Capital-Reallocation Frictions and Trade Shocks*

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June 2019
PRELIMINARY AND INCOMPLETE

Abstract

What are the short- and medium-run aggregate effects of an international-trade shock that increases competition for domestic manufacturing industries? In this paper, we address this question by combining detailed firm-level investment data from several manufacturing industries in Peru, data on the import penetration of Chinese manufacturing goods in Peru, and a quantitative general-equilibrium model of trade with heterogeneous firms subject to idiosyncratic shocks. In the data, we find evidence of large frictions that slow down capital reallocation, either through disinvestment or firm exit, in response to negative profitability shocks. These frictions shape the empirical response of reallocation and selection to the increase in Chinese import competition. In our quantitative model, we show that partial investment irreversibility and general-equilibrium forces are key to assess the aggregate effects of the increase in Chinese import competition. The trade shock induces slow transitional dynamics, with gradual gains in aggregate productivity over several years, while the distribution of firm-level capital and productivity adjusts to the new stationary equilibrium.

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*We thank Allan Collard-Wexler, Fabio Ghironi, Diego Restuccia, and Daniel Xu for insightful conversations, as well as participants of seminars at Bank of Canada, UC Denver, University of Toronto, and International Economics Association. We are also very grateful to CAF-Development Bank of Latin America for financial support.

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1 Introduction

Understanding the effects of trade liberalizations is a key question both in the academic literature and in policy institutions. There is a wide consensus that, in the long run, international trade increases welfare. Trade allows consumers to expand their consumption bundle and increases their real income. Moreover, selection and reallocation of factors across firms and industries lead to higher aggregate productivity.

However, less is known about the consequences of accounting for transitional dynamics after trade shocks, and to what extent frictions in the reallocation of factors may delay the aggregate-productivity gains. This gap in the literature is surprising, given that a large and influential body of empirical evidence points to the presence of large frictions in capital reallocation, as shown by the persistent dispersion in returns from capital across firms.

In this paper, we ask the following question: what are the short- and medium-run aggregate effects of an international trade shock? We show that the answer depends importantly on the size of frictions in capital reallocation. Large unproductive firms find it costly to disinvest or to exit. Thus, the transitional dynamics that follow an import-competition shock are slow and feature gradual gains in productivity over time.

In order to analyze the role of these frictions in the response of an economy to a trade shock, we combine detailed firm-level investment data for manufacturing industries in Peru in the years 2000-2015 with a general-equilibrium model of firm dynamics with costly capital reallocation. The Peruvian economy is an ideal subject for our study for two main reasons. First, it features a large manufacturing industry that was hit by a large import-competition shock after China gained accession to the World Trade Organization. The bilateral trade between Peru and China can be approximated by a balanced relation with Peru importing manufacturing goods from China and mainly exporting commodities. Hence, this is a clear case of trade shock that induces downsizing of several manufacturing industries in the domestic economy. Second, firm-level data from Peru are uniquely rich in terms of their information on capital composition and dynamics, and we leverage this feature in our empirical analysis.

In the data, we find three key empirical patterns that point towards substantial capital-reallocation frictions. First, returns from investment in physical capital are highly dispersed among manufacturing firms (within industries), consistent with many existing studies on several countries. Second, the persistence of returns from capital is asymmetric, in the following sense: Firms with high returns from capital (measured by marginal revenue product of capital - MRPK) tend to invest and grow, while firms that have low returns, because their productivity is low relative to their capital stock, tend to stay in a low-MRPK state for several years. Instead of disinvesting, they underutilize their capital and let it gradually depreciate over time. Third, we find that the level of capital affects the probability of firms' survival, conditional on their productivity. Firms with larger capital stock are less likely to exit their industry, even if their productivity is relatively low. From these patterns, as well as further empirical analyses, we infer that frictions in downsizing and reallocating capital are substantial.

We then measure a trade shock as faster growth in imports from China within each industry. In response to this shock, we find that the joint distribution of firm-level capital and productivity, summarized by the distribution of MRPK, is key to account for the reallocation and firm selection dynamics. Low-MRPK firms respond to the shock by accelerating their downsizing process and disinvesting. Hence, we find that trade shocks are drivers of capital reallocation. However, this reallocation response is smaller than the one implied by models that do not account for disinvestment frictions. Moreover, firm size as measured by level of capital affects the patterns of exit and, hence, average industry productivity, in response to the trade shock.

To assess the aggregate effects of the trade shock, we build a quantitative general-equilibrium model of firm dynamics and trade, and use our micro evidence on reallocation and selection to discipline the key margins. Monopolistically-competitive firms face idiosyncratic productivity shocks, hire workers, and adjust their capital stock subject to partial investment irreversibility. Standard fixed operations costs determine firms' decisions to continue producing or exit their industry. Investment irreversibility induces both high persistence of low returns and patterns of selection that depend on the level of capital, consistent with the key features of our data.

We simulate an import competition shock, i.e. the availability of low-cost imported varieties, and compute the whole equilibrium path of the economy to its new stationary equilibrium. We focus on two aggregate results. First, consistent with what we find in the data, low-MRPK firms respond to the shock by downsizing. However, because of partial irreversibility, the adjustment process takes a long time. Moreover, some small but relatively productive firms choose to exit, worsening selection relative to a model without frictions. Hence, while the joint distribution of firm-level capital and productivity - the key aggregate state variable in our model - responds to the shock, measured aggregate TFP is significantly and persistently lower than in the long run.

Second, the welfare gain from accounting for the transition is higher than the welfare gain typically computed by comparing steady states. This is because the domestic manufacturing industry takes time to downsize, implying an initial large decline in the price of manufacturing goods. This price decline overshoots the long run value, inducing short-run welfare gains for consumers. However, by comparing our calibrated economy to one without irreversibility, these gains are reduced by the negative effect of capital-reallocation frictions on aggregate productivity.

Related Literature.

This paper contributes to two main strands of literature: the literature on the aggregate impact of frictions in the allocation of capital across firms and the literature on the effects of trade shocks.

Since the work of Restuccia and Rogerson (2008) and Hsieh and Klenow (2009), a large and growing literature documents substantial dispersion in firm-level returns from capital (or MRPK) and argues that such dispersion may generate significant aggregate productivity losses. Asker, Collard-Wexler, and De Loecker (2014) show that a model of firm dynamics subject to idiosyncratic profitability shocks and capital adjustment costs - akin to the one proposed by Cooper and Haltiwanger (2006) - is quantitatively consistent with the observed degree of dispersion in MRPK within different industries in a large number of countries. Midrigan and Xu (2014), and more recently David and Venkateswaran (2018), show that MRPKs are not only highly dispersed, but also highly persistent.[1]

We build on these contributions and show empirically that, in the context of Peruvian manufacturing, *low* MRPKs are more persistent than *high* MRPKs.[2] In other words, it is harder for firms to downsize in response to negative profitability shocks, than it is for them to expand in response to positive ones. We obtain this finding by applying statistical methods previously used in the literature on wealth mobility (e.g., Charles and Hurst, 2003) to a firm-dynamics context. The observation that the persistence of MRPKs depends

[1]This literature builds on the seminal model of firm dynamics of Hopenhayn (1992) by introducing capital and adjustment frictions. Hopenhayn (2014) provides a survey of the literature on firm heterogeneity and misallocation.

[2]We confirm this finding also in two other datasets using Chilean and Colombian manufacturing firms. Tan (2018) finds similar results in the context of US entrepreneurial firms, and argues that this asymmetry in the persistence of MRPKs is a challenge for theories of misallocation that give a prominent or unique role to financial frictions. The latter would instead induce slower adjustment to positive shocks, but would not impede the adjustment to negative ones.

on their level guides us towards a theory of asymmetric adjustment costs: investment is partially irreversible at the firm level.

In their seminal paper, Ramey and Shapiro (2001) provide direct empirical evidence of the slow and costly downsizing of the US aerospace industry in the 1990s. Similar frictions in reallocation of used capital play an important role in several macro studies on business-cycles (e.g., Veracierto, 2002; Eisfeldt and Rampini, 2006; Bloom, 2009; Khan and Thomas, 2013; Lanteri, 2018).[3]

Our paper studies the role of these frictions in the context of trade liberalizations. Most of the literature on international trade with heterogeneous firms, starting from the seminal work of Melitz (2003), abstracts from capital, and the related reallocation frictions, which are instead at the center of the literature on MRPK dispersion. Moreover, in the literature on the effects of trade liberalizations, the focus is typically on steady-state comparisons, or long-run outcomes.[4] Our paper contributes to this literature by explicitly considering the short- and medium-run transitional dynamics after trade shocks. Consistent with our findings, recent empirical work finds evidence for the role of slow capital adjustment to explain labor-market transitional dynamics after trade liberalization episodes (Dix-Carneiro, 2014; Dix-Carneiro and Kovak, 2017) as well as the effect of capital specificity on the change in product mix and quality upgrading following import competition shocks (Medina, 2017).

By casting a model of trade with heterogeneous firms into a macro general-equilibrium framework and focusing on aggregate dynamics, we build on the contribution of Ghironi and Melitz (2005). Relative to their model of firm dynamics, we explicitly model firm-level capital accumulation and adjustment frictions. In particular, we build on the business-cycle analysis of Clementi and Palazzo (2016) in modeling entry and exit jointly with capital adjustment costs. Few other papers introduce frictions and dynamics in models with trade shocks. Caggese and Cuñat (2013) and Brooks and Dovis (2018) focus on the role of credit-market frictions in the growth dynamics of exporters after a trade reform. Relatedly, Buera and Shin (2013) show that financial frictions lead to slow transitional dynamics after reforms that trigger large reallocations. Artuc, Brambilla, and Porto (2017) study the impact of

[3] Eisfeldt and Shi (2018) provides a survey the literature on capital reallocation over the business cycle.

[4] A growing body of work in the international trade literature has incorporated financial and labor market frictions to understand trade activity (Antràs and Caballero, 2009; Helpman, Itskhoki, and Redding, 2010; Chor and Manova, 2012; Cuñat and Melitz, 2012; Manova, 2013; Foley and Manova, 2015). A full survey can be found in Manova (2010). Relatedly, Bai, Jin, and Lu (2018) study the gains from trade liberalization in presence of heterogeneous firms and factor misallocation. This body of work focuses on the static or long-run effects of frictions, rather than on their effect on transitional dynamics in response to trade shocks.

capital adjustment costs and costs in labor reallocation across sectors on the labor-market dynamics following trade shocks. Alessandria and Choi (2014) and Alessandria, Choi, and Ruhl (2018) study the transitional dynamics after a trade liberalization and focus on the gradual growth of exporters. Ravikumar, Santacreu, and Sposi (2018) study the role of capital accumulation for gains from trade in a dynamic multi-country model. Our work complements these studies by providing empirical evidence on the effects of trade shocks on capital reallocation and by focusing on the role of partial irreversibility for the aggregate response to the trade shock in the context of a macro general-equilibrium framework.[5]

Our paper proceeds as follow. Section 2 describes the data sources and measurement of MRPK. Section 3 presents the main supportive facts on capital adjustment irreversibility frictions and section 4 shows the empirical effects of a trade shock on capital reallocation. Section 5 introduces a firm dynamic model with partial capital irreversibility. Section 6 explains the main quantitative findings. Section 7 concludes.

2 Data Description

In this section, we describe our main data source on firm-level investment dynamics in Peruvian manufacturing and the measurement of marginal revenue product of capital (MRPK).

2.1 Data Sources

Our main data source is the *Encuesta Economica Nacional* (EEA), for the period between 2000 and 2015. This is a firm-level survey administered by the Peruvian Statistical Agency (INEI) at the national-level. The data include firm balance-sheet information, including variables related to inputs and profitability. Moreover, the EEA provides detailed information on fixed assets, i.e., capital. Beside total capital stock and expenditure, it records two capital measures rarely found in other datasets. First, it includes information on both the stock and flow of assets. This includes capital additions and retirements. Additions refer to purchases, own construction, and revaluations. Retirements refer to sales and withdrawals. Second, it disaggregates capital in different types. These categories are land, fixed installations, buildings, machinery and equipment, furniture, computers, and transportation. For

[5] Berthou, Chung, Manova, and Charlotte (2018) also examine the impact of trade on aggregate productivity in presence of resource misallocation. However, they do not model the underlying reasons why productivity is distorted in the economy.

every type of capital, both stock and flows of capital are listed.[6] As it is often the case with administrative surveys, the EEA is effectively a census for large and medium firms, but only a sample for small firms.[7] Thus, panel data for small firms are limited and unbalanced. We perform several robustness tests considering only the subset of medium and large firms that generate a balanced panel.

While these firms account for a large share of any manufacturing industry, we discuss the implications for small ones in more detail in the next sections. We also supplement the EEA with the Peruvian registry of firms *(Padrón RUC)*, covering 2007-2015. While these data do not provide many firms' characteristics, they allow us to compute accurate exit-entry rates.

Finally, we complement these firm-level data with the UN Comtrade dataset for information on trade-flows at the product level between China and other countries. This information spans the period from 2000 to 2015 and is available at the annual level. We use the correspondences of the World Integrated Trade Solution (WITS) from the World Bank to convert six-digit Harmonized System (HS) product level codes to CIIU Rev.3, the industry classification in Peruvian data.[8]

2.2 Measurement

We use data on value added and inputs to recover revenue total factor productivity (TFPR) following the procedure of Asker, Collard-Wexler, and De Loecker (2014), to account for the fact that we do not separately observe output prices and quantities. Hence, we assume that a firm j at time t produces physical value added y_{jt} by using an industry-specific constant-return technology that takes capital k_{jt} and labor n_{jt} as inputs, $y_{jt} = s_{jt} k_{jt}^{\alpha} n_{jt}^{1-\alpha}$, where s_{jt} is firm-level idiosyncratic physical productivity. Demand for firm j's product is given by $y_{jt} = B_t p_{jt}^{-\epsilon}$, with constant elasticity ϵ, where B_t is an aggregate shifter.[9]

With these assumption, the nominal value-added sold by the firm, which we observe in the data, is

$$p_{jt} y_{jt} = B_t^{\frac{1}{\epsilon}} s_{jt}^{\theta} k_{jt}^{\theta\alpha} n_{jt}^{\theta(1-\alpha)} \tag{1}$$

[6]We report in Appendix A.1 a broad summary of the investment characteristics of these firms.

[7]The threshold for a firm to be sampled on the survey is determined annually and it is based on sales relative to Peruvian tax units.

[8]See `https://wits.worldbank.org/product_concordance.html`

[9]We abstract from firm-specific demand shocks, because we cannot separately identify them from productivity shocks.

with $\theta \equiv \frac{\epsilon-1}{\epsilon}$.

We assume a standard value for the elasticity of substitution ($\epsilon = 4$), and obtain an industry-specific value for α by computing the median share of the labor expenditure in firm's value added. TFPR is calculated as the residual in the log of equation (1), where v_{jt} is value-added, n_{jt} is the number of employees in the firm and k_{jt} is its capital stock measured as the book value. Finally, TFPR's volatility corresponds to the standard deviation of the residual of an AR(1) process of $log(s_{jt})$, correcting for the factor θ.

Given these technological assumptions, we measure the marginal revenue product of capital (MRPK) as follows:

$$MRPK_{jt} = \frac{\partial p_{jt} y_{jt}}{\partial k_{jt}} = \theta\alpha \frac{p_{jt} y_{jt}}{k_{jt}} \tag{2}$$

Throughout the paper, we will focus on MRPK dispersion, i.e., the standard deviation of the log of MRPK within an industry and year, and MRPK persistence over time, i.e., the autocorrelation of the log of MRPK within an industry.

3 Key Facts on MRPK and Selection

In this section, we describe three key facts about the distribution of MRPK and firm selection in the Peruvian manufacturing sector. These facts guide our understanding of the underlying frictions preventing capital reallocation. In particular, all these facts are consistent with significant downsizing frictions, namely, investment irreversibility.

Fact 1: MRPKs are highly dispersed and persistent

Consistent with the findings of a large literature on capital misallocation, we find that MRPKs show large dispersion across firms within the same industries, and the relative rankings of MRPKs display persistence over time. In the Peruvian manufacturing industry, the standard deviation of (log) MRPK controlling for industry and time fixed effects is 1.43.[10] This dispersion is not driven by a particular industry, but rather, it is large for all manufacturing industries.[11] Moreover, MRPKs are not only highly dispersed in the

[10]This is larger than similar estimates for other developing countries such as Chile, Mexico or India.

[11]This fact is in line with results from Bartelsman, Haltiwanger, and Scarpetta (2013) that document misallocation also occurs within narrowly defined industries.

cross section of firms, but also remarkably persistent at the firm level. In our sample, the within-firm autocorrelation coefficient of MRPK is considerably large (0.74), and is in the same range as the within-firm TFPR autocorrelation (0.72).[12]

Dispersion of MRPKs suggests the existence of frictions in capital reallocation in response to firm-level profitability shocks. In particular, firm-level persistence in the returns from capital indicates that it takes a long time for firms to adjust to profitability shocks. In the presence of frictions, firms respond to profitability shocks by only gradually adjusting their capital stock.[13]

Fact 2: Low MRPKs are more persistent than high MRPKs

We now move beyond the cross-sectional properties of MRPK and characterize its dynamic evolution at the firm level. In order to formally study the mobility of MRPK, we perform a non-parametric estimation, borrowing from the literature on household wealth and income "mobility" (e.g., Charles and Hurst, 2003). Specifically, we estimate the matrix of transition probabilities across terciles of the distribution of MRPKs. A generic element of this matrix is the probability that a firm in a given tercile of the current distribution of MRPK (within its industry) moves to another given tercile in the following year.

A motivation for this analysis is that the mobility of MRPK can be thought of as a useful diagnostic for capital-reallocation frictions in the context of models of investment with firm-level profitability shocks. To see this, consider first a firm with high current MRPK, that is, a high level of value added relative to its value of capital. The future level of this firm's MRPK can be affected by changes in its profitability and by the firm's investment decisions. Absent changes in profitability, if the firm responds to its high return from capital by increasing its capital stock, its MRPK will fall accordingly. Hence, high persistence of high MRPKs would suggest that there are frictions that slow down firms' investment and growth. Conversely, a firm with low MRPK may respond to its relative low return from capital by downsizing. Moreover, its MRPK may increase if its profitability improves. Hence, conditional on a given process for the profitability shocks, a high persistence in low MRPKs signals the presence of frictions that make disinvestment costly.

[12]This finding that has also been highlighted by Midrigan and Xu (2014) in a different context.

[13]Consistent with this view, proposed by Asker, Collard-Wexler, and De Loecker (2014), we find that dispersion in MRPK is positively correlated with dispersion in firm-level TFPR within each industry. In Figure B1 of Appendix B.1, we show a scatter plot of the pairs of industry-level MRPK dispersion and within-industry firm-level TFPR dispersion for each industry-year in our sample.

To exploit this insight, we first pool our data to generate a single set of estimates of MRPK mobility. In order to so, we first de-mean MRPKs by regressing them on year and industry fixed effects and then estimate the transition probabilities across terciles of MRPK for all Peruvian manufacturing firms. In Table 1, we report our estimates. The probability of staying in the bottom tercile is 82%, whereas the probability of staying in the top tercile is 77% , showing that firms adjust more slowly to negative profitability shocks, than to positive ones. We also perform the same analysis for the mobility of TFPR, and find that instead high levels of TFPR are more persistent than low levels. This suggests that the high persistence of low MRPKs is likely due to frictions in capital reallocation, and not due to asymmetry in the distribution of profitability shocks.

		at $t+1$		
		1	2	3
	1	0.83	0.16	0.01
Tercile at t		(0.01)	(0.01)	(0.00)
	2	0.18	0.71	0.11
		(0.01)	(0.01)	(0.01)
	3	0.02	0.21	0.77
		(0.00)	(0.01)	(0.01)

Table 1: Transition Probabilities of MRPK. Standard Errors in Paranthesis.

In order to allow for industry-specific definitions of the MRPK terciles, we also perform this analysis separately for the six largest industries in our sample and systematically find that the probability of staying in the first tercile (i.e., lowest MRPK within industry) is larger than the probability of staying in the third tercile (i.e. highest MRPK).[14] In Appendix B.2, Figure B2 plots the results of this estimation. For all but one of the industries considered, we can reject the null hypothesis (at least at the 10% level) that the probabilities of staying in the first and third tercile are equal. In Appendix B.3, we provide our estimated probabilities of transition across all terciles of all six industry-specific MRPK distributions. We also estimate the transition matrix of MRPK allowing for firm exit as an additional

[14]The probability of staying in the first tercile is also larger than the probability of staying in the middle tercile. Moreover, these results are robust to the choice of a different number of quantiles, as well as to several implementation details in the construction of the quantiles. We focus on three quantiles in order to have sufficient power to test for the estimated differences.

fourth state. The asymmetric persistence is robust to this specification, and the results are displayed in Appendix B.3.2.

Our results corroborate the notion that frictions in capital adjustment are larger for firms with lower returns from capital, i.e. investment in physical capital is partially irreversible. Consistent with this interpretation, in Figure 1 we display the distribution of growth rates of capital for firms in the bottom tercile of MRPK (solid blue line) and contrast it with the distribution of growth rates of capital in the top tercile (dashed red line). We find a large spike of zero growth rates for firms with low MRPK, suggesting that these firms are not downsizing in response to negative shocks. On the other hand, we find a long right tail of positive growth for firms with high returns from capital.

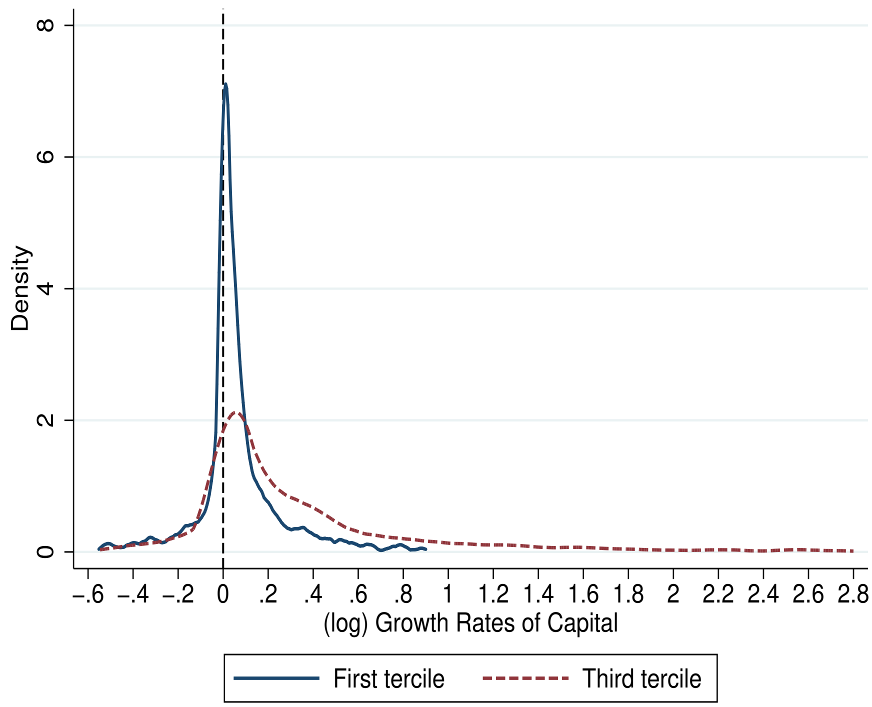


Figure 1: Density of Firm-level Growth Rates of Capital.

Notes: we plot the kernel density of the (log) growth rate of capital $\frac{k_{j,t+1}}{k_{jt}}$ for firms in the bottom tercile of MRPK within their industry (solid blue line) and firms in the top tercile (dashed red line). Graph is winsorized at 2.5% and 97.5%.

We further investigate the asymmetric persistence of MRPK by considering the following specification,

$$\log MRPK_{jnt} = \alpha + \sum_{q \in \{1,2,3\}} (\rho_q \log MRPK_{jnt-1} \times \mathcal{I}_{jnt-1,q}) + \gamma_n + \gamma_t + \epsilon_{jnt} \tag{3}$$

where j denotes a firm, n denotes its industry, t denotes a year, q denotes a tercile of the distribution of MRPKs, and $\mathcal{I}_{j,n,t-1,q}$ is an indicator function that takes value of one if firm j is in the quantile q of MRPKs within industry n in year $t-1$.

Column 1 of Table 2 reports the coefficients ρ_q of this regression. Relative to the pooled regression, we find a substantial heterogeneity in the degree of persistence of MRPKs. Low realizations of MRPK are significantly more persistent than high realizations, consistent with our analysis of MRPK mobility. The estimated coefficient of autocorrelation goes from 0.84 for the lowest-MRPK firms (1st tercile) to 0.55 for the highest-MRPK firms (3rd tercile), and they are significantly different from each other. Consistent with Figure 1, the endogenous process of adjustment of firm-level capital stock appears to be highly asymmetric: capital adjustment frictions appear to be larger for low-return firms that are trying to downsize, than for high-return firms that are expanding. As a consequence, lower returns have more persistence. To our knowledge, this paper is the first to document this stylized fact.

	MRPK	TFPR
ρ	0.742	0.720
	(0.026)	(0.018)
ρ_{MRPK-1}	0.843	0.513
	(0.017)	(0.026)
ρ_{MRPK-2}	0.641	0.565
	(0.025)	(0.024)
ρ_{MRPK-3}	0.546	0.608
	(0.050)	(0.023)

Table 2: Persistence of MRPK and TFPR in Different Terciles of MRPK.

In contrast, Column 2 of Table 2 shows that the degree of persistence of firm-level TFPR is not significantly affected by firms' MRPK ranking.[15] We also find that the persistence of TFPR does not depend on the current position of the firm in the TFPR distribution. In contrast to the process of capital adjustment, the stochastic process for TFPR is approximately symmetric.

Fact 3: Selection depends both on productivity and capital stock

In order to investigate the role of productivity and capital for firms' exit decisions, we estimate the following probit model, which relates the probability of survival of a firm j in industry n between year t and $t+1$, $Prob(survival_{jnt,t+1})$ with TFPR and capital stock at the firm level. Specifically,

$$Survival_{jnt,t+1} = \begin{cases} 1 & \text{if} \quad z^*_{jnt} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

and

$$z^*_{jnt} = \alpha + \beta_1 TFPR_{jnt} + \beta_2 KStock_{jnt} + \gamma_n + \gamma_t + \epsilon_{jnt} \tag{5}$$

Figure 2 shows the contours of the probability of firm survival in the Peruvian manufacturing industry, with (log) capital on the x-axis and (log) TFPR on the y-axis. The figure shows that firm survival probabilities are determined both by productivity and the level of capital. In particular, conditional on productivity, we find that firms with a lower capital stock have a significantly higher probability of exiting their industry.[16] Conditional on capital level, unproductive firms are more likely to exit.

The fact that size affects selection conditional on productivity is at at odds with the implications of most standard trade models with firm heterogeneity. These models typically predict a straighforward relationship between survival and firm-level idiosyncratic productivity. For instance, in the model of Melitz (2003), firm-level productivity is a sufficient statistic for entry and production. Even when capital is included in trade models, its reallocation is typically assumed to be frictionless, due to the presence of spot rental

[15] To obtain these results, we run the following regression: $\log TFPR_{i,j,t} = a + \sum_{q\in\{1,2,3\}} (\rho_q \log TFPR_{i,j,t-1} \times \mathcal{I}_{i,j,t-1,q}) + \gamma_j + \gamma_t + \epsilon_{i,j,t}$ where i denotes a firm, j denotes its industry, t denotes a year, q denotes a tercile of the distribution of MRPKs. Again, $\mathcal{I}_{i,j,t-1,q}$ is in indicator function that takes value of one if firm i is in the tercile q of MRPKs within industry j in year $t-1$.

[16] Lee and Mukoyama (2015) provide evidence of an unconditional relationship between size (measured by employment) and exit in US manufacturing.

markets.[17] Hence, in the absence of capital reallocation frictions, the capital stock does not matter for survival.[18]

In contrast, downsizing frictions such as investment irreversibility are consistent with these empirical patterns of selection. Firms with a high level of capital face a larger cost of exiting and are thus more likely to survive, conditional on their level of productivity.

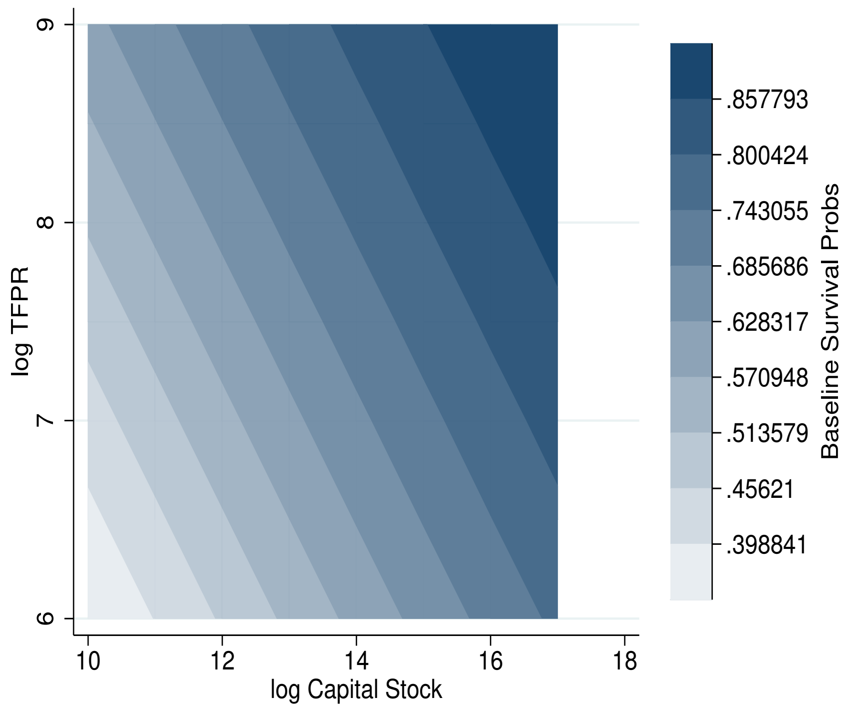


Figure 2: Selection Effects of TFP and Capital Stock.

Notes: Heat map of survival probabilities as a function of (log) TFP and (log) capital stock.

Further Evidence of Investment Irreversibility

Taken together, these three facts support the existence of large capital reallocation frictions. In particular, they highlight the role of frictions in downsizing both on the intensive and on the extensive margin, in response to low realizations of idiosyncratic productivity. Thus, the empirical evidence suggests the presence of a large degree investment irreversibility. In

[17]See, for instance Alessandria and Choi (2014).

[18]Consistent with this existing literature, in Section 6 we illustrate that the contours of the survival probability in the absence of capital-reallocation frictions are horizontal in the capital-productivity space, that is, the survival probability does not depend on the level of capital.

order to provide further evidence in favor of this interpretation, we perform two additional exercises.

Heterogeneous depreciation rates. We leverage a unique feature of our dataset, namely the information on the composition of the capital stock at the firm level. For each firm, we observe the portfolio composition of its capital stock among the following categories: machines, land, fixed installation, computers, furniture, and transportation equipment. We exploit the fact that the depreciation rate of capital goods is very heterogeneous across different types of capital. For instance, land does not depreciate, whereas transportation equipment depreciates at a yearly rate of approximately 15%. Since firms' capital composition is heterogeneous, i.e. different firms hold different portfolios of capital goods, even within an industry, the effective average depreciation rate of capital is also heterogeneous at the firm level.

This heterogeneity in capital depreciation has important consequences for the ability of firms to downsize in response to negative profitability shocks particularly when investment is partially irreversible. High depreciation implies that a firm can decrease its level of capital relatively fast, even without selling used capital. Conversely, low depreciation implies that the only way a firm can decrease its level of capital is by disinvesting, which is a costly activity in presence of partial irreversibility. Therefore, if capital irreversibility prevents downsizing, the persistence of MRPK should be more prevalent for firms with low firm-level depreciation rates.

We explore the relevance of this mechanism by examining the impact of firm-level depreciation rates on the probability of staying in same tercile of MRPK distribution.[19] We first focus on firms in the first tercile of the MRPK distribution, i.e., low MRPK firms, which are more likely to be directly affected by capital resale frictions. We find a statistically-significant negative effect of depreciation rates on the persistence of MRPK, meaning that a higher depreciation rate makes it more likely that a firm with currently low MRPK will move to a tercile associated with higher MRPK in the following year. The estimated effect implied that a 1% increase in the firm-level depreciation rate decreases the probability of staying in the first tercile of the MRPK distribution by 0.14% on average. We also perform this estimation for firms in higher MRPK terciles, and find smaller effects, consistent with the notion that depreciation is more salient for firms that are trying to

[19] See Appendix B.4 for a detail discussion of the construction of firm-level depreciation and the empirical results.

downsize.

Capital utilization. If unproductive firms find it hard to sell their capital, in presence of utilization costs, they will optimally choose how much capital to use in production. We find that firms with low MRPK, instead of downsizing, hold on to their capital and under-utilize it. To analyze the capital utilization margin, we use data on firms' expenditures on energy. Assuming energy is complementary to the amount of capital used in production (at least in the short run), we measure the utilization rate as the ratio of energy inputs to capital stock. We then recompute firms' MRPK using utilized capital instead of total capital stock.[20] Two key findings suggest that utilization is an important channel, especially for firms with low MRPK. We first find that after adjusting for utilization, the cross-sectional dispersion of MRPK decreases for most industries and years (about 71% of industry-year observations). For the observations that saw a decrease in the dispersion of MRPK, the average reduction was around 14%. In addition, the high relative persistence of low returns (relative to high returns) disappears, once MRPK is adjusted for utilization.[21]

After adjusting for utilization, the persistence of MRPK becomes relatively flat with respect to the current rank of MRPK. In fact, MRPKs in the lowest tercile are even less persistent than higher MRPKs, in contrast to our baseline estimates, which do not account for utilization. We interpret this result as follows. Firms hit by negative profitability shocks do not downsize, but hold on to their capital and decrease the intensity of utilization. Hence, their measured MRPK - based only on the size of the capital stock - remains persistently low, whereas their adjusted MRPK - which accounts for energy consumption - increases faster, as the effective capital input shrinks through under-utilization.[22]

Consistent with these regression results, we find that our non-parametric estimates of persistence based on transition probabilities across terciles of the MRPK distribution also change significantly after controlling for utilization. In particular, for utilization-adjusted MRPK, we often cannot reject that the probability of remaining in the lowest tercile equals the probability of remaining in the highest tercile. The analysis of utilization suggests that this margin of adjustment is important in general to correctly measure dispersion in returns

[20]See Appendix B.5 for a more detailed description of the construction of this variable and empirical results.

[21]Table B5 in Appendix B.5 reports the autocorrelation of MRPK, both unconditional and conditional on the current tercile of MRPK after the utilization adjustment (first column), and compares to the baseline estimates of Table 2 (reproduced in the second column to facilitate the comparison).

[22]We also perform this analysis using materials instead of energy consumption to proxy for utilization and find qualitatively similar results.

from capital, and even more salient when we analyze the behavior of low-MRPK firms, consistent with the presence of frictions in capital reallocation.

Overall, this analysis, which relies on our rich dataset with information on capital composition and firm-level information, allows us to provide more direct evidence that partial investment irreversibility affects the persistence of low returns from capital. In Appendix B.7, we provide further evidence of partial irreversibility of capital such as the fact that the asymmetric persistence is indeed driven by low disinvestment rates for low-MRPK firms.

Facts About Labor Reallocation

To conclude this section, we analyze the properties of labor reallocation in our dataset. First, we compute the standard deviation of the (log) marginal revenue product of labor (MRPN). When we consider the whole sample and we residualize MRPN using industry and time fixed effects, this standard deviation equals 0.86. When we consider each industry separately, we find values in the range (0.68, 0.97). Thus, consistent with the previous literature, we find that returns from labor are substantially less dispersed than returns from capital at the firm level.

Next, we study the mobility of MRPN, using the same methodology we described for MRPK. We construct terciles of MRPN for each industry and year and estimate the transition probabilities across these terciles. In Appendix B.6, we report the estimated transition matrix for the whole sample. We find evidence of persistence of MRPN (i.e., higher probabilities on the diagonal of the transition matrix). However, we do not find evidence of asymmetric persistence, different from our key finding about the dynamics of MRPK.

Taken together, these results suggests that firms face smaller frictions in the reallocation of labour than in the reallocation of capital, and the frictions affecting labor adjustment do not display asymmetry with respect to positive or negative profitability shocks. Thus, in the following we focus our attention on the role of capital-reallocation frictions after import-competition shocks.

4 Trade Shocks and Reallocation

In this section, we present empirical evidence on how the frictions in capital-reallocation examined in Section 3 interact with the effects of a trade shock. First, we consider China's accession to the WTO as a large import competition shock that affected Peruvian manufacturing. Second, we document the effects of this trade shock on two margins of firms' reallocation decisions: extensive (exit) and intensive (investment). Firms' responses on both are highly heterogeneous. Importantly, they depend on their position in the distribution of capital and productivity. Moreover, conditional on survival, firms' investment responses depend on their pre-shock MRPK. These reactions are consistent, again, with capital frictions that dampen firms' downsizing.

4.1 Chinese Import Competition

In 2001, China gained accession to the World Trade Organization (WTO). This event resulted in a worldwide reduction in tariffs placed on Chinese products and a fast growth in the volume of goods exported by China.[23] Since then, China's exports of manufacturing products have grown by more than 6 times. Initially, China's exports were labor-intensive manufactured goods (Chen, 2009). Accordingly, many countries experienced a sizable increase in Chinese import competition over this period. Peru, a country with a manufacturing sector focused on labor-intensive goods, was no exception.

The first column in Panel A of Table 3 shows the value of annual Peruvian imports from China for the years 1998, 2003, and 2008 (all values are in 1998 US Dollars). During this period, Chinese import value increased by a factor of 15 and went from 3% to 15% of total Peruvian imports. Unlike Chinese imports, we do not observe this trend in imports from other countries. As shown in the second column of Panel A, Peruvian imports originated in the rest of the world (ROW) only grew 2.3 times over this period. Moreover, China's accession to the WTO affected other countries in the region and the world. Panel B of Table 3 presents the same statistics for Latin American countries sharing a border with Peru. This set includes Argentina, Bolivia, Brazil, Chile, Colombia and Ecuador. While they did experience a large increase in Chinese import competition, it is much lower compared to the Peruvian economy. Considering the scope and scale of China's accession to the WTO, we consider it a profitability shock to Peruvian manufacturing firms, which might induce firm selection and factor reallocation.

While large, this shock affected individual Peruvian industries differently. Industries such as agricultural products or food and beverages received a low influx of Chinese im-

[23] This also decreased tariffs on imports into China given the requirements placed upon China by WTO members.

Table 3: Chinese Import Competition.

	Bilateral Trade (Millions of 1998 US$)	
	Imports China	Imports ROW
A: Peru		
1998	213.3	7,566.9
2003	583.9	6,249.6
2008	3,233.2	17,788.4
Growth 1998-2008	1,416%	135.1%
B: LATAM countries		
1998	3,355.8	127,130.7
2003	5,379.5	82,108.3
2008	33,237.6	249,297.4
Growth 1998-2008	890%	96.1%

Source: UN Comtrade.
Notes: Values are in Millions of 1998 US dollars. Panel A shows the values of annual Peruvian imports from China (column 1) and from the Rest Of the World (column 2). Panel B shows these values for Latin American countries sharing a border with Peru: Argentina, Bolivia, Brazil, Chile, Colombia and Ecuador.

ports. Textile, apparel, chemicals and communication equipment faced large imports flows from China during this period. In Figure 3 below, we report the time series of import penetration for the six industries of interest. Despite all showing an upward trend, there is large heterogeneity on the speed and magnitude of the shock. Moreover, the government's reaction to Chinese import competition largely varied with industry. For instance, apparel imports decreased significantly during 2004 since the Peruvian government established 200-day temporary tariffs to Chinese clothing. This effectively shut down imports originated in China for 6 months in this sector, providing an important source of heterogeneity on exposure.

Given the steady increase of Chinese imports during the 2000s in most industries, we do not use import penetration as the competition shock but, rather, deviations from import penetration trend by industry. This approach allows us to focus on the responses to (likely) unexpected increases in Chinese import penetration. In particular, to construct these

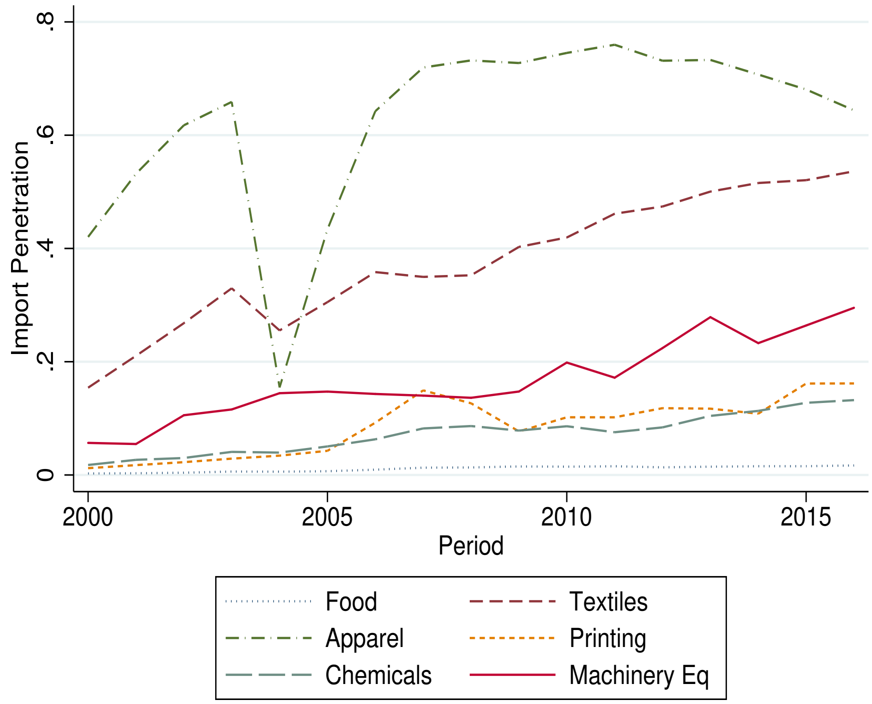


Figure 3: Chinese Import Penetration.

Source: UN Comtrade.
Notes: Import Penetration refers to the percentage of imports originated in China relative to total Peruvian imports.

deviations from trend, we first regress the raw import penetration measure $Ch\tilde{Comp}_{nt} = \frac{Imports_{China,nt}}{Imports_{World,nt}}$ of 4-digit CIIU Rev 3.1. industry n on a series of dummy variables for two-digit industry and year. Then, we construct the shock as the residuals of this regression. We define this shock as $ChComp_{nt}$. As a robustness check, we also consider measures that only use the level of import penetration. This analysis provides similar results, as illustrated in Appendix C.

In addition, to capture increases on Chinese import penetration that come from productivity enhancement in China rather than to demand trends in the local economy, we instrument this measure following Autor, Dorn, and Hanson (2013). That is, we use deviations from import penetration trends in other border Latin American countries as an instrument for our competition shock in Peru. The idea is that these instruments will capture increase in Chinese imports that are not driven by a particular local economy.

Finally, we consider import competition as the primary effect of China's accession to the WTO, given that this shock did not immediately represent a significant exporting opportunity for the Peruvian manufacturing sector. As shown in Figure C1 of Appendix C.1, commodity sectors in Peru derived the largest benefits by China's trade liberalization. Meanwhile, most manufacturing industries –including our six selected ones– did not show any increase in exporting activity to China.

4.2 Effects of Trade Shocks on Selection and Investment

To understand the effects of a trade shock on firm's decisions on exit and investment, we proceed in two steps. First, we examine the importance of Chinese competition on survival. Second, for continuing firms, we analyze the effect on firms' investment decisions. In all our specifications, we allow the effects to be heterogenous by the location of the firm in the MRPK distribution.

4.2.1 Selection

Conditional on TFPR, does the level of capital matter for firm selection after a trade shock? To examine this question, we estimate the following probit specification,

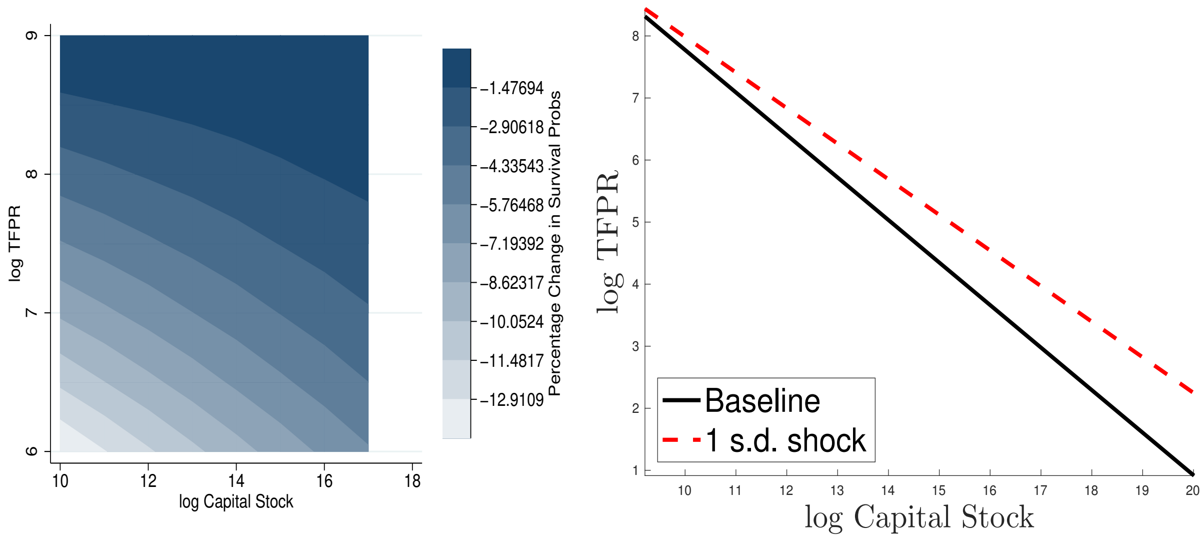
$$Survival_{jnt,t+1} = \begin{cases} 1 & \text{if} \quad z^*_{jnt} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{6}$$

and

$$\begin{aligned} z^*_{jnt} = \beta_0 + \beta_1 ChComp_{nt} + \beta_2 TFPR_{jnt} + \beta_3 ChComp_{nt} * TFPR_{jnt} \\ + \beta_4 KStock_{jnt} + \beta_5 ChComp_{nt} * KStock_{jnt} + \eta X_{jnt} + \gamma_n + \gamma_t + \epsilon_{jnt} \end{aligned} \tag{7}$$

where j again denotes the individual firm, n the industry, and t the year. X_{jnt} includes now the trade competition measure, $ChComp_{nt}$, firm-level productivity $TFPR_{jnt}$, and firm-level capital stock, $KStock_{jnt}$. γ_t and γ_n, represent year and industry fixed effects, respectively. β_1 gives the direct impact of an import competition shock on survival, while β_3 and β_5 allow for the differentiated effects of the shock by level of productivity and capital stock.

We then construct the average effect of an increase in Chinese import competition on firm survival probability, conditional on firm productivity and capital. This is shown in Figure C4a and C4b. In Figure C4a, the average effect is computed as the percentage change



(a) Average Effect of 1 s.d. Shock

(b) Prob. Survival = 50%, at Baseline and 1 s.d. Shock

Figure 4: Effects of Trade Shock on Survival Probabilities.

in survival probability for a firm of given productivity and capital stock, when the firm faces a one standard deviation increase in import competition.[24] Appendix C.2 presents the full estimates used to generate these graphs. In Figure C4b, we plot a line corresponding to the set of level of capital and productivity that give a probability of survival equal to 50%, at baseline (solid black line) and when firms are hit by a one standard deviation import competition shock (dashed red line). Similar effects can be obtained for other levels of survival probabilities.

Overall, the trade shock induces an outward shift in these isoprobability lines, implying that smaller and less productive firms are more likely to exit in industries and periods corresponding to fast increases in Chinese import competition. The result that a trade shock induces exit of unproductive firms is consistent with the predictions of standard trade models. However, we find that the level of capital plays an important role, even conditional on productivity. In particular, some unproductive but large firms are more likely to survive the trade shock, while some small, but relatively productive firms may be selected out by the shock. As we show in the quantitative analysis of Section 6, this feature of the data is consistent with the presence of partial investment irreversibility, while at odds with a model in which capital can be freely adjusted.

[24]Figure 2 in Section 3 shows the baseline survival probabilities.

4.2.2 Investment

We now study the effects of import competition on firms' investment decisions, conditional on survival. As previously explained, the trade shock creates sample attrition through firm exit, a result that would lead to attenuation bias. Thus, we estimate the following specification allowing for selection. In particular,

$$z_{jnt} = \theta_0 + \theta_1 ChComp_{nt} + \eta X_{jnt} + \gamma_n + \gamma_t + \epsilon_{jnt} \tag{8}$$

where z_{jnt} is only observed when,

$$z^*_{jnt} = \alpha_0 + \alpha_1 ChComp_{nt} + \sigma Y_{jnt} + \gamma_j + \gamma_t + \nu_{jnt} > 0 \tag{9}$$

In equation 8, z_{jnt} are outcome variables such as the investment rate, X_{jnt} considers employment, γ_t and γ_n, represent year and industry fixed effects, respectively. In equation 8, Y_{jnt} considers firm-level sales and employment.

We are interested in the impact of trade on investment and disinvestment decisions, as well as firms' mobility across the MRPK distribution. In Table 4, we report the marginal effect of an import competition shock for firms on two key variables related to the intensive margin of capital reallocation. Those are firm-level capital growth (first column) and mobility in the MRPK distribution (second column).[25] The standard deviation of the trade shock is 0.08.

In the first row, we see that an import competition shock has relatively weak effects on capital reallocation. In terms of capital growth rates, the effect is statistically insignificant; in terms of mobility in the MRPK distribution, the shock induces a small amount of reshuffling. Looking further into the responses of firms across the MRPK distribution, we notice that this result arises because of heterogeneity in responses across firms with different levels of MRPK (as measured before the shock). In particular, we see that firms in the lowest tercile of MRPK (second row) respond to the shock by downsizing. Specifically, a one percentage point increase in import penetration leads to an approximately 0.2% decrease in the growth rate of capital. This, in turn, drives a large response in the mobility of this set of firms in the MRPK distribution. In the second column, a one percentage point increase in import penetration leads to a 0.3% decrease in the probability that a firm that starts in

[25] In Appendix C.4, we show the effects of the trade shock on TFPR and employment, which are not statistically significant.

the first tercile will stay in the first tercile going into the next year.[26] In contrast, firms in the other two terciles (third and fourth rows) do not exhibit any meaningful responses to the import penetration shock. Thus, when we estimate the effect of the import shock on the entire sample (as in the first row), the result becomes muted as the strong responses of the low MPRK firms are countered by the weak responses of the other higher MRPK firms.

	Growth Rate of K	Prob of Staying in Current Tercile
Pooled	0.080	-0.122
	(0.092)	(0.065)
First Tercile MRPK	-0.225	-0.251
	(0.095)	(0.101)
Second Tercile MPRK	0.164	-0.080
	(0.106)	(0.121)
Third Tercile MRPK	-0.084	0.031
	(0.285)	(0.127)

Table 4: The Effect of a Trade Shock on Investment.

How does the trade shock affect positive investment, negative investment, and inaction? To investigate this question, we run the following specification:

$$z_{jnt} = \delta_0 + \delta_1 ChComp_{nt} + \delta_2 TFPR_{jnt} + \delta_3 KStock_{jnt} + \gamma_n + \epsilon_{jnt} \tag{10}$$

where z_{jnt} are variables such as the size of the inaction region (probability of firms' investment absolute value less than 10 percent), the fraction of positive investment (probability of firms' investment value larger than 10 percent), and negative investment (probability of firms' investment value lower than -10 percent).

Results using our IV-strategy are shown in Table 5. Consistent with our findings of weak effects of the trade shock on capital reallocation, the first column of Table 5 shows that the import competition shock increases the inaction region in the short-run. This effect, in turn, comes entirely from a decrease on the positive investment region (second column), rather than from significant effects on the negative investment region (third column). This

[26] An increase of a standard deviation would have led to a percent change decrease of 1.6 on the growth rate of capital and a 2.4% decrease on the probability of staying in the same tercile.

decomposition highlights once more the difficulty for surviving firms to adjust downwards their capital stock.

	Inaction	Positive Investment	Negative Investment
ChComp	0.096	-0.095	-0.000
	(0.051)	(0.058)	(0.035)

Table 5: The Effect of a Trade Shock on Investment (continued).

Taken together, our results suggest that the returns to capital are an important variable in predicting a firm's capital-reallocation response to a trade shock. In the next section, we build a model that will help us quantify how the dynamic effects of a trade shock look in the presence of capital-reallocation frictions.

5 Model

In this section, we present a general-equilibrium model of firm dynamics, which features three key elements: (i) a CES demand structure; (ii) partial investment irreversibility; (iii) endogenous entry and exit. We use the model to study quantitatively the aggregate implications of a trade shock as the one analyzed in our empirical sections, i.e. an increase in competition for domestically-produced manufacturing output. We begin by describing the model in absence of trade in manufacturing varieties, and then introduce import competition.

5.1 Households

Time is discrete and infinite. An infinitely-lived representative household ranks streams of consumption and labor effort according to the following utility function

$$U_0 \equiv \sum_{t=0}^{\infty} \beta^t \left(\log C_t - \chi N_t\right) \tag{11}$$

where C_t is aggregate consumption and N_t is labor effort, $\beta \in (0, 1)$ is the discount factor and $\chi > 0$ a labor disutility parameter.

Aggregate consumption is a Constant Elasticity of Substitution (CES) aggregator of a continuum of measure M_t of different varieties of goods

$$C_t = \left(\int_0^{M_t} c_{jt}^{\theta} dj \right)^{\frac{1}{\theta}} \tag{12}$$

where j is a generic variety, $\theta = \frac{\epsilon - 1}{\epsilon}$ and $\epsilon > 0$ is the elasticity of substitution across varieties.

The budget constraint of the household is

$$\int_0^{M_t} p_{jt} c_{jt} dj = N_t + \Pi_t \tag{13}$$

where we are normalizing the wage to 1, i.e. labor is the numeraire of our economy, and Π_t are aggregate dividends from ownership of all the firms in the economy.[27]

We can define the CES price index associated with the consumption bundle C_t as $P_t \equiv \left(\int_0^{M_t} p_j^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}}$. Using this definition, we obtain the cost-minimizing demand schedule for each variety as

$$p_{jt} = c_{jt}^{-\frac{1}{\epsilon}} P_t C_t^{\frac{1}{\epsilon}} \tag{14}$$

and aggregate expenditure on consumption goods is $\int_0^{M_t} p_{jt} c_{jt} dj = P_t C_t$.

The optimality condition for the consumption-leisure margin is

$$\chi C_t = \frac{1}{P_t} \tag{15}$$

where the left-hand-side reports the marginal rate of substitution between consumption and leisure and the right-hand-side is the real wage.

5.2 Manufacturing Firms

Consumption good varieties are produced by monopolistically-competitive manufacturing firms. Each generic variety i is produced by a single firm, with production function

$$y_{jt} = s_{jt} k_{jt}^{\alpha} n_{jt}^{1-\alpha} \tag{16}$$

[27] We could also explicitly assume that the household can trade shares in all the domestic firms. This would not affect the solution, as in equilibrium the household would own the aggregate value of these stocks in every period, i.e. the equilibrium would feature no trade in stocks.

where s_{jt} is stochastic idiosyncratic productivity, k_{jt} is the level of capital and n_{jt} is labor employed by firm j at time t. The capital share is $\alpha \in (0, 1)$. Idiosyncratic productivity follows a stochastic transition $F(s_{jt}, s_{j,t+1})$.

Firms internalize the demand function (14) in their input demand decisions. Under the assumption that all manufacturing output is consumed domestically (i.e., $y_{jt} = c_{jt}$ for all j, in absence of international trade of manufacturing varieties), we get that for a given level of productivity and inputs, revenues are given by

$$p_{jt}y_{jt} = P_t C_t^{\frac{1}{\epsilon}} s_{jt}^{\theta} k_{jt}^{\theta\alpha} n_{jt}^{\theta(1-\alpha)}. \tag{17}$$

We now introduce our key capital adjustment friction, namely partial investment irreversibility. Firms that wish to increase the size of their capital stock import capital goods from the foreign economy at constant price Q (relative to the numeraire, labor).[28] We assume that the domestic economy is small, in the sense that it takes the price of capital goods as given and it is not large enough to affect it in equilibrium. Investment takes one period to become productive.

Firms that wish to downsize sell used capital to other domestic firms on the secondary market at constant price $q \leq Q$, where strict inequality implies partial irreversibility, whereas equality implies free adjustment, i.e., no irreversibility. The difference $Q - q$ is the cost involved in reallocating a unit of capital previously installed by a firm.[29]

The capital stock at the firm level evolves according to the following accumulation equation

$$k_{j,t+1} = (1 - \delta) k_{jt} + i_{jt} \tag{18}$$

where $\delta \in (0, 1)$ is the constant depreciation parameter and i_{jt} is investment. When investment is positive, the firm pays a unit price Q for its new capital goods. When investment is negative, the firm receives a unit price q for each unit of capital sold. We

[28]This assumption is motivated by the fact that Peru imports a substantial share of the investment goods employed in domestic production.

[29]We verify in our numerical solutions that there is never excess supply of domestic used capital at price q, that is, demand for capital goods from investing firms is larger than supply of used capital, implying that part of the investment takes place thanks to imports of new capital goods.

summarize the marginal cost of investment as follows

$$Q(i_{jt}) = \begin{cases} Q, & \text{if } i_{jt} \geq 0 \\ q, & \text{if } i_{jt} < 0 \end{cases} \tag{19}$$

Let Z_t be the aggregate state of the economy, to be fully specified below. We assume that the labor input is freely adjustable in every period. Hence, firms' labor choice is static: firms optimally set the marginal revenue product of labor equal to the wage.

$$\theta(1-\alpha)P_t C_t^{\frac{1}{\epsilon}} s_{jt}^{\theta} k_{jt}^{\theta\alpha} n_{jt}^{\theta(1-\alpha)-1} = 1 \tag{20}$$

This labor decision, for a given value of the state vector, determines the firm's level of production through the production function (16) and the firm's output price through (14).

Each firm incurs an idiosyncratic fixed cost of operations f_{jt}, denominated in units of labor, iid across time and firms, with distribution $G(f)$. After observing this cost and producing, firms choose whether to pay the cost and continue operations into the following period, or to exit at the end of the current period.

Let sales net of labor cost, after choosing the optimal level of labor input, be

$$\pi(k, s, Z) \equiv \max_{n} P(Z)C(Z)^{\frac{1}{\epsilon}} s^{\theta} k^{\theta\alpha} n^{\theta(1-\alpha)} - n.$$

The value of a firm with state (k, s, f, Z), that chooses to continue operations in the following period is defined recursively as follows.

$$V^c(k, s, f, Z) = \max_{i,k'} \pi(k, s, Z) - f - Q(i)i + \beta\mathbb{E}\left[\frac{C(Z)}{C(Z')} V(k', s', f', Z')\,|s, Z\right] \tag{21}$$

subject to the capital accumulation equation (18), $k' = (1-\delta)k + i$ and a transition law for the aggregate state $Z' = \Gamma(Z)$. Notice that the continuation value in equation (23) discounts the future value using the household's discount factor, because households owns all manufacturing firms.

The value of a firm that chooses to cease operations at the end of the present period is

$$V^x(k, s, Z) = \pi(k, s, Z) + q(1-\zeta)(1-\delta)k \tag{22}$$

where $\zeta \in [0, 1]$ is an additional irreversibility parameter that applies only when firms exit and sell their whole capital stock, so that the overall resale price of capital in this case is $q(1-\zeta)$.

Firms optimally choose whether to continue or exit, that is,

$$V(k,s,f,Z) = \max\left\{V^c(k,s,f,Z), V^x(k,s,Z)\right\} \tag{23}$$

The investment decision of continuing firms can be characterized with three possible types of actions. If firms are sufficiently productive, given the aggregate state and their current capital level, they will expand their capital stock. If they are sufficiently unproductive, they will downsize. If their productivity is in an intermediate region, they will choose to be in the inaction region, set $i=0$ and let their capital depreciate. The presence of this inaction region arises because of the assumption of partial irreversibility of investment.

We now introduce entry of new firms. In every period, there is a constant mass of potential entrants M^p. Each potential entrant receives a signal s^e about its future productivity conditional on entry, drawn from the unconditional distribution of idiosyncratic productivity. Entry entails the payment of an iid cost f^e, drawn from the same distribution as the continuation costs ($G(f)$), and denominated in units of labor. Upon entry, idiosyncratic productivity is drawn according to the transition $F(s^e, s')$. Hence, a potential entrant chooses to enter the market if

$$f^e \leq \max_{k'} -Qk' + \beta\mathbb{E}\left[\frac{C(Z)}{C(Z')}V(k',s',f',Z')\,|s^e, Z\right] \tag{24}$$

5.3 Commodity Firms

We assume that the economy also produces another good X_t, which is traded with the foreign economy, and for simplicity is not consumed domestically. We refer to this good as a commodity, consistent the fact that a substantial share of Peru's exports are commodities.

Commodities are produced by homogeneous perfectly-competitive firms using a linear technology that takes labor as only input:

$$X_t = A^X N_t^X \tag{25}$$

where A^X is a constant productivity parameter and N_t^X is labor employed in the commodity sector. These firms are also owned by the representative household.

The domestic economy is small, and thus takes as given the price of commodities. We assume that this price p^X is constant and satisfies $p^X = \frac{1}{A^X}$. Hence, profit maximization of commodity firms implies that they are indifferent between any level of production and make zero profits.

5.4 Foreign Economy

For simplicity, we abstract from fully modelling the production structure of the foreign economy, but this could be easily done, without affecting the insights of the paper. In our initial stationary equilibrium, the foreign economy simply supplies investment goods at constant price Q and imports commodities from the domestic economy. Our trade shock, fully specified below, is a change in the structure of domestic imports: a trade liberalization allows the foreign economy to sell a positive measure of manufacturing varieties at an exogenous price, in the domestic market.

5.5 Recursive Stationary Equilibrium

For simplicity of notation, we assume the state space is discrete. In a stationary equilibrium, the aggregate state Z is constant. Given exogenous probability distributions (idiosyncratic productivity transition $F(s, s')$ and operation cost $G(f)$), a **recursive stationary equilibrium** is defined as:

- Household's decision for consumption C and labor N;
- Value functions:
$$V\left(k, s, f\right), V^c\left(k, s, f\right), V^x\left(k, s\right);$$
- Firms' decision rules: entry $e(s^e) \in \{0, 1\}$, initial capital for entrants $k' = g^e(s^e)$, future capital for continuing firms $k' = g(k, s)$, exit $x(k, s, f) \in \{0, 1\}$, labor demand $n(k, s)$;
- Aggregate price index P;
- Employment N^X and output X in the commodity sector;
- Equilibrium distributions: producing firms $\lambda(k, s)$, continuing firms $\mu(k, s)$; total measure of producing firms $M = \sum_k \sum_s \lambda(k, s)$;

such that

- Household's decision rules satisfy (15);
- Firms' value functions and decision rules solve the dynamic program (21), (22), (23), (24);
- Output market and labor market clear, that is

$$C = \left(\sum_k \sum_s (sk^\alpha n(k,s)^{1-\alpha})^\theta \lambda(k,s) \right)^{\frac{1}{\theta}} \tag{26}$$

$$N = \sum_k \sum_s n(k,s)\lambda(k,s) + N^X + \bar{f}^e + \bar{f}; \tag{27}$$

where $\bar{f}^e$ and $\bar{f}$ are the aggregate levels of labor inputs employed to pay for entry and continuation costs respectively.

- The value of imports, i.e. aggregate domestic investment, equals the value of exports, i.e. commodity output;

$$\sum_k \sum_s Q(i(k,s))i(k,s)\lambda(k,s) = p^X X; \tag{28}$$

where the marginal cost of investment is Q for firms doing positive investment, q for continuing firms doing negative investment, and $(1-\zeta)q$ for exiting firms.

- The equilibrium distributions satisfy

$$\mu(k,s) = \sum_k \sum_s \sum_f \lambda(k,s)G(f)\left(1 - x(k,s,f)\right) \tag{29}$$

$$\begin{aligned} \lambda(k',s') = {} & \sum_k \sum_s \mu(k,s)F(s,s')\mathcal{I}(k' = g(k,s)) \\ & + \sum_{s^e} F^e(s^e)F^{es'}(s^e,s')e(s^e)\mathcal{I}(k' = g^e(s^e)). \end{aligned} \tag{30}$$

Notice that this definition also implies market-clearing in each manufacturing variety.

5.6 Trade Shock and Aggregate Dynamics

After the trade shock, the foreign economy sells varieties $\left[M_t, M_t^F\right]$ in the domestic market, at exogenous price p_t^F. We model this shock as an unexpected change hitting the economy in its stationary equilibrium. After the shock, aggregates and (endogenous) prices are no longer constant. They move over time along a transition path that brings the economy to a different stationary equilibrium with manufacturing imports.

Along the transition path, the key aggregate state variable Z_t in firms' problem is the distribution of individual states, $\lambda_t(k_{it}, s_{it})$. Hence, the Bellman equations (21), (22), (23), (24) still hold, with aggregate state $Z_t \equiv \lambda_t(k_{it}, s_{it})$.

The market clearing condition for goods is modified, to account for the fact that consumers purchase both domestic and foreign varieties of the consumption good:

$$C_t = \left(\int_0^{M_t} y_{j,t}^{\theta} dj + \int_{M_t}^{M_t^F} c_{j,t}^{\theta} dj \right)^{\frac{1}{\theta}}. \tag{31}$$

where the second term inside the parenthesis represents manufacturing imports. Furthermore, domestic production of commodities for export ensures balanced trade in every period:

$$\int_0^{M_t} Q(i_{jt}) i_{jt} dj + p_t^F \int_{M_t}^{M_t^F} c_{j,t} dj = p^X X_t. \tag{32}$$

6 Quantitative Analysis

In this section, we first present a preliminary calibration of our model. We then use our quantitative model to study the aggregate effects of a trade shock.

6.1 Calibration

We now describe our choices for parameter values, reported in Table 6. We set the discount factor to reflect the annual frequency of our data. The labor disutility parameter is chosen to get aggregate hours worked approximately equal to one third. We borrow the value of the elasticity of substitution across varieties from the literature (see for instance, Asker, Collard-Wexler, and De Loecker (2014)).

We further set the parameter values related to technology to match key moments of our data on Peruvian manufacturing. We obtain the median capital share and use it to inform our calibration of α. Next, we use the set δ equal to the median firm-level depreciation rate. We parameterize idiosyncratic productivity as an AR(1) in logs and then set the parameters to match autocorrelation and volatility of TFPR in the data, controlling for industry and time fixed effects. We set the price of new investment Q goods equal to the aggregate manufacturing price level in the stationary equilibrium, consistent with standard assumptions in the real-business-cycles literature, and choose the value of q in order to match the fraction of firms with a negative investment rate (approximately 11%). The implied degree of irreversibility for continuing firms, $1 - \frac{q}{Q}$ is 0.58, meaning that firms loose approximately sixty percent of the value of their used capital when they sell it. We parameterize the distribution of continuation costs $G(f)$ as a log-normal distribution and choose its mean and its standard deviation, jointly with the additional irreversibility at exit, ζ, in order to approximately match the average exit rate and slope of the exit thresholds in the (k, s) space, and the average relative size of continuing firms to exiting firms. Finally, we normalize productivity in the commodities sector $A^Z = 1$.

Parameter	Value	Target / Source
β	0.96	Standard (annual frequency)
χ	2.15	Average hours $\approx \frac{1}{3}$
ϵ	4	Asker, Collard-Wexler, and De Loecker (2014)
α	0.41	Capital share
δ	0.11	Depreciation rate
ρ_s	0.729	TFPR autocorrelation
σ_s	0.812	TFPR volatility
q/Q	0.42	Fraction of negative investment
μ_f	-2.58	Exit rate
σ_f	0.81	Relative size at exit
ζ	0.23	Slope of exit thresholds
A^Z	1	Normalization

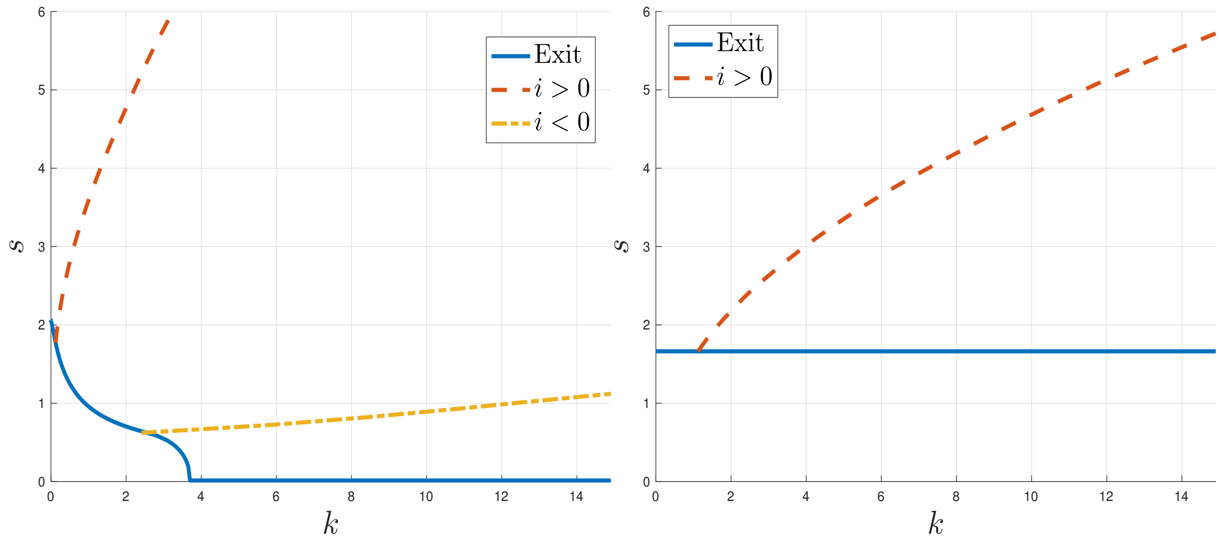
Table 6: Parameter Values.

6.2 Key Properties of Stationary Equilibrium

We now describe some key properties of the stationary equilibrium. First, we illustrate firms' decision rules and then we report the key statistics implied by the equilibrium of the model.

In Figure 5a we show the thresholds for positive investment (red dashed line), negative investment (yellow dashed-dotted line) and exit, conditional on drawing the average continuation cost (blue solid line), as functions of capital stock on the x-axis and productivity on the y-axis. Firms below the exit threshold choose to exit. Among continuing firms, those with individual states above the positive investment thresholds, increase their capital stock; those firms below the negative investment threshold downsize and the remaining ones are in the inaction region and let their capital depreciate.

We highlight that the model induces selection on capital, conditional on productivity, consistent with the empirical evidence on Peruvian manufacturing (see Fact 3 of Section 3). Specifically, the exit threshold is downward sloping, meaning that smaller firms are more likely to exit. This is a direct consequence of partial irreversibility, because in presence of this friction, firms with larger capital stock find it more costly to downsize and exit. In the interest of comparison, Figure 5b displays the exit threshold (solid blue line) implied by a "frictionless" model, i.e., without irreversibility, that is with $q = Q$ and $\zeta = 0$. In this model, the exit decision depends only on productivity. Hence, the exit threshold is horizontal. Moreover, absence of irreversibility implies that there is no inaction region. Firms above the red dashed line increase their capital, and firms below this same line decrease their capital.



(a) Baseline model
(b) Frictionless model

Figure 5: Thresholds for Investment, Disinvestment, and Exit

We now move to a brief discussion of the key statistics implied by the model, and compare them to our empirical evidence. A key empirical feature of the Peruvian manufacturing industry is the high persistence of MRPK across the distribution, with substantially higher persistence for firms with low returns to capital. In Table 7 below, we report the model-implied transition probabilities for our baseline model, as well as the frictionless model, without capital irreversibility. Clearly, irreversibility is key in delivering both persistence in MRPK, and importantly, *asymmetry* in the persistence of MRPK, with higher probabilities of remaining low-returns firms. In contrast, a frictionless model predicts that there is no persistence in MRPK. Moreover, the partial irreversibility of capital also amplifies the dispersion of MRPK relative to the comparison model, bringing the model-implied standard deviation of MRPK closer to the data (1.47 in the data, 1.31 in the baseline, and 1.09 in the comparison).

		Tercile at $t+1$		
		1	2	3
Tercile at t	1	0.68	0.25	0.07
	2	0.38	0.38	0.24
	3	0.17	0.36	0.47

(a) Baseline Model

		Tercile at $t+1$		
		1	2	3
Tercile at t	1	0.33	0.33	0.33
	2	0.33	0.33	0.33
	3	0.33	0.33	0.33

(b) Frictionless Model

Table 7: Mobility (Transition Probabilities) of MRPK in Stationary Equilibrium.

Overall, the stationary equilibrium of the model is consistent with the main facts that we find in the data, namely: MRPKs are highly dispersed, asymmetrically persistent, and selection is driven both by productivity and the level of capital. All these properties are direct consequences of partial investment irreversibility.

To conclude the analysis of the stationary equilibrium, we now compare the key aggregate variables in our model with their counterpart in the frictionless model without irreversibility. In Table 8, we show the values of aggregate consumption, capital stock, labor input in manufacturing, mass of active firms and average firm TFPQ in the two models. The degree of irreversibility consistent with our calibration strategy is substantial and induces large differences between the two economies considered. Specifically, manufacturing output (and hence consumption) is almost forty percent lower in presence of irreversibility, as firms optimally choose to be significantly smaller on average. Consistently, the aggregate level of the capital stock is less then half than it frictionless counterpart, while a higher price level (i.e. a lower real wage) in the baseline model leads to similar levels of manufacturing employment between the two economies, and a higher mass of active firms in presence of irreversibility, with lower average productivity.

VARIABLE	BASELINE	FRICTIONLESS
C	1.43	2.30
K	1.93	4.68
N (MANUF.)	0.21	0.21
M	0.72	0.60
$TFPQ$ (AVERAGE)	2.41	2.61

Table 8: Steady-state Comparison: Baseline and Frictionless Model.

6.3 Trade Shock: Long-run Effects

We parametrize the trade shock as follows. The measure of imported varieties is such that $M^F = M + 0.15$ and their common price is $p^F = 0.85P$, where P is the equilibrium price index in the domestic economy before the shock. This leads to a long run import penetration of around 22%, approximately consistent with the current share of Chinese imports in Peruvian consumer expenditures.

We first compute the new steady-state and compare the key aggregates of interest in Table 9. The first column lists the key aggregate variables: consumption, capital, hours worked in manufacturing, average TFPQ in manufacturing, and the mass of active firms. The second column reports the percentage change in the steady-state after the trade shock, relative to the initial steady-state. Consumption (first row) increases by approximately three percentage points, which with our choices of preferences implies an equal decline in the price level (see equation (15)).

The capital stock and hours in manufacturing (second and third row) decline by about twenty percent and nineteen percent respectively. This large decline is primarily driven by a fall in the mass of active firms (fourth row), which results due to increased competition for domestic manufacturers after the trade shock. Due to improved selection, however, the average productivity of firms increases (fifth row). Improved selection occurs because the fall in the price level leads primarily to exit of lower productivity firms.

Variable	$\Delta\%$
C	3.93%
K	-23.88%
N (manuf.)	-21.71%
M	-20.13%
$TFPQ$ (average)	5.70%

Table 9: Steady-state Comparison: Before and After Trade Shock.

6.4 Trade Shock: Transitional Dynamics

We now study the equilibrium transition path that takes the economy from the initial steady-state to the new one. We find that convergence to the new steady-state takes approximately twenty years. In Figure 6, we show our first result. Even though the shock is a sudden and permanent change in the set of varieties available to domestic consumers, and the price of this imported varieties is constant over time, import penetration is slowly increasing over a period of two decades, from around 16% on impact to around 22% when the economy converges to its new steady-state. This is because general-equilibrium forces (i.e., consumption smoothing) slow down the investment and reallocation response of domestic manufacturing.

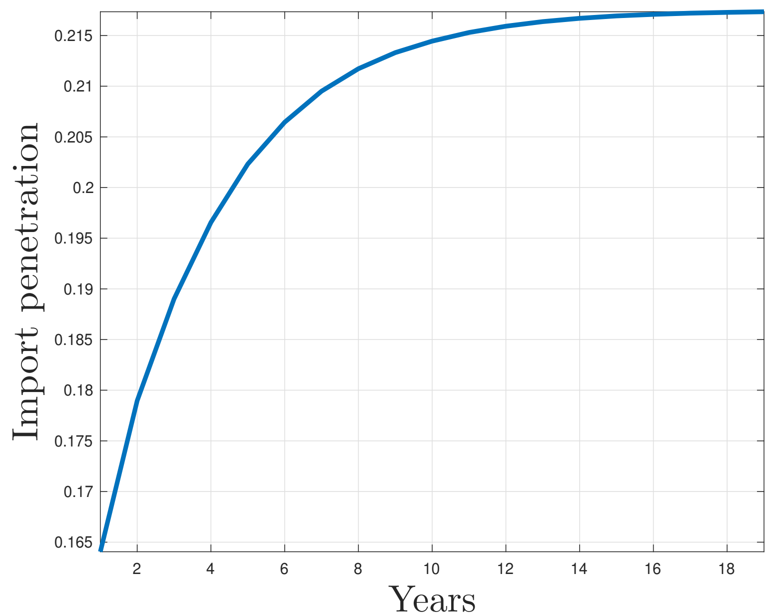
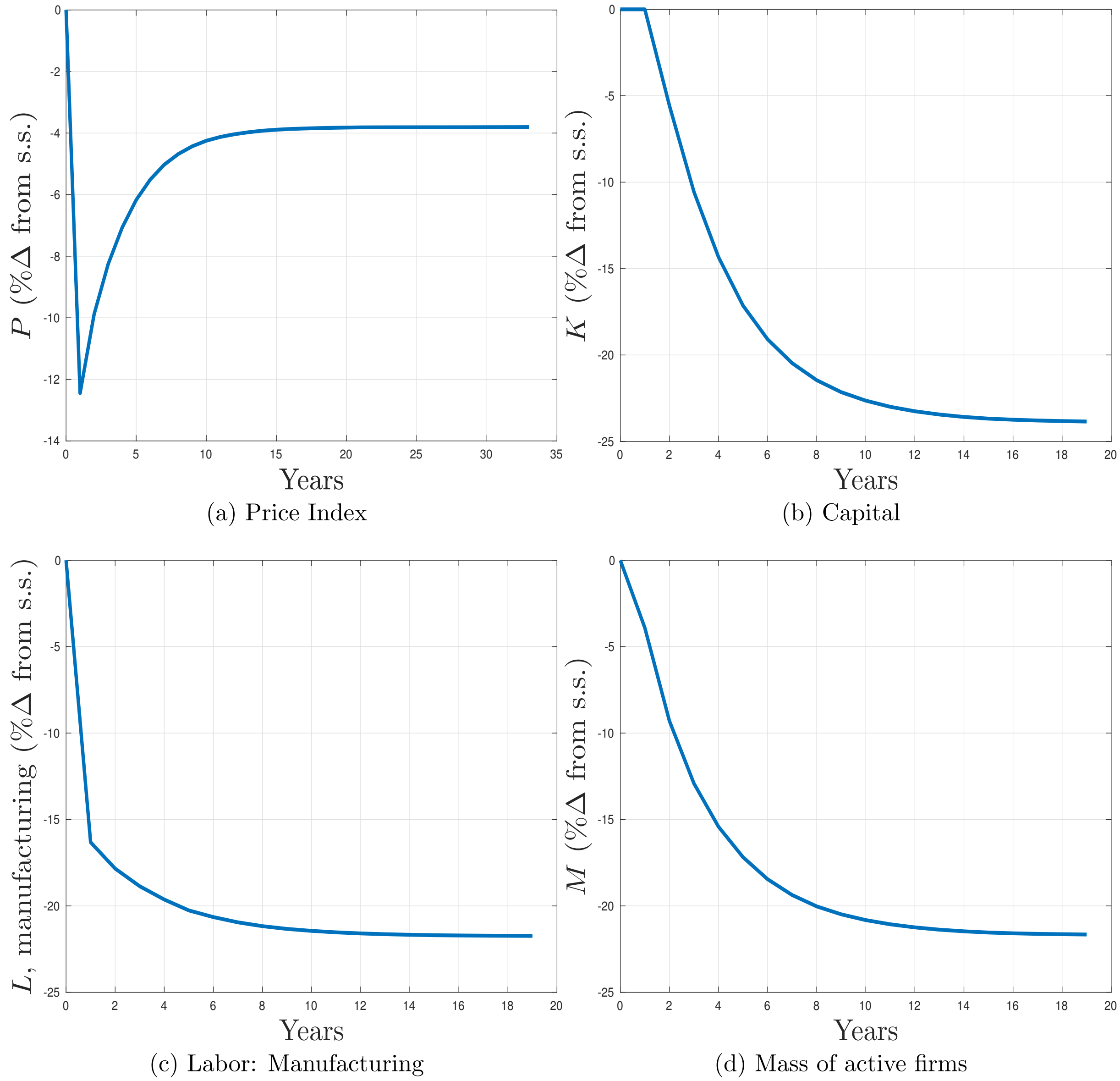


Figure 6: Import Penetration After the Trade Shock.

Figure 7 displays the transitional dynamics of the aggregate price level (top left), aggregate capital stock (top right), aggregate hours in manufacturing (bottom left), and mass of active firms (bottom right). After the trade shock hits, the increase in competition induces a drop in the price level, which then gradually recovers as the domestic industry adjusts to the new conditions. At the same time, investment falls, leading to a decline in the aggregate level of capital. Both the the labor input employed in manufacturing and the mass of active firms decline.



(a) Price Index (b) Capital

(c) Labor: Manufacturing (d) Mass of active firms

Figure 7: Aggregate Dynamics After the Trade Shock.

Next, we focus on the effects of the trade shock on selection. In Figure 8, we show the exit thresholds associated with drawing an average fixed cost, both under the baseline calibration (thick blue lines) and in the model without irreversibility (thin red lines). For each model, the solid line denotes the exit threshold in the initial stationary equilibrium, whereas the dashed line denotes the exit threshold after the trade shock hits the economy in the first period. In general, the shock shifts the exit thresholds up, indicating a larger exit flow. Moreover, consistent with the patterns of selection in stationary equilibrium, the shock induces selection as a function of both productivity and capital stock in our baseline model; in contrast, productivity is the only determinant of exit in the comparison model. As a consequence, the shock induces some relatively productive, but small, firms to leave the market only in the presence of investment irreversibility.

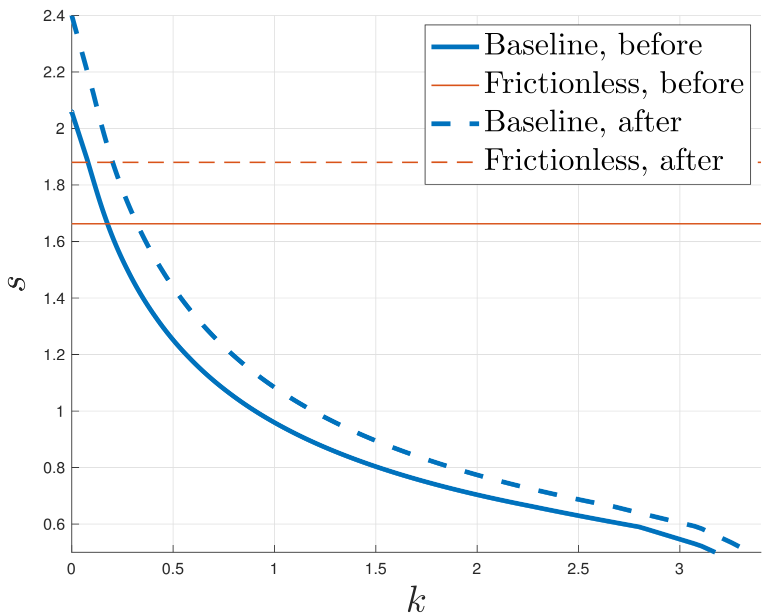


Figure 8: Exit Thresholds Before the Trade Shock and on Impact.

These patterns of selection are consistent with our empirical findings (see Figure 2) and affect the short-run response of aggregate productivity to the trade shock. In Figure 9 we plot the dynamic response of the average productivity of active firms (i.e. average firm TFPQ), both in the baseline model (blue solid line) and in the comparison model (red dashed line). In the short run, the model with partial irreversibility induces a lower gain in average TFPQ relative to the comparison model. This is consistent with our finding in Figure 8, where the trade shock drives out smaller but highly productive firms in our baseline model, whereas these firms are unaffected under the comparison model.

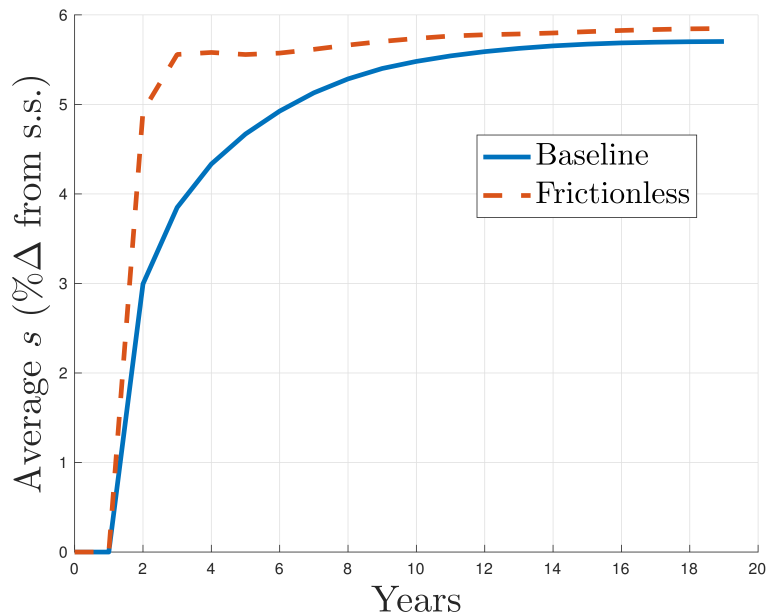
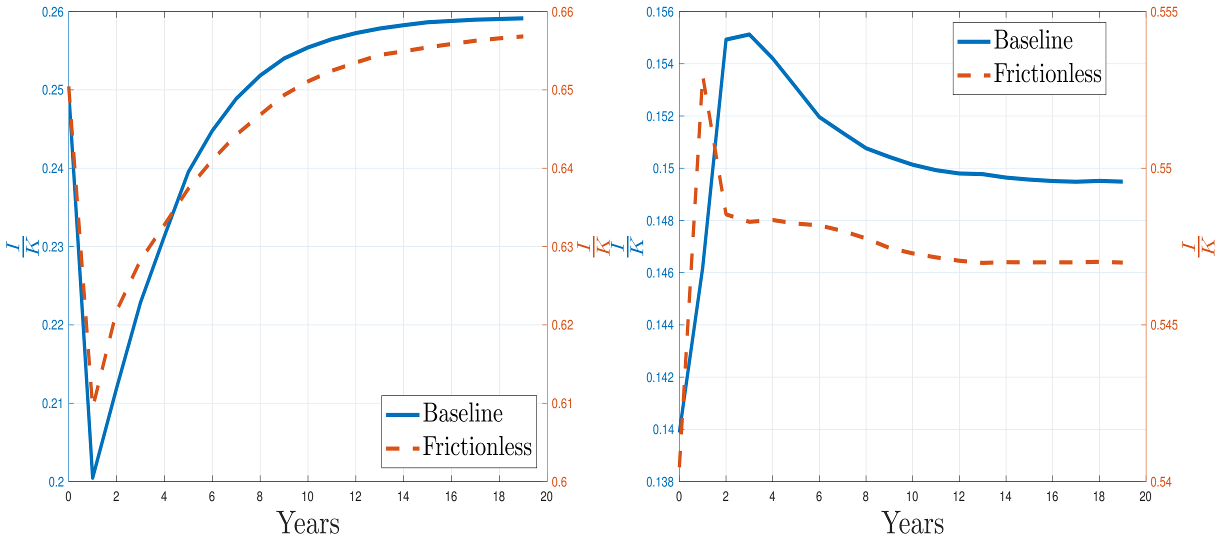


Figure 9: Average Productivity of Firms After the Trade Shock.

Next, we zoom in on the capital reallocation dynamics and show the importance of accounting for downsizing frictions. In Figure 10, we split the investment dynamics into total positive investment from expanding firms (left panel) and total negative investment from downsizing firms (right panel). We normalize investment and disinvestment by the size of the capital stock and, once again, we compare our model (solid line, left scale) with a model with no irreversibility (dashed line, right scale). In our model, there is substantially less capital reallocation both on average and in response to the trade shock, as can be seen by comparing left and right scale. Consistent with our empirical evidence, we find that the shock leads to a sharp decline in the fraction of firms doing positive investment, and a small effect on the fraction of firms doing negative investment.



(a) Positive Investment (b) Negative Investment

Figure 10: Positive and Negative Investment.

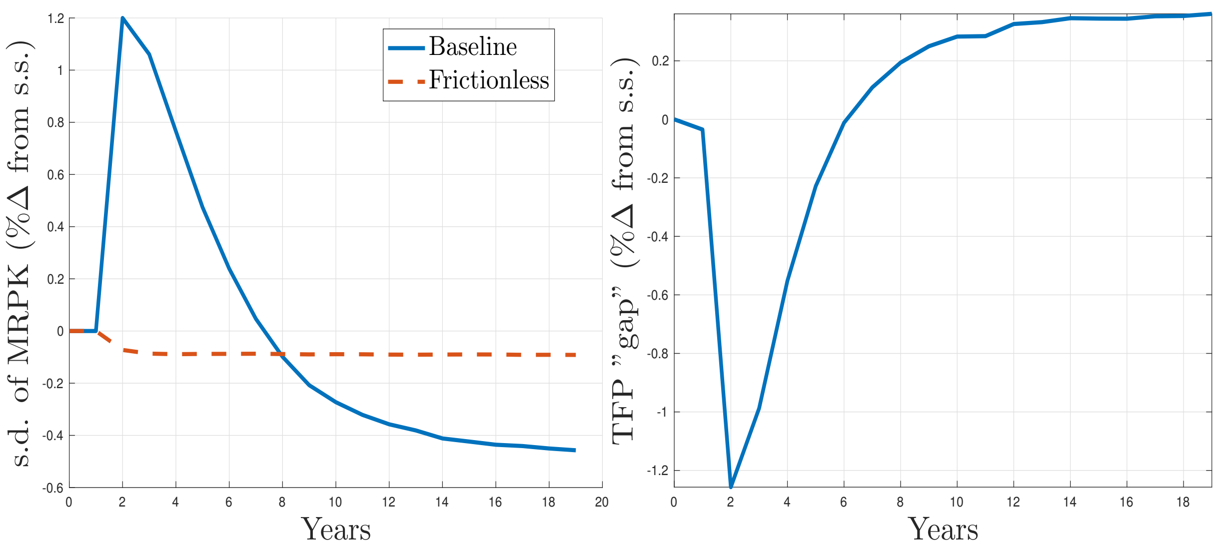
The slow response of capital reallocation to the trade shock, together with the effects on the extensive margin discussed above, has important implications for the transitional path of aggregate productivity, which we illustrate in Figure 11 by reporting the dynamic responses of two measures of "misallocation". In Figure 11a, we report the change in the cross-sectional standard deviation of MRPK, while in Figure 11b, we plot the change in the ratio of measured TFPQ under our baseline model to that of the comparison model.[30]

Figure 11a shows that the dispersion of MRPK falls in the long run for both models, suggesting that the trade shock improves the allocation of capital in the long run. In the short run, however, the dynamic responses of the two models are starkly different. In the baseline model, the increase in the size of the inaction region, coming from a decline in the fraction of investing firms, leads to an increase in the dispersion of MRPK; in contrast, the dispersion of MRPK quickly falls to the long run level in the frictionless model, driven by the sharp capital reallocation responses in Figure 10. This suggests that the trade shock

[30] We report the dispersion of MRPK as a measure of misallocation along the intensive margin due to its use in the prior literature (for instance, Hsieh and Klenow, 2009). As far as the ratio of TFPQ in the two models, this measure allows us to understand how much closer or farther the trade shock brings the economy with respect to the frictionless allocation. Specifically, our baseline model generates some short-run capital "misallocation" relative to the comparison model due to the presence of investment partial irreversibility. This in turn generates a "gap" between measured TFPQ in our baseline calibration and the comparison model, and the dynamic response of this "gap" gives us a sense of the extent of the deviation of measured TFPQ from an undistorted allocation.

in fact generates a short-run increase in capital misallocation along the intensive margin in our baseline model.

Figure 11b shows that measured TFPQ rises faster under the comparison model than our baseline model in the short run, leading to a sharp fall in the ratio — that is to say, the productivity gains from trade are realized much faster in the comparison model in than our baseline model. This result arises as a consequence of the short run responses along the intensive margin as reported in Figure 10, as well as the selection effect reported in Figure 9. In the long run, we see that the ratio actually rises above the initial steady-state — that is, in the long run, opening the economy to trade in fact brings our baseline model closer to the comparison in terms of capital allocation.



(a) Standard deviation of MRPK (b) TFP gap with frictionless model

Figure 11: Effect of the Trade Shock on Capital Misallocation.

We conclude this section by reporting, in Table 10, the model results for welfare in response to the trade shock. In the first column, we report the welfare gains by comparing steady-states, while in the second column, we report the welfare gains taking into account the entire transition path. We find that the comparison across steady-states substantially understates the true welfare gains from trade liberalization. The reason for this result is that consumption overshoots its long-run average in the initial periods after the trade shock, as displayed in Figure 7. Due to general-equilibrium forces in the model, i.e. consumption smoothing, this overshooting leads to a high consumption level for several years. As a result, ignoring the transitional dynamics would lead to a substantial understating of the true welfare gains.[31] However, we also find that this short-run gain is more muted under our baseline calibration. Due to the presence of partial irreversibility, the dampened capital reallocation in response to a trade shock initially leads to lower productivity gains. As a consequence, the short-run welfare gains are also dampened in our model.

Model	Steady-state	Transition
Baseline	0.49%	2.02 %
Frictionless	0.02%	2.38 %

Table 10: Welfare (Consumption Equivalent Variation).

6.5 The Role of General-Equilibrium Forces

In our model, firms discount future profits using the representative household's discount factor. Following the trade shock, the economy experiences an initial increase in consumption, followed by negative consumption growth.[32] Thus, the shock leads to a fall in the implicit interest rate that firms use to discount their continuation value.

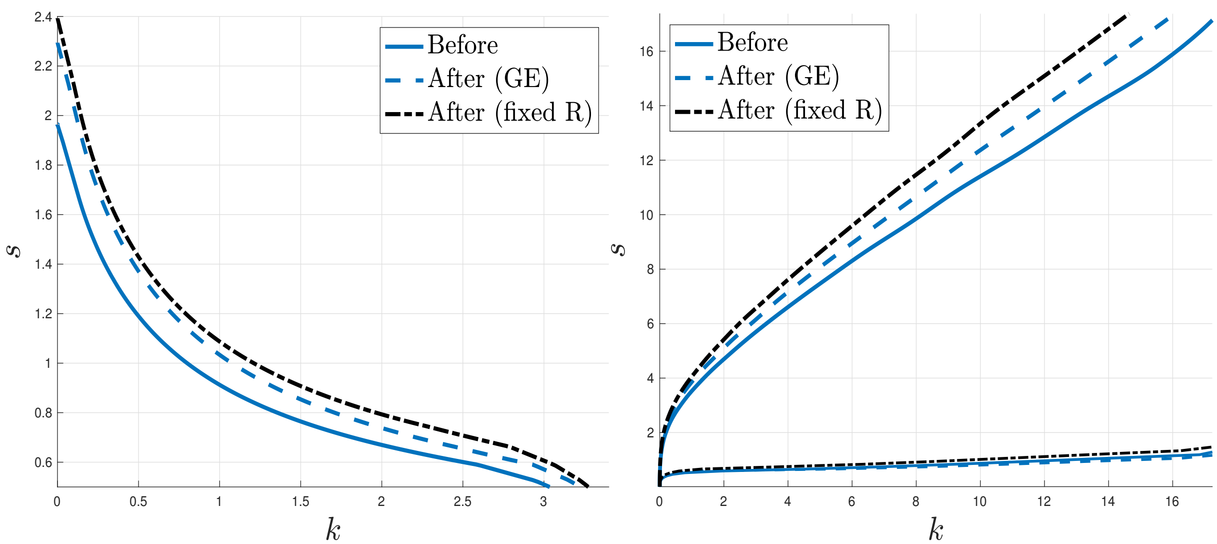
In order to assess the role of these general-equilibrium forces for the short-run response of the economy to the trade shock, we perform the following counterfactual. We hit the economy with the same shock considered above, and clear the market for consumption goods, but let firms discount future profits with a constant interest rate, equal to the stationary-equilibrium interest rate. This exercise allows us to isolate the role of increased competition in the output market from the equilibrium adjustment of interest rates.

In Figure 12a, we plot the exit threshold associated with drawing the average continuation cost, in the initial stationary equilibrium (solid blue line), after the shock in GE (dashed blue line, replicating Figure 8), and in this counterfactual economy with constant interest rate (dashed-dotted black line). We find that the shock would induce even stronger selection, particularly of large unproductive firms, with constant interest rates. In turn, the equilibrium fall in the real rate dampens this selection effect in our benchmark GE model. In Figure **??**, we do the same decomposition for the positive and negative investment thresholds. We find that the shock would lead to a more sizeable widening of the

[31] This result is consistent with the recent findings of Alessandria, Choi, and Ruhl (2018).

[32] To see this, recall that the labor supply equation 15 states that consumption is inversely proportional to the aggregate price level.

inaction region with a constant interest rate. Thus, the equilibrium fall in the interest rate in our benchmark economy counteracts the effects of the shock, by partly stimulating firms' capital accumulation.



(a) Decomposition of Exit Margin

(b) Decomposition of Investment and Disinvestment Margin

Figure 12: Thresholds with Fixed Interest Rate.

Consistent with this finding, in Figure 13, we plot the transition of the aggregate capital stock in our benchmark GE model (solid blue line) and in the counterfactual model with fixed interest rate (dashed-dotted black line). We find that the equilibrium decline in the interest rate significantly slows down the decline in the capital stock associated with the trade shock.

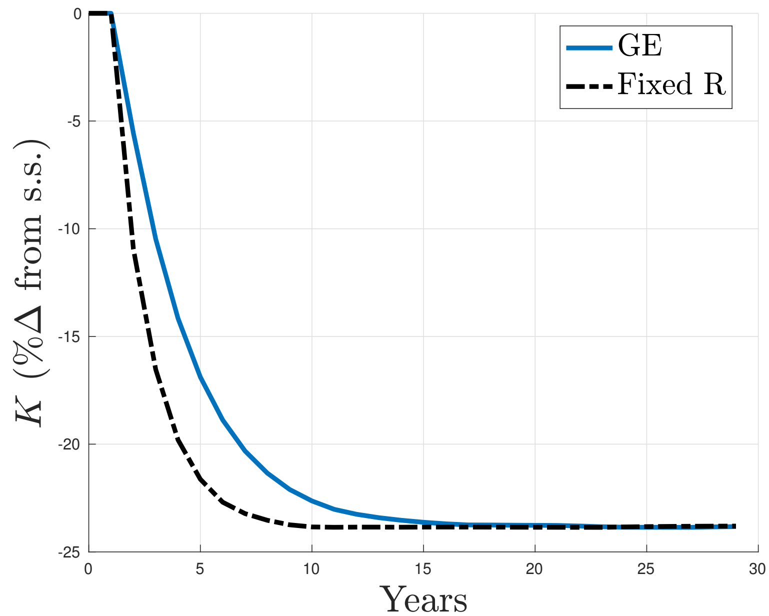


Figure 13: Aggregate Capital with Fixed Interest Rate.

7 Conclusions

This paper provides a quantitative analysis of the role of capital reallocation frictions for the response of an economy to a foreign-competitition shock. While a large literature focuses on long-run gains from trade, we focus on short- and medium-run transitional dynamics, and argue that adjustment frictions play a key role in shaping the equilibrium dynamics after a trade shock.

Capital reallocation is costly, particularly in manufacturing, where capital is more likely to be specific at the firm and the industry level. This friction induces dispersion in MRPK, and slows down the process of downsizing of manufacturing that takes place when cheap manufacturing imports become available in the domestic economy. Moreover, frictions in reallocation affect the patterns of selection, making larger firms more likely to survive, conditional on productivity.

The joint effects of general-equilibrium forces and frictions in capital reallocation on the transitional dynamics following an import competition shock are sizable. The economy takes about 20 years to transition to the new stationary equilibrium. The lack of capital reallocation induces smaller TFP gains in the short and medium run compared to a frictionless model.

In future drafts, we will address two key extensions. First, we will use our non-linear model to investigate the effects of closing the economy, protecting the domestic industry from foreign competition. Second, we will endogenize irreversibility by explicitly modeling the market for used capital and investigate the role of endogenous capital resale price dynamics.

References

Alessandria, G., and H. Choi (2014): "Establishment heterogeneity, exporter dynamics, and the effects of trade liberalization," *Journal of International Economics*, 94(2), 207–223.

Alessandria, G., H. Choi, and K. Ruhl (2018): "Trade Adjustment Dynamics and the Welfare Gains from Trade," Working Paper.

Antràs, P., and R. J. Caballero (2009): "Trade and Capital Flows: A Financial Frictions Perspective," *Journal of Political Economy*, 117(4), 701–744.

Artuc, E., I. Brambilla, and G. Porto (2017): "Patterns of Labor Market Adjustment to Trade Shocks with Imperfect Capital Mobility," Working Paper.

Asker, J., A. Collard-Wexler, and J. De Loecker (2014): "Dynamic Inputs and Resource (Mis)Allocation," *Journal of Political Economy*, 122(5), 1013–1063.

Autor, D. H., D. Dorn, and G. H. Hanson (2013): "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review*, 103(6), 2121–68.

Bai, Y., K. Jin, and D. Lu (2018): "Misallocation under Trade Liberalization," Mimeo.

Bartelsman, E., J. Haltiwanger, and S. Scarpetta (2013): "Cross-Country Differences in Productivity: The Role of Allocation and Selection," *American Economic Review*, 103(1), 305–34.

Berthou, A., J. J.-H. Chung, K. Manova, and S. Charlotte (2018): "Productivity, (Mis)allocation and Trade," Mimeo.

Bloom, N. (2009): "The Impact of Uncertainty Shocks," *Econometrica*, 77(3).

Brooks, W., and A. Dovis (2018): "Credit Market Frictions and Trade Liberalization," Working Paper.

Buera, F. J., and Y. Shin (2013): "Financial Frictions and the Persistence of History: A Quantitative Exploration," *Journal of Political Economy*, 121(2), 221–272.

Caggese, A., and V. Cuñat (2013): "Financing Constraints, Firm Dynamics, Export Decisions, and Aggregate Productivity," *Review of Economic Dynamics*, 16(1), 177–193.

Charles, K. K., and E. Hurst (2003): "The Correlation of Wealth across Generations," *Journal of Political Economy*, 111(6), 1155–1182.

Chen, C. (2009): *China's Integration with the Global Economy: WTO Accession, Foreign Direct Investment and International Trade*. Edward Elgar Publishing.

Chor, D., and K. Manova (2012): "Off the cliff and back? Credit conditions and international trade during the global financial crisis," *Journal of International Economics*, 87(1), 117 – 133, Symposium on the Global Dimensions of the Financial Crisis.

Clementi, G. L., and B. Palazzo (2016): "Entry, Exit, Firm Dynamics, and Aggregate Fluctuations," *American Economic Journal: Macroeconomics*, 8(3), 1–41.

Cooper, R. W., and J. Haltiwanger (2006): "On the Nature of Capital Adjustment Costs," *Review of Economic Studies*, 73(3), 611–633.

Cuñat, A., and M. J. Melitz (2012): "Volatility, Labor Market Flexibility, and the Pattern of Comparative Advantage," *Journal of the European Economic Association*, 10(2), 225–254.

David, J. M., and V. Venkateswaran (2018): "The Sources of Capital Misallocation," Working Paper.

Dix-Carneiro, R. (2014): "Trade Liberalization and Labor Market Dynamics," *Econometrica*, 82(3), 825–885.

Dix-Carneiro, R., and B. K. Kovak (2017): "Trade Liberalization and Regional Dynamics," *American Economic Review*, 107(10), 2908–46.

Eisfeldt, A., and A. Rampini (2006): "Capital Reallocation and Liquidity," *Journal of Monetary Economics*, 53(3), 369–399.

Eisfeldt, A., and Y. Shi (2018): "Capital Reallocation," *Annual Review of Financial Economics*, 10, 361–386.

Foley, C. F., and K. Manova (2015): "International Trade, Multinational Activity, and Corporate Finance," *Annual Review of Economics*, 7(1), 119–146.

Ghironi, F., and M. J. Melitz (2005): "International Trade and Macroeconomic Dynamics with Heterogeneous Firms," *Quarterly Journal of Economics*, 120(3), 865–915.

Helpman, E., O. Itskhoki, and S. Redding (2010): "Inequality and Unemployment in a Global Economy," *Econometrica*, 78(4), 1239–1283.

Hopenhayn, H. (1992): "Entry and Exit in Long Run Equilibria," *Econometrica*, 60(5).

——— (2014): "Firms, Misallocation, and Aggregate Productivity: A Review," *Annual Review of Economics*, 6, 735–770.

Hsieh, C.-T., and P. J. Klenow (2009): "Misallocation and Manufacturing TFP in China and India," *The Quarterly Journal of Economics*, 124(4), 1403.

Khan, A., and J. K. Thomas (2013): "Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity," *Journal of Political Economy*, 121(6), 1055–1107.

Lanteri, A. (2018): "The Market for Used Capital: Endogenous Irreversibility and Reallocation over the Business Cycle," *American Economic Review*, 108(9), 2383–2419.

Lee, Y., and T. Mukoyama (2015): "Entry and Exit of Manufacturing Plants over the Business Cycle," *European Economic Review*, 77, 20–27.

Manova, K. (2010): "Credit Constraints and the Adjustment to Trade Reform," in *The Costs of Adjustment to Trade Reform, World Bank Trade and Development Series, Palgrave Macmillan.*

——— (2013): "Credit Constraints, Heterogeneous Firms, and International Trade," *Review of Economic Studies*, 80(2), 711–744.

Medina, P. (2017): "Import Competition, Quality Upgrading and Exporting: Evidence from the Peruvian Apparel Industry," Mimeo, University of Toronto.

Melitz, M. J. (2003): "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 71(6), 1695–1725.

Midrigan, V., and D. Y. Xu (2014): "Finance and Misallocation: Evidence from Plant-Level Data," *American Economic Review*, 104(2), 422–58.

Ramey, V. A., and M. D. Shapiro (2001): "Displaced Capital: A Study of Aerospace Plant Closings," *Journal of Political Economy*, 109(5), 958–992.

Ravikumar, B., A. M. Santacreu, and M. Sposi (2018): "Capital Accumulation and the Dynamic Gains from Trade," Working Paper.

Restuccia, D., and R. Rogerson (2008): "Policy distortions and aggregate productivity with heterogeneous establishments," *Review of Economic Dynamics*, 11(4), 707 – 720.

Tan, E. (2018): "Entrepreneurial Investment Dynamics and the Wealth Distribution," Working Paper.

Veracierto, M. L. (2002): "Plant-Level Irreversible Investment and Equilibrium Business-Cycles," *American Economic Review*, 92(1).

APPENDIX

A Data and Measurement

A.1 Distribution of Investment Rates

We report here broad characteristics of the distribution of investment rates. As is commonly reported in the firm dynamics literature, investment at the firm level is lumpy and volatile, which is reflected in Figure A1 and Table A1. Investment rate here is constructed as

$$i_{i,t} = \frac{k_{i,t+1} - (1 - \delta)\, k_{i,t}}{k_{i,t}}$$

where we set δ to 10%, which corresponds to the average depreciation rate faced by firms in the survey. Section 3 in the main text and Appendix B.4 provide more details on how the firm level depreciation rates are constructed, and report the distribution and characteristics of our constructed depreciation rates.

Industry	Food	Textiles	Apparel	Recorded media	Chemical	Machinery
Mean	0.429	0.389	0.487	0.435	0.336	0.501
Median	0.159	0.159	0.188	0.169	0.158	0.170
SD	0.868	0.778	0.917	0.870	0.685	0.941
Fraction $<= 0$	0.101	0.085	0.121	0.120	0.110	0.123
Fraction $<= \frac{mean}{4}$	0.277	0.232	0.325	0.258	0.236	0.362
$E[\frac{I}{K} \| \frac{I}{K} < 0]$	-0.214	-0.164	-0.207	-0.213	-0.179	-0.208
Inaction (1%)	0.005	0.006	0.007	0.012	0.011	0.018
Inaction (5%)	0.054	0.052	0.044	0.045	0.083	0.073
Inaction (10%)	0.186	0.188	0.175	0.142	0.227	0.196
Inaction (20%)	0.556	0.573	0.467	0.495	0.558	0.482

Table A1: Broad Characteristic of Investment Rates, for selected industries.

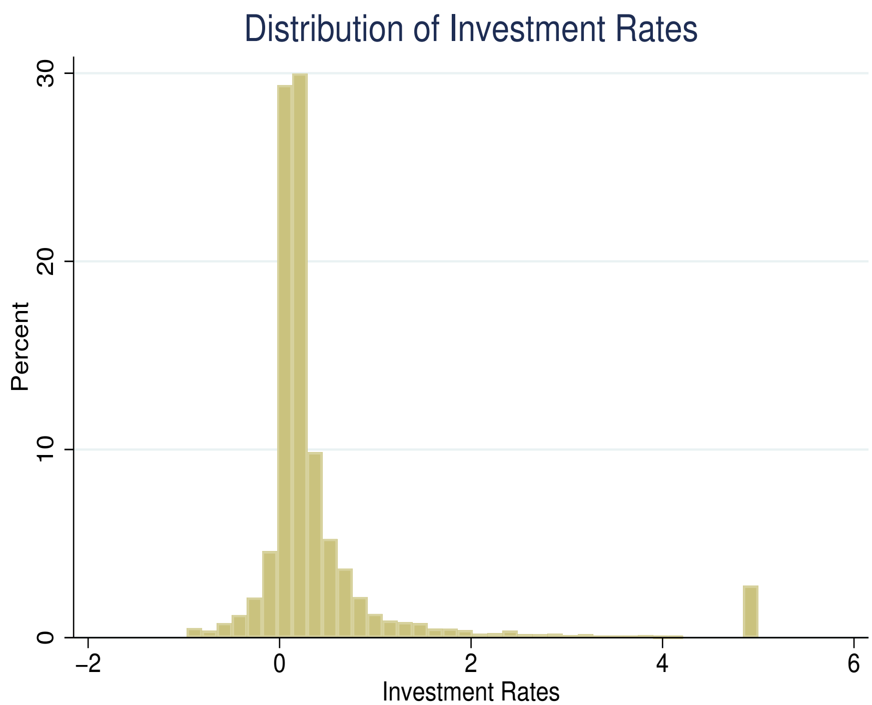


Figure A1: Distribution of Investment Rates.

Notes: The distribution has been winsorized at the 5th and 95th percentile for clarity of presentation.
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B Key Facts of MRPK: Additional Evidence

B.1 Dispersion of MRPK and TFP Volatility

Figure B1 shows a scatter plot of the dispersion in MRPK against the volatility of TFPR in our sample. As discussed in the main text, each observation corresponds to an industry-year pair. Thus, dispersion in MRPK refers to the within industry-year standard deviation of MRPK, while volatility of TFPR refers to the standard deviation of the innovations to TFPR within an industry and year. Innovations to TFPR are computed as the residual to an AR(1) process. We also overlay the implied predicted dispersion in MRPK by fitting an OLS regression line.

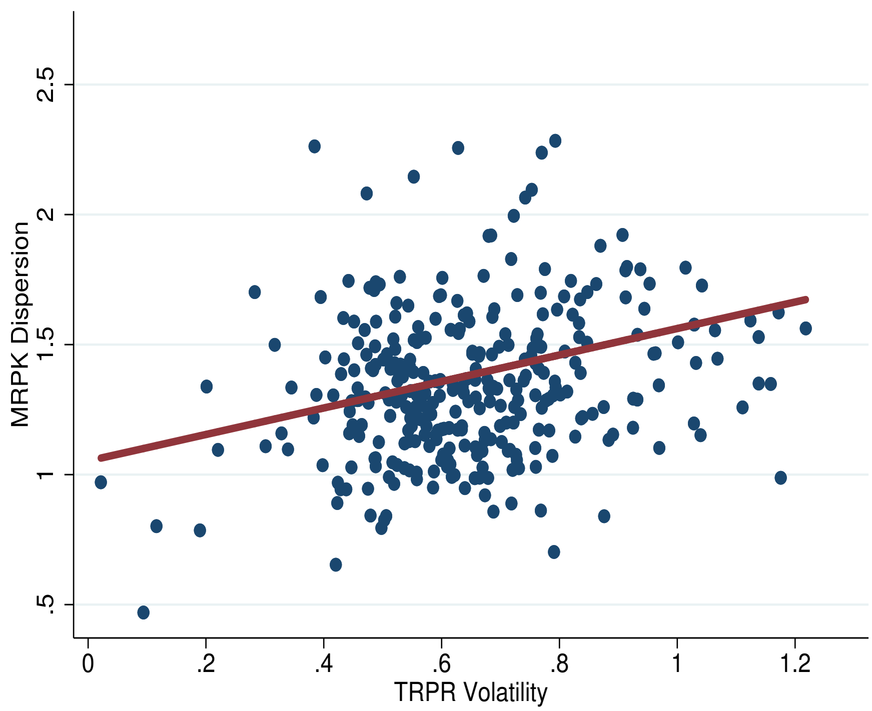


Figure B1: Dispersion of MRPK and TFP Volatility.

Notes: Each observation is a single industry-year pair. The solid line is generated by a (weighted) OLS regression, the slope is 0.48 (0.01).

B.2 Dynamics of MRPK: Non-Parametric Estimation

In this section, we report the non-parametric estimation described in the main text by the selected industries.

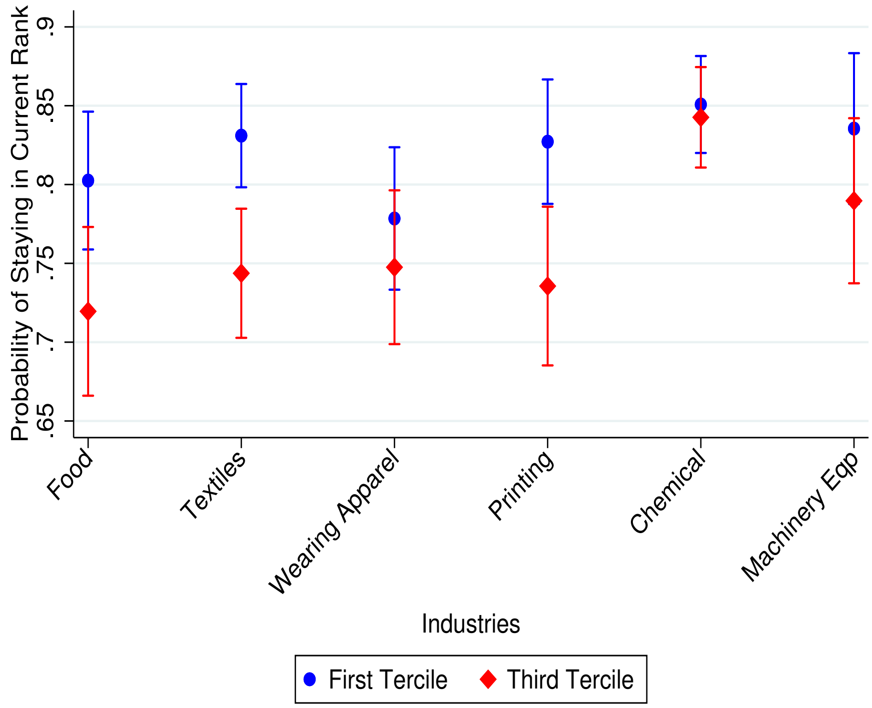


Figure B2: Persistence of Relative Rankings of MRPK Distribution.

Notes: Confidence intervals at the 95% significance.

B.3 Dynamics of MRPK: Transition Matrices

In this section, we report the full transition matrices of MRPK and TFPR and that were discussed in the main text.

B.3.1 MRPK Transitions: Benchmark

	1	2	3
1	0.803	0.196	0.055
2	0.176	0.670	0.225
3	0.022	0.134	0.720

(a) Food

	1	2	3
1	0.831	0.197	0.046
2	0.155	0.707	0.211
3	0.014	0.096	0.744

(b) Textiles

	1	2	3
1	0.778	0.203	0.056
2	0.182	0.671	0.197
3	0.040	0.126	0.748

(c) Apparel

	1	2	3
1	0.827	0.174	0.024
2	0.164	0.695	0.241
3	0.008	0.130	0.736

(d) Printing

	1	2	3
1	0.851	0.159	0.016
2	0.143	0.705	0.141
3	0.006	0.137	0.843

(e) Chemicals

	1	2	3
1	0.835	0.229	0.017
2	0.152	0.654	0.193
3	0.013	0.117	0.790

(f) Machinery Eq

Table B1: Transition Matrices of MRPK.

B.3.2 MRPK Transitions: Including exit

		at $t+1$			
		1	2	3	exit
	1	0.54	0.11	0.01	0.34
Tercile at t		(0.01)	(0.01)	(0.00)	(0.01)
	2	0.13	0.49	0.09	0.29
		(0.01)	(0.01)	(0.00)	(0.01)
	3	0.02	0.12	0.46	0.41
		(0.00)	(0.01)	(0.01)	(0.01)

Table B2: Transition probabilities of MRPK. Standard errors in paranthesis.

B.3.3 MRPK Transitions: Utilization Corrected

	1	2	3
1	0.690	0.211	0.060
2	0.244	0.626	0.206
3	0.065	0.162	0.733

(a) Food

	1	2	3
1	0.680	0.188	0.039
2	0.267	0.634	0.202
3	0.053	0.178	0.758

(b) Textiles

	1	2	3
1	0.658	0.232	0.042
2	0.264	0.515	0.233
3	0.078	0.253	0.725

(c) Apparel

	1	2	3
1	0.708	0.173	0.053
2	0.249	0.639	0.211
3	0.043	0.189	0.736

(d) Printing

	1	2	3
1	0.770	0.151	0.023
2	0.205	0.688	0.146
3	0.026	0.161	0.831

(e) Chemicals

	1	2	3
1	0.725	0.168	0.029
2	0.210	0.687	0.202
3	0.065	0.145	0.769

(f) Machinery Eq

Table B3: Transition Matrices of Utilization Correction MRPK.

B.3.4 TFPR Transitions

	1	2	3
1	0.676	0.245	0.044
2	0.251	0.561	0.221
3	0.073	0.194	0.735

(a) Food

	1	2	3
1	0.679	0.295	0.041
2	0.222	0.565	0.236
3	0.099	0.140	0.723

(b) Textiles

	1	2	3
1	0.698	0.238	0.058
2	0.265	0.551	0.261
3	0.037	0.211	0.681

(c) Apparel

	1	2	3
1	0.701	0.267	0.052
2	0.225	0.554	0.234
3	0.074	0.180	0.715

(d) Printing

	1	2	3
1	0.723	0.211	0.018
2	0.248	0.600	0.172
3	0.029	0.189	0.809

(e) Chemicals

	1	2	3
1	0.636	0.254	0.035
2	0.257	0.575	0.160
3	0.107	0.172	0.804

(f) Machinery Eq

Table B4: Transition Matrices of TFPR.

B.4 Firm-level Depreciation and Persistence

To construct firm-level depreciation rates we proceed as follows. First, for each firm i and year t, we construct the share $S_{i,l,t}$ of capital stock held in capital of type l. Next, we use data from the U.S. Bureau of Economic Analysis (BEA) to obtain capital-type-year-specific depreciation rates $\delta_{l,t}$ for the U.S. We then use these depreciation rates to compute firm-year-specific average depreciation rates, using the following formula:

$$\delta_{i,t} = \sum_{l} S_{i,l,t}\delta_{l,t} \tag{B1}$$

Specifically, we obtain the depreciation rates from Tables 2.1 and 2.4 of the Fixed Asset tables of the National Income and Products Accounts. Figure B3 provides further details on the distribution of average depreciation rates.

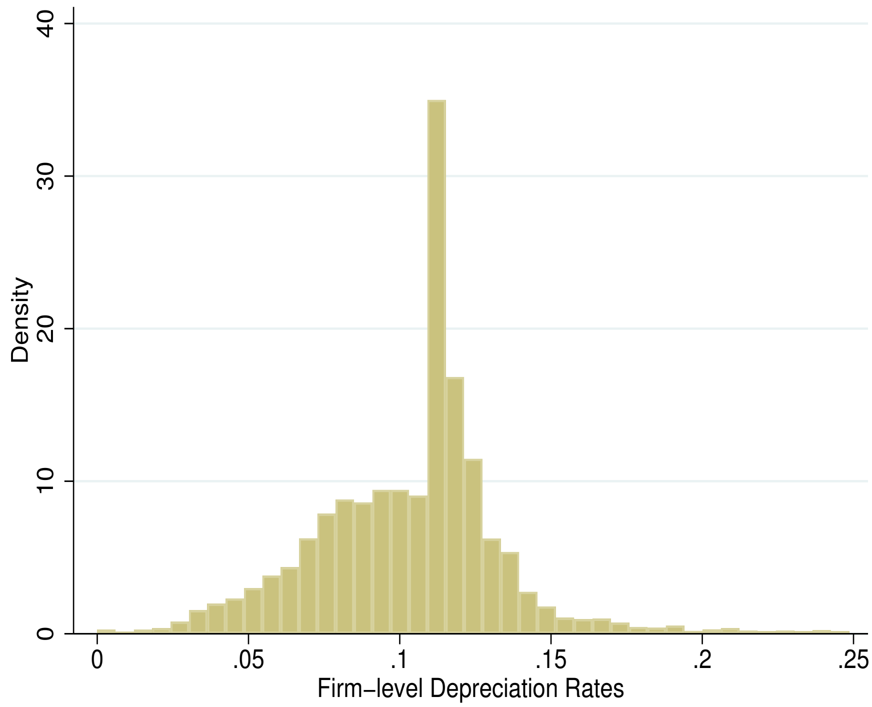


Figure B3: Distribution of Imputed Firm-level Depreciation Rates.

Finally, we estimate the impact of capital depreciation rates on the persistence of a firms' MRPKs by estimating the following probit model:

$$\mathcal{I}_{i,j,t}\left(q'=q\right)=\begin{cases}0 & \text{if } Y_{i,j,t}<0\\ 1 & \text{if } Y_{i,j,t}\geq 0\end{cases} \tag{B2}$$

$$Y_{i,j,t}=a+\eta\delta_{i,t}+\theta X_{i,t}+\gamma_j+\gamma_t+\epsilon_{i,j,t} \tag{B3}$$

where $\mathcal{I}_{i,j,t}\left(q'=q\right)$ is an indicator function that takes a value of one if firm i is in tercile q of the MRPK distribution of industry j in year t and remains in the same tercile in year $t+1$, η is our coefficient of interest, mapping firm-level depreciation rates into the probability of staying in the same rank of MRPK, $X_{i,t}$ are firm-level controls (e.g., capital level and value added), γ_j is an industry fixed effect, and γ_t is a year fixed effect.

Figure B4 shows the average marginal effect on the probability of staying in the same tercile by different levels of firm-level depreciation rates for low-MRPK firms.

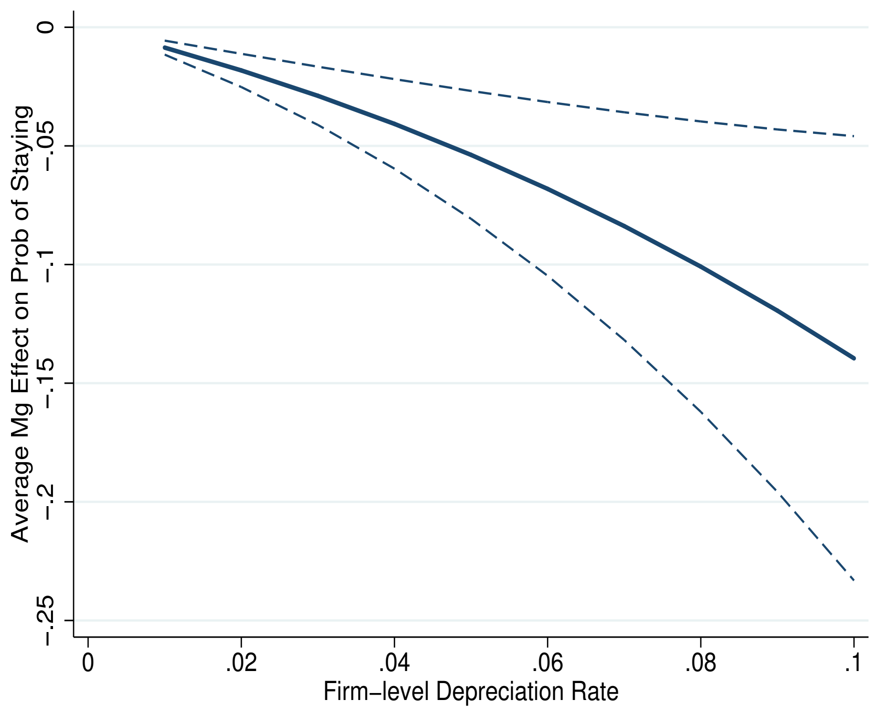


Figure B4: The Effect of Depreciation Rates on Low Return Firms' Persistence.

B.5 Capital Utilization and Persistence

To compute utilization rates, we use data on firms' expenditures on energy, e_{it}. For simplicity, we assume that energy is complementary to the amount of capital used in production and measure the utilization rate u_{it} of capital as the ratio of energy inputs to capital stock, that is, $u_{it} = \frac{e_{it}}{k_{it}}$. We then recompute firms MRPK using utilized capital $u_{it}k_{it}$ as capital input instead of k_{it}. Then, we re-estimate equation 3 with the corrected measure of MRPK. Table B5 shows the results.

Variables	MPRK (utilization adjusted)	MRPK
ρ (no interaction)	0.744	0.742
	(0.009)	(0.026)
ρ_1 (1st tercile MRPK)	0.619	0.843
	(0.023)	(0.017)
ρ_2 (2nd tercile MRPK)	0.731	0.641
	(0.015)	(0.025)
ρ_3 (3rd tercile MRPK)	0.735	0.546
	(0.009)	(0.050)

Table B5: Persistence of MRPK and Capital Utilization.

B.6 Labor Reallocation

		at $t+1$		
		1	2	3
	1	0.71	0.22	0.06
Tercile at t		(0.01)	(0.01)	(0.00)
	2	0.25	0.59	0.16
		(0.01)	(0.01)	(0.01)
	3	0.06	0.24	0.70
		(0.00)	(0.01)	(0.01)

Table B6: Transition probabilities of MRPN. Standard errors in paranthesis.

B.7 What Drives MRPK Persistence? Direct Evidence and Alternative Stories

B.7.1 Variance Decomposition of MRPK

Here, we first provide *direct* evidence that the skewed (left-tail) persistence is driven by a small disinvestment response to negative profitability shocks. We do this via a simple variance decomposition approach.

Recall that by definition,

$$\log MRPK_t = \log(\alpha) - \log(k_t) + \log(y_t) \tag{B4}$$

$$\implies \log(\frac{MRPK_{t+1}}{MRPK_t}) = \log(\frac{k_{t+1}}{k_t}) + \log(\frac{y_{t+1}}{y_t}) \tag{B5}$$

$$\implies var(\log(\frac{MRPK_{t+1}}{MRPK_t})) = var(\log(\frac{k_{t+1}}{k_t})) + var(\log(\frac{y_{t+1}}{y_t})) + cov(\log(\frac{k_{t+1}}{k_t}), \log(\frac{y_{t+1}}{y_t})) \tag{B6}$$

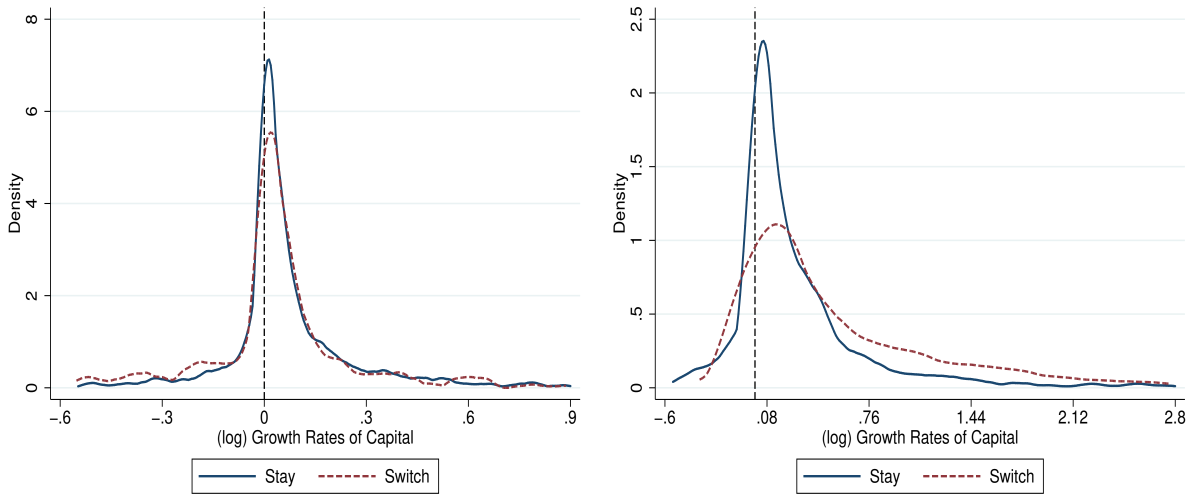
That is, the growth rate of MRPK can be decomposed into a component that comes from the choice of capital today (i.e. k_{t+1}), and a component that arises from a shock to value added tomorrow (i.e. y_{t+1}). This decomposition is reflected in Table B7. Moreover, this also implies that *mechanically*, the probability that a firm stays in a current quantile is simply a combination of the change in the firm's capital stock and the shock to profitability in the next period.

	First Tercile	Third Tercile
$var(\log(\frac{k_{t+1}}{k_t})))$	0.14	0.86
$var(\log(\frac{y_{t+1}}{y_t}))$	0.48	0.47
$cov(\log(\frac{k_{t+1}}{k_t}), \log(\frac{y_{t+1}}{y_t}))$	0.06	-0.06

Table B7: Variance Decomposition of Growth Rate of MRPK

Given by the decomposition above, we see that for firms in the first tercile, the majority of the variation in MRPK is simply driven by shocks to value added (almost 80% when we ignore the contribution of the covariance term). In contrast, in the third tercile, the variation in MRPK has a more even split between changes in the capital stock and value added shocks. This fact suggests that when firms in the first tercile switch out of their ranks, they do so not because they are downsizing (as would be predicted by standard theories); instead, they simply received very good productivity draws in the next period.

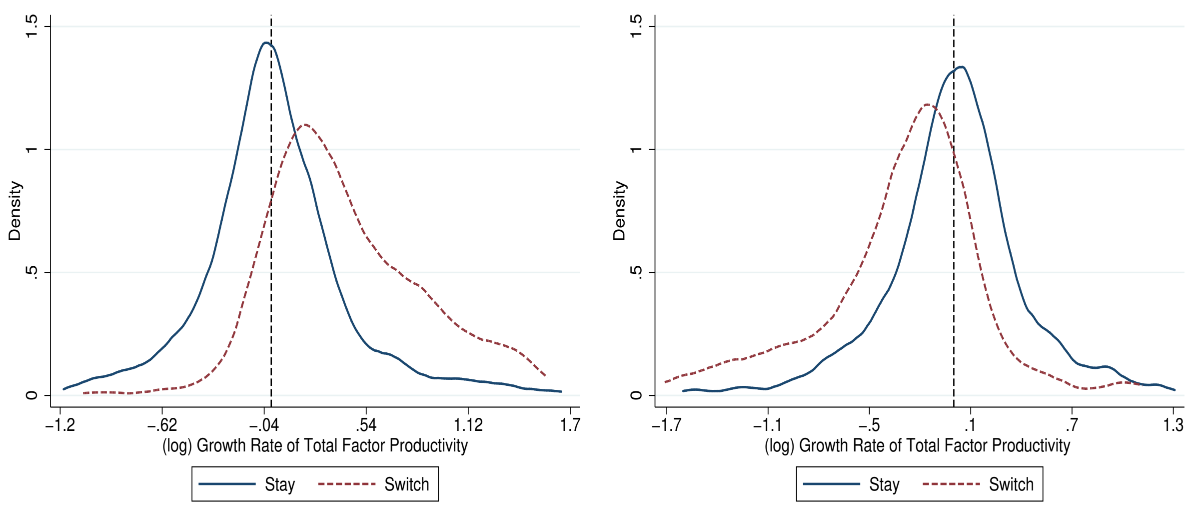
This result is also reflected in Figures B5 and B6, where we have plotted the kernel density estimates of the growth rates of capital and TFPR for firms that stayed in their current quantiles, or switched out of their current quintiles. For low-MRPK firms, we see in Panel (a) of Figure B5 that there is practically no difference in the distribution of capital growth rates for firms that switched or stayed; however, their draws of future productivity is distinctly different, as reflected in Panel (a) of Figure B6. For high MRPK firms, Panel (b) of Figures B5 and B6, we see that the firms that switch out generally have higher growth rates of capital, and lower TFPR growth rates,



(a) First Tercile

(b) Third Tercile

Figure B5: Distribution of $\log(\frac{k_{t+1}}{k_t})$ for first and third terciles.



(a) First Tercile

(b) Third Tercile

Figure B6: Distribution of $\log(\frac{z_{t+1}}{z_t})$ shocks for first and third terciles

In this sense, this stylized fact provides support for our theory that downsizing frictions are indeed a potential driver for the higher left tail persistence.

B.7.2 Skewed TFPR Persistence?

One natural question is whether this asymmetric persistence is driven by TFP shocks; that is, whether the asymmetric persistence is simply an artifact of (left) skewed TFPR persistence. It is important to note that the persistence of TFPR has no impact on the persistence of MRPK if firms can frictionlessly adjust their capital stock.[33] However, to ameliorate concerns that this might be a confounding factor, we used our transition matrix approach and estimated the transition probabilities for TFPR. In Figure B7 below, we see that TFPR generally does *not* exhibit substantial asymmetry in persistence; if anything, it appears to be weakly more persistent in the right tail.

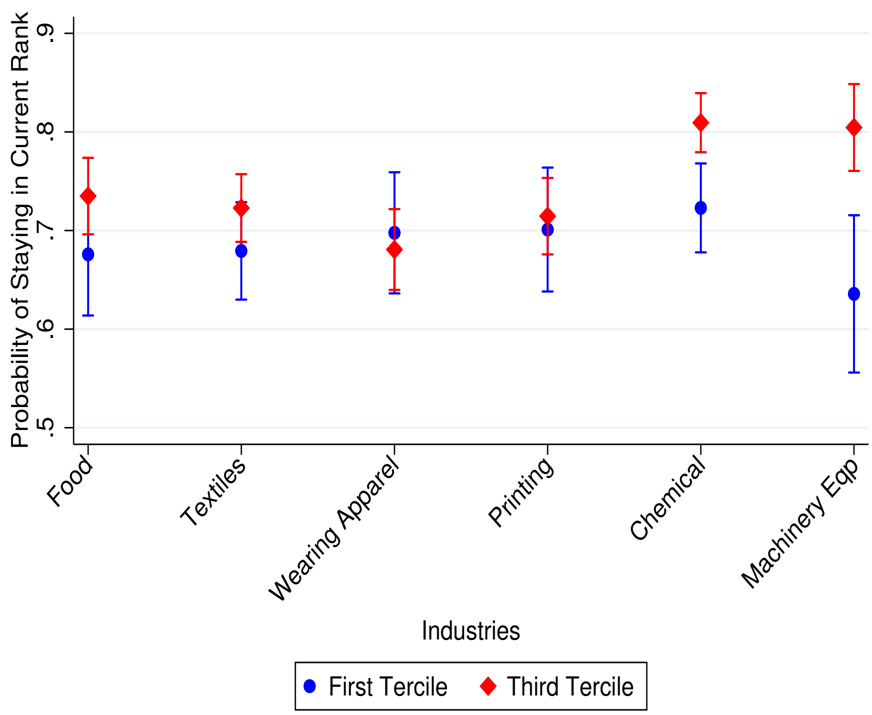


Figure B7: Left and Right Tail Persistence of TFPR.

[33] For instance, see the proof in Tan (2018)

B.7.3 Employment Subsidies?

Another natural question is whether larger firms are subsidized; this might lead poor performing firms to stay large. Figure B8 below reports the marginal effect of employment on tail persistence. That is, the likelihood of staying on the same tercile. Larger firms in the first tercile are in fact more likely to switch out of the first tercile (relative to large firms in the third tercile), suggesting that concerns about employment subsidies might not be warranted.

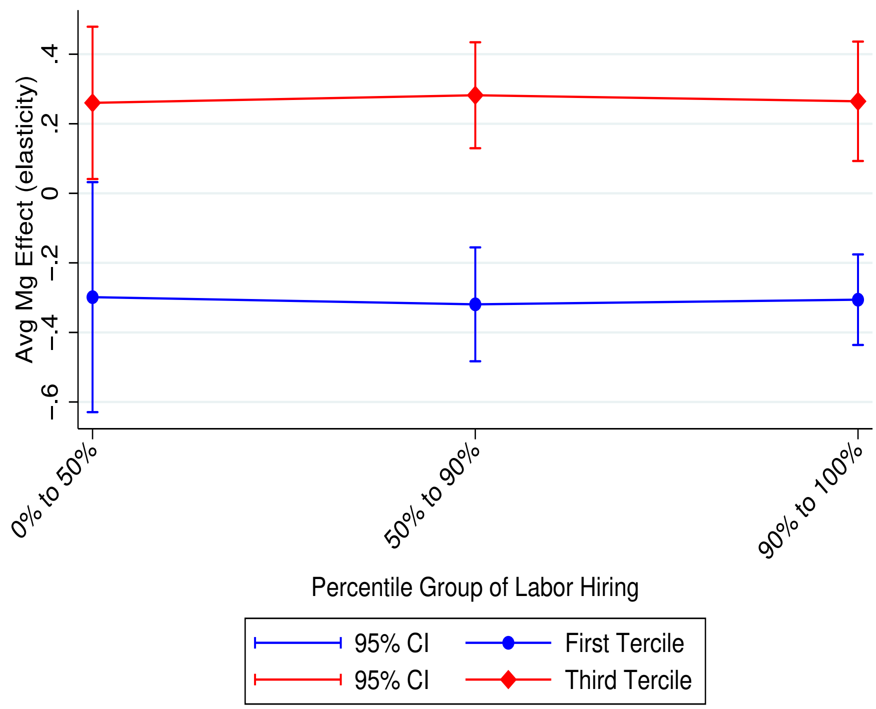


Figure B8: Effect of Firm Size by Employment on Tail Persistence.

C Effect of Trade Shock: Details and Robustness

C.1 Export Behavior

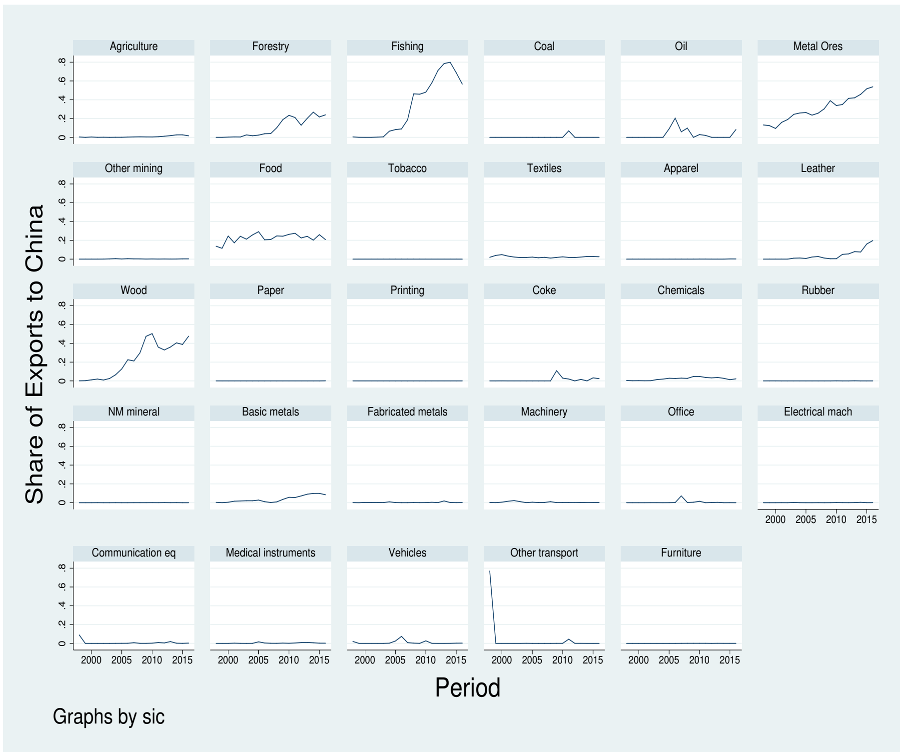


Figure C1: Export Intensity to China.

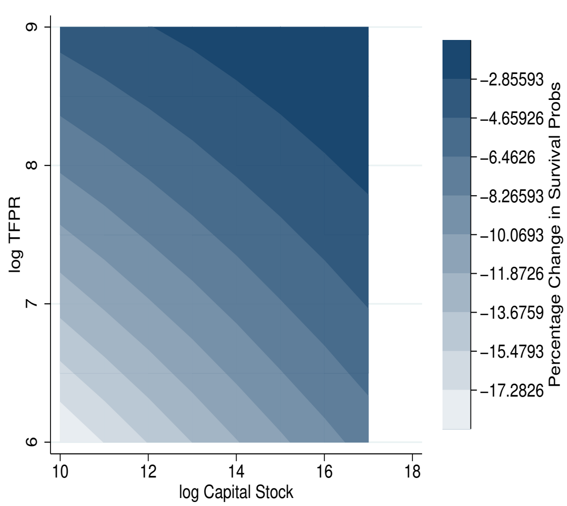
C.2 Extensive Margin

In this section, we provide the point estimates for equation 7. Columns 1 and 2 use as import competition shock the level of Chinese import penetration by industry, while Columns 3 and 4 use as import competition shock the deviations from trend of import penetration. Columns 1 and 3 report the OLS estimates while Columns 2 and 4 correspond to the IV results. Our benchmark speficiation is Column 4.

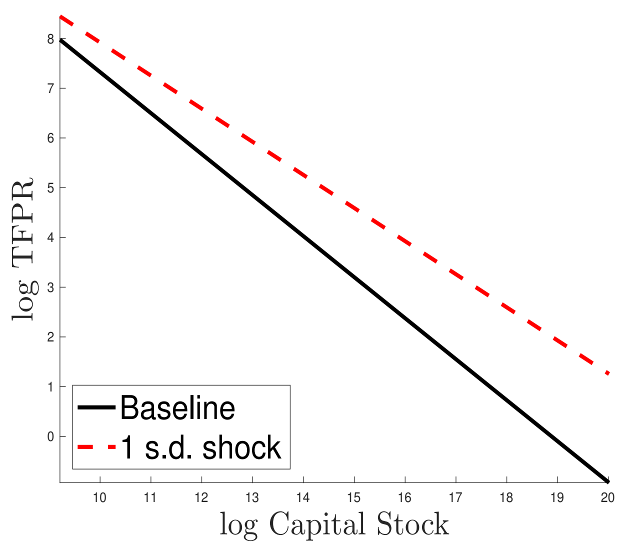
	$P(surv_{jnt})$ (1)	$P(surv_{jnt})$ (2)	$P(surv_{jnt})$ (3)	$P(surv_{jnt})$ (4)
$ChComp_{nt}$	-3.419	-4.079	-3.426	-6.474
	(0.539)	(0.598)	(1.103)	(1.544)
$TFPR_{jnt}$	0.224	0.221	0.251	0.247
	(0.019)	(0.020)	(0.014)	(0.015)
$KStock_{jnt}$	0.143	0.137	0.169	0.167
	(0.008)	(0.009)	(0.006)	(0.006)
$ChComp_{nt}*TFPR_{jnt}$	0.152	0.158	0.250	0.472
	(0.057)	(0.062)	(0.125)	(0.173)
$ChComp_{nt}*KStock_{jnt}$	0.126	0.149	0.083	0.156
	(0.025)	(0.027)	(0.048)	(0.067)
N. Observations	12,014	11,559	12,014	11,559

Table C1: Effect of Trade Shock on Survival.

In addition, we present the equivalent graphs to Figure 4 when using other specifications. In particular, we use the definition of import competition shocks measured with import penetration at the industry level and deviations from trend of import penetration by industry.

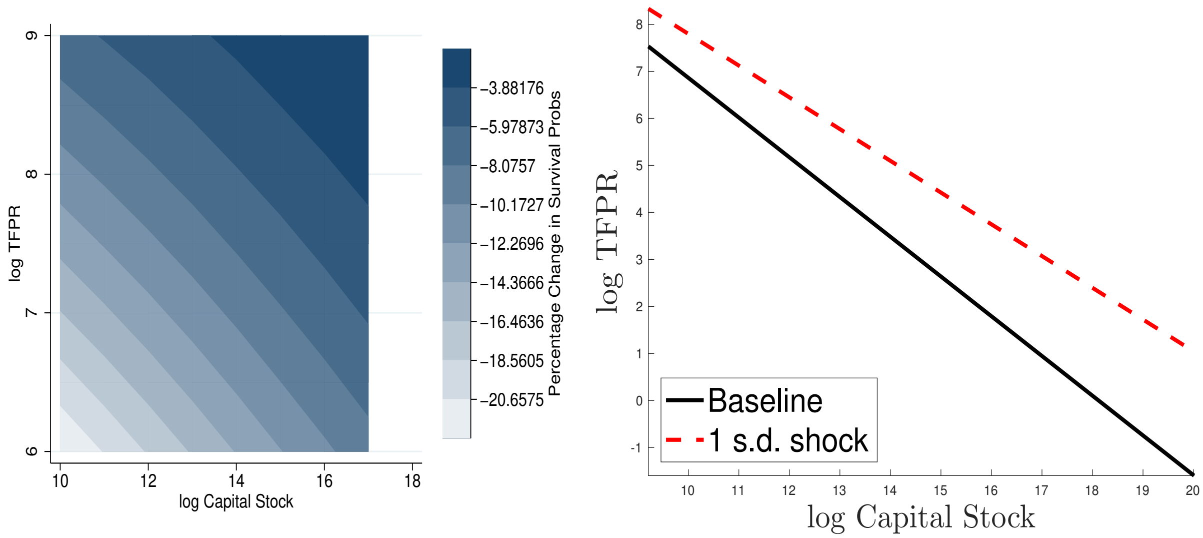


(a) Average Effect of 1 s.d. Shock



(b) Prob. Survival = 50%, at Baseline and 1 s.d. Shock

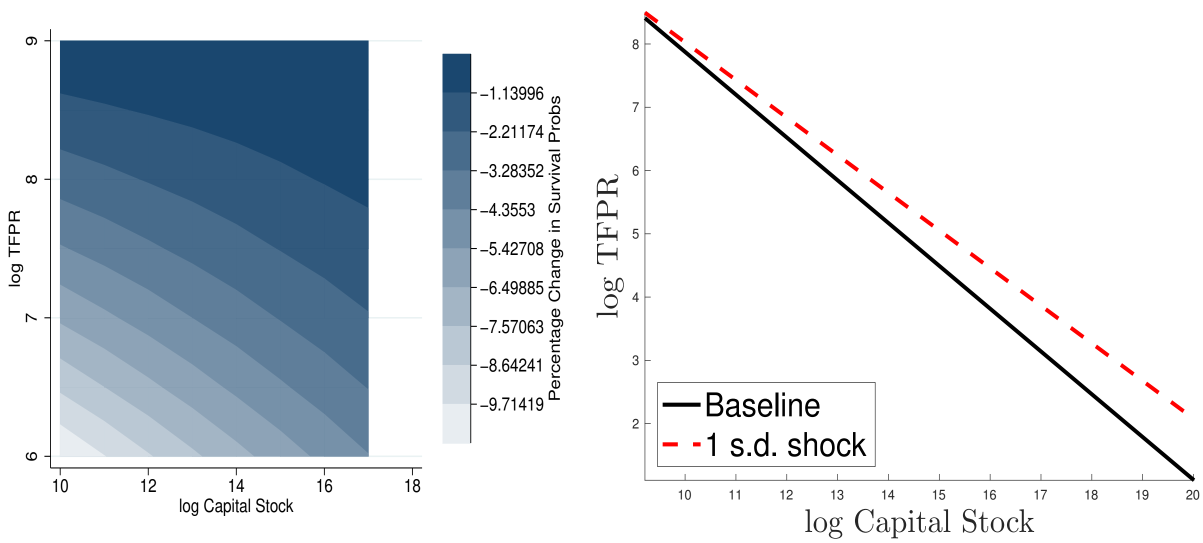
Figure C2: Effects of Trade Shock on Survival Probabilities. Import Penetration and OLS.



(a) Average Effect of 1 s.d. Shock

(b) Prob. Survival = 50%, at Baseline and 1 s.d. Shock

Figure C3: Effects of Trade Shock on Survival Probabilities. Import Penetration and IV.



(a) Average Effect of 1 s.d. Shock

(b) Prob. Survival = 50%, at Baseline and 1 s.d. Shock

Figure C4: Effects of Trade Shock on Survival Probabilities. Deviation from trend on import penetration and OLS.

C.3 Intensive Margin

We perform the same analysis in Table 4 considering different measures of trade shocks and by OLS and IV.

	Growth Rate of K	Prob of Staying in Current Tercile
Pooled	0.049	-0.082
	(0.066)	(0.046)
First Tercile MRPK	-0.217	-0.151
	(0.072)	(0.077)
Second Tercile MPRK	0.100	-0.037
	(0.075)	(0.085)
Third Tercile MRPK	0.055	-0.019
	(0.192)	(0.086)

Table C2: The Effect of a Trade Shock on Investment. Import Penetration and OLS.

	Growth Rate of K	Prob of Staying in Current Tercile
Pooled	0.009	-0.098
	(0.088)	(0.062)
First Tercile MRPK	-0.284	-0.194
	(0.095)	(0.101)
Second Tercile MPRK	0.119	-0.049
	(0.099)	(0.113)
Third Tercile MRPK	-0.184	0.020
	(0.267)	(0.120)

Table C3: The Effect of a Trade Shock on Investment. Import Penetration and IV.

	Growth Rate of K	Prob of Staying in Current Tercile
Pooled	0.089	-0.092
	(0.067)	(0.047)
First Tercile MRPK	-0.169	-0.159
	(0.070)	(0.075)
Second Tercile MPRK	0.132	-0.055
	(0.078)	(0.089)
Third Tercile MRPK	0.098	-0.029
	(0.201)	(0.090)

Table C4: The Effect of a Trade Shock on Investment. Deviation from trend on import penetration and IV.

C.4 Intensive Margin: Effect on TFPR, MRPK and Employment

In this section, we show the effects of an import competition shock on TFPR, MRPK, and Employment levels.

	TFPR	MRPK	Employment
Pooled	0.460	0.325	0.185
	(0.216)	(0.116)	(0.068)
First Tercile MRPK	1.146	0.270	0.118
	(0.578)	(0.130)	(0.105)
Second Tercile MPRK	-0.034	0.078	0.265
	(0.337)	(0.045)	(0.101)
Third Tercile MRPK	0.539	-0.051	0.148
	(0.447)	(0.174)	(0.126)

Table C5: The Effect of a Trade Shock on TFPR, MRPK and Employment. Deviation from trend on import penetration and IV.

	TFPR	MRPK	Employment
Pooled	0.661	0.527	0.354
	(0.296)	(0.159)	(0.093)
First Tercile MRPK	1.522	0.125	0.288
	(0.771)	(0.176)	(0.137)
Second Tercile MPRK	-0.073	0.101	0.467
	(0.456)	(0.062)	(0.138)
Third Tercile MRPK	0.449	-0.279	0.166
	(0.637)	(0.246)	(0.180)

Table C6: The Effect of a Trade Shock on TFPR, MRPK and Employment. Deviation from trend on import penetration and IV.

	TFPR	MRPK	Employment
Pooled	0.267	0.313	0.141
	(0.224)	(0.119)	(0.071)
First Tercile MRPK	0.871	0.279	0.122
	(0.567)	(0.127)	(0.108)
Second Tercile MPRK	-0.118	0.097	0.275
	(0.354)	(0.047)	(0.106)
Third Tercile MRPK	0.439	-0.146	0.082
	(0.470)	(0.182)	(0.133)

Table C7: The Effect of a Trade Shock on TFPR, MRPK and Employment. Deviation from trend on import penetration and IV.

	TFPR	MRPK	Employment
Pooled	0.350	0.512	0.242
	(0.312)	(0.164)	(0.098)
First Tercile MRPK	1.292	0.207	0.256
	(0.774)	(0.175)	(0.142)
Second Tercile MPRK	-0.268	0.123	0.433
	(0.491)	(0.065)	(0.149)
Third Tercile MRPK	0.238	-0.590	-0.020
	(0.671)	(0.259)	(0.190)

Table C8: The Effect of a Trade Shock on TFPR, MRPK and Employment. Deviation from trend on import penetration and IV.