shows TFP.

two steady states. Panel (a) plots aggregate employment, capital, and sales, while Panel (b) plots TFP. All variables are measured in percentage changes relative to the steady state, and time on the x-axis is measured in years. Several features are notable. Panel (a) shows that for these macro aggregates the transition to the new steady state is very slow. Interestingly, for capital it is even non-monotone, with a short-run drop followed by a long-run increase. The explanation for this pattern is that after τ drops at $t = 0$, new exporters reallocate towards export production. This tends to tighten their borrowing constraints, which prompts them to accumulate internal funds. This in turn forces them to postpone investment in physical capital, explaining the short-run drop in capital in Panel (a). Panel (b) shows that the increase in TFP, by contrast, occurs relatively rapidly and is almost entirely complete within 20 years.

B.7 Export Promotion Policy in the Analytical Model

The profit maximization problem facing an exporter who receives an export sales subsidy ν_X and an employment subsidy ν_L is,

$$\pi_X(z,a) = \max_{l_D, l_X} \quad (zl_D)^{\frac{\sigma-1}{\sigma}} + (1+\nu_X)\left(\frac{zl_X}{\tau}\right)^{\frac{\sigma-1}{\sigma}} - (1-\nu_L)w(l_D + l_X)$$

$$(1-\nu_L)w(l_D + l_X) \leq a + \lambda\,(zl_D)^{\frac{\sigma-1}{\sigma}} + (\lambda-\theta)(1+\nu_X)\left(\frac{zl_X}{\tau}\right)^{\frac{\sigma-1}{\sigma}}. \qquad (102)$$

As in (13), this can be rewritten as an unconstrained problem distorted by wedges,

$$\max_{e,l} \quad \left((1-e)^{\frac{\sigma-1}{\sigma}} + (1+\nu_X)(1-t_X)\left(\tau^{-1}e\right)^{\frac{\sigma-1}{\sigma}}\right)(zl)^{\frac{\sigma-1}{\sigma}} - (1-\nu_L)(1+t_L)wl,$$
$$t_X = \left(\frac{\mu}{1+\mu\lambda}\right)\theta, \quad t_L = \left(\frac{\mu}{1+\mu\lambda}\right)(1-\lambda). \tag{103}$$

Suppose the parameter restriction (15) holds in the absence of the subsidy policy. Notice that the only way these subsidies can enter (15) is via the export sales share $x(\rho - r)$. Since a positive export subsidy ν_X will only ever raise the export sales share, if (15) when $\nu_X = 0$ it will certainly hold whenever $\nu_X > 0$. Thus Lemma 1 applies in the new steady state after the introduction of the subsidy policy, and the exporter constraint multiplier μ_X is constant at $\rho - r$. With this observation in hand, we can easily obtain subsidies such that the net-of-subsidy export and employment wedges are zero. In particular, set,

$$\nu_X = \frac{t_X}{1-t_X} = \frac{\mu_X\theta}{1+\mu_X(\lambda-\theta)}, \quad \nu_L = \frac{t_L}{1+t_L} = \frac{\mu_X(1-\lambda)}{1+\mu_X}. \tag{104}$$

When ν_X and ν_L are chosen in this way the resulting first order conditions for exporters are identical to those one would obtain from a problem without credit constraints, implying that, in the steady state, these subsidies maximize TFP.

To see the role of self-financing in this result, consider the convenient parameterization $\lambda = \theta = 1$ and assume the export sales subsidy ν_X is small enough that we can use a first order approximation around the no-subsidy steady state. Using the borrowing constraint of exporters, as well as the result in Theorem 2 that tells us that we can aggregate within the set of exporters along the transition path between steady states, we have

$$\Delta \log A_X = \left(\frac{wEL}{A_X}\right) \times (\sigma\nu_X), \tag{105}$$

and the resulting long-run change in TFP is given by,

$$\Delta \log Z = (X-E)\left(\frac{A_X}{wEL}\right)\Delta \log A_X, \tag{106}$$

exactly as in (21). In words, the subsidy prompts exporters to accumulate internal funds, expand employment for export production, and raise aggregate TFP.