Capital-Reallocation Frictions and Trade Shocks∗

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Abstract

What are the short- and medium-term effects of an international-trade shock that increases competition for domestic manufacturing firms? We address this question by combining firm-level investment data from Peruvian manufacturing, bilateral trade-flows between Peru and China, and a quantitative general-equilibrium model with heterogeneous firms subject to idiosyncratic shocks. In the data, we find evidence of substantial frictions that slow capital reallocation, either through disinvestment or firm exit. In our model, these frictions induce slow transitional dynamics after a trade shock, with gradual productivity gains. On impact, a spike in inaction increases the aggregate productivity wedge relative to a frictionless benchmark.

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1 Introduction

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

Less is known, however, about the consequences of accounting for transitional dynamics after trade shocks and to what extent frictions in the reallocation of factors may delay 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 substantial frictions in capital reallocation, especially in emerging economies, 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-term effects of an international trade shock on domestic production? 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 several years. In fact, in the short run, trade liberalization may temporarily take the economy further from a frictionless allocation of resources.

To analyze the role of these frictions in an economy’s response to a trade shock, we combine detailed firm-level investment data for manufacturing industries in Peru for the years 2000-2014 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 the 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 allow us to identify capital-reallocation frictions. First, returns from investment in physical capital are highly dis-
persed among manufacturing firms (within industries), consistent with many prior studies on several countries. Second, the adjustment of capital to firm-level shocks 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 depreciate gradually 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.

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. Productive firms postpone their investment, leading to an increase in inaction. Moreover, the level of capital affects the patterns of firm exit and, hence, average industry productivity.

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. Fixed operations costs determine firms’ decisions to continue producing or exit their industry. Importantly, 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 use the model to 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 emphasize two key findings. First, on impact the shock selects against firms with low productivity and firms with low capital. Thus, some productive, but small, firms exit the market. Because of these patterns of selection, average firm productivity in the domestic industry increases only gradually. Specifically, the half life of the transition of this key variable is five years. In contrast, convergence is almost immediate in the absence of frictions.

Second, consistent with our empirical evidence, the trade shock leads to a temporary
increase in the size of the inaction region, as many productive firms choose to postpone their investment. Thus, the dispersion in marginal products increases in the short run, leading to a larger wedge between aggregate TFP in our economy and in a frictionless benchmark. In terms of welfare, trade is overall beneficial. However, capital-reallocation frictions decrease these welfare gains by approximately 25%.

**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 (2019), 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 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). The application of this tool to firm dynamics is an independent contribution of our paper and may provide a useful diagnostic for future researchers interested in understanding whether frictions in capital reallocation mainly affect expanding firms (e.g., financial frictions), or downsizing firms (e.g., irreversibility).

Our empirical evidence guides us toward a theory of asymmetric adjustment costs: Investment is partially irreversible at the firm level. In their seminal paper, Ramey and

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\(^1\)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 in two other datasets using Chilean and Colombian manufacturing firms. Tan (2018) also finds similar results in the context of US entrepreneurial firms.
Shapiro (2001) provide direct evidence of the slow and costly downsizing of the US aerospace industry in the 1990s. Similar frictions in reallocation of used capital play a key 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 liberalization.

The literature on international trade with heterogeneous firms, starting from the seminal work of Melitz (2003), typically abstracts from investment dynamics. Moreover, this literature often focuses on steady-state comparisons, i.e., long-term outcomes. Our paper contributes to this literature by explicitly considering transitional dynamics and focusing on capital-reallocation frictions.\(^4\) By casting a model of trade with heterogeneous firms into a macro general-equilibrium framework and computing aggregate dynamics, we build on the contribution of Ghironi and Melitz (2005). Moreover, we follow the business-cycle analysis of Clementi and Palazzo (2016) in modeling capital adjustment frictions jointly with entry and exit.

A growing literature studies adjustment dynamics in models of trade. Alessandria and Choi (2014) and Alessandria, Choi, and Ruhl (2018) study transitional dynamics after a trade liberalization and focus on the gradual growth of exporters. Caggese and Cuñat (2013) and Brooks and Dovis (Forthcoming) examine the role of credit-market frictions in the growth dynamics of exporters. Guren, Hemous, and Olsen (2015) study the role of sector-specific human capital. Caliendo, Dvorkin, and Parro (2019) analyze the labor-market effects of the China trade shock in a spatial general-equilibrium model of the US economy. We contribute to this literature by emphasizing the downsizing process induced by import competition, and thus focus on capital-reallocation frictions. Therefore, we apply computational tools from the literature on macro models with heterogeneous agents to explicitly keep track of the distribution of capital and productivity along the transition path of the economy.\(^5\)

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\(^3\)Eisfeldt and Shi (2018) provide a survey of 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 (Antrás and Caballero, 2009; Helpman, Itskohki, 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 (2019) and Berthou, Chung, Manova, and Charlotte (2018) study the effects of trade liberalization with heterogeneous firms and factor misallocation. This body of work focuses on the static or long-term effects of frictions, rather than on their effect on transitional dynamics in response to trade shocks. Moreover, Federico, Hassan, and Rappoport (2019) provide an empirical analysis of the reallocation of bank credit in response to trade shocks.

\(^5\)In a related study, Buera and Shin (2013) show that financial frictions lead to slow transitional
Consistent with our findings on slow adjustment, recent empirical work highlights the role of slow capital dynamics to explain labor-market transitions 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, 2019). Relatedly, Artuc, Brambilla, and Porto (2017) study the impact of capital adjustment costs and costs in labor reallocation across sectors on labor-market dynamics following trade shocks.

Our paper proceeds as follows. Section 2 describes the data sources and measurement of key variables. Section 3 presents key facts on firm dynamics and reallocation. Section 4 shows the empirical effects of a trade shock on capital reallocation. Section 5 introduces our model. Section 6 discusses 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) and trade shocks.

2.1 Data Sources

Our main data source is the Encuesta Economica Nacional (EEA) for the period between 2000 and 2014. This is a firm-level survey administered by the Peruvian Statistical Agency (INEI) at the national level. The data contain firm balance-sheet information, including variables related to inputs and profitability. Moreover, the EEA provides detailed information on fixed assets, i.e., capital. In particular, the survey disaggregates capital in different categories: land, fixed installations, buildings, machinery and equipment, furniture, computers, and transportation.

As is often the case with administrative surveys, the EEA is effectively a census for large and medium-size firms, but only a sample for small firms. Therefore, panel data for small dynamics after reforms that trigger large reallocations. Ravikumar, Santacreu, and Sposi (2019) emphasize the role of capital accumulation for gains from trade in a dynamic multi-country model.

The threshold for a firm to be sampled on the survey is determined annually and based on sales relative to Peruvian tax units. Prior to 2007, the annual net sales threshold was around 600,000 USD; it went up to approximately 1 million USD in 2007.
firms are limited and unbalanced. To more accurately compute entry and exit rates, we also use the Peruvian registry of firms (Padrón RUC) for the period 2007-2014. For these years, we construct firm-level entry and exit rates by using the legal operation dates of firms in the sample, instead of survey entry and exit.

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 2014 and is available at the annual level.\textsuperscript{7}

2.2 Measurement

We now discuss how we construct the key variables of interest for our empirical analysis.

**Capital and Productivity.** We use data on value added and inputs to recover revenue total factor productivity (TFPR) following a standard procedure (e.g., Asker, Collard-Wexler, and De Loecker, 2014), to account for the fact that we do not separately observe output prices and quantities. We assume that a firm \( j \) at time \( t \) produces value added \( y_{jt} \) by using an industry-specific constant-return technology that takes capital \( k_{jt} \) and labor \( n_{jt} \) as inputs, \( y_{jt} = s_{jt} k_{jt}^{\alpha_{jt}} n_{jt}^{1-\alpha_{jt}} \), where \( s_{jt} \) is firm-level idiosyncratic physical productivity. Demand for firm \( j \)'s output is given by \( y_{jt} = B_t p_{jt}^{-\epsilon} \), with constant elasticity \( \epsilon \), where \( B_t \) is an aggregate shifter.\textsuperscript{8}

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

\[
p_{jt} y_{jt} = B_t^{\frac{1}{\epsilon}} s_{jt}^{\theta} k_{jt}^{\theta\alpha_{jt}} n_{jt}^{\theta(1-\alpha_{jt})}
\]

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 \( \alpha \) by computing the median share of the labor expenditure in firm’s value added. We then obtain \( TFPR_{jt} \) as the residual of a regression of value added on \( n_{jt} \) (the number of employees in the firm) and \( k_{jt} \) (the capital stock measured as the deflated book value). We measure the marginal revenue product of capital (MRPK) as

\textsuperscript{7}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. See https://wits.worldbank.org/product_concordance.html

\textsuperscript{8}We abstract from firm-specific demand shocks, because we cannot separately identify them from productivity shocks.
follows:

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

We also exploit information about the composition of the capital stock at the firm level. In particular, we construct firm-specific depreciation rates by combining information on the share of capital stock invested in different types of assets with the asset-specific depreciation rates in U.S. Fixed Asset Tables. Appendix A.1 provides more details on this procedure. In addition, we use information on the consumption of energy and materials at the firm level to construct measures of capital utilization.

**Import Competition.** We use bilateral trade data to construct two different industry-level measures of exposure to import competition shocks. First, we use Chinese import intensity, defined as the share of Chinese-originated imports relative to global Peruvian imports, at the 4-digit level of CIIU Rev 3.1 industries. We call this measure $ImpInt_{nt} = \frac{Imports_{China,nt}}{Imports_{World,nt}}$. Second, given the steady increase of Chinese imports during the 2000s in most industries, we also create an exposure measure using deviations from import intensity trends by industry. This approach allows us to focus on the responses to (likely) unexpected increases in Chinese import intensity. In particular, to construct these deviations from trends, we first regress the raw import intensity measure $ImpInt_{nt}$ at the 4-digit CIIU Rev 3.1. industry $n$ on a series of dummy variables for two-digit industry and year. Then, we construct the import competition shock as the residuals of this regression. We label this variable $ChComp_{nt}$; it refers to our preferred specification and will be the one used in the main text, while we leave all other results to the appendix.

In addition, to capture increases in Chinese import intensity that derive from productivity enhancement in China rather than from demand trends in Peru, we instrument both $ImpInt_{nt}$ and $ChComp_{nt}$ following the approach of Autor, Dorn, and Hanson (2013). Specifically, we use import intensity and deviations from import intensity trends in several border Latin American countries as instruments for our competition shocks in Peru.

### 3 Key Facts on Capital, Productivity, and Selection

In this section, we describe three key facts about firm dynamics in the Peruvian manufacturing sector. We argue that all of these facts are consistent with significant downsizing frictions in capital, namely, investment irreversibility. Accordingly, key moments from this section directly inform the quantification of capital-reallocation frictions in the model of
3.1 Fact 1: MRPKs are highly dispersed and persistent

Consistent with the findings of a large literature on capital misallocation, we find that MRPKs display 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 1.47. This dispersion is not driven by a particular industry, but rather is large for all manufacturing industries. Moreover, MRPKs are not only highly dispersed in the cross-section of firms, but also remarkably persistent at the firm level. In our sample, the within-firm autocorrelation coefficient of (log) MRPK is considerably large (0.74), and is in the same range as the within-firm (log) TFPR autocorrelation (0.72).

Dispersion of MRPKs suggests the existence of frictions in capital reallocation in response to firm-level profitability shocks. Moreover, firm-level persistence in the returns from capital indicates that it takes a long time for firms to adjust to these shocks. In the presence of frictions, firms respond to profitability shocks by only gradually adjusting their capital stock.\textsuperscript{10}

3.2 Fact 2: Capital adjustment is asymmetric

We now move to characterize the dynamic evolution of capital at the firm level. Across a number of different analyses, we find that firm capital is downwardly rigid, leading to asymmetric adjustments in response to firm-level shocks. First, to illustrate this point we follow the literature and consider the fraction of negative investment rates. We find that only 10\% of adjustments are negative, which suggests the presence of partial investment irreversibility.\textsuperscript{11}

The mobility of MRPK. Next, we study the dynamics of MRPK, by applying a non-parametric estimation procedure that borrows from the literature on household wealth

\textsuperscript{9}This is larger than similar estimates for other developing countries such as Chile, Mexico, or India.
\textsuperscript{10}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.
\textsuperscript{11}Cooper and Haltiwanger (2006) target this moment in their estimation of irreversibility, and we also follow this approach in Section 6. See Appendix B.2 for detailed statistics about the investment distribution.
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. Hence, conditional on a given process for the profitability shocks, a high persistence in low MRPKs signals the presence of frictions that render disinvestment costly.

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. We report our estimates in Table 1. The probability of staying in the bottom tercile is 82%, whereas the probability of staying in the top tercile is 77% , which shows 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 in contrast, 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 to asymmetry in the distribution of profitability shocks.
<table>
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<th>Tercile at $t$</th>
<th>at $t + 1$</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
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<td>1</td>
<td>0.83</td>
<td>0.16</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.00)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.18</td>
<td>0.71</td>
<td>0.11</td>
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<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
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</tr>
<tr>
<td>3</td>
<td>0.02</td>
<td>0.21</td>
<td>0.77</td>
<td></td>
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<td></td>
<td>(0.00)</td>
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</table>

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

To allow for industry-specific definitions of 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).\(^{12}\) Figure B3 in Appendix B.3 plots the results of this estimation. In Appendix B.4, 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 fourth state. The asymmetric persistence is robust to this specification, and the results are displayed in Appendix B.4.2.

**MRPK and capital adjustment.** 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.

**Capital composition, depreciation, and MRPK mobility.** We now leverage a unique feature of our dataset. For each firm, we observe the portfolio composition of its

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\(^{12}\)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 to have sufficient power to test for the estimated differences.
capital stock among the following categories: land, buildings, fixed installations, machinery, 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.

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 the 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. 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 implies 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 and non-statistically significant effects, consistent with the notion that depreciation is more salient for firms that are trying to downsize.

**Capital utilization.** We now consider the margin of capital utilization. We find that, instead of downsizing, firms with low MRPK hold on to their capital and underutilize it. To measure capital utilization, 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.

Two 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. Second, the high relative persistence of low returns (relative to high returns) disappears once MRPK is adjusted for utilization. We cannot reject that the probability of remaining in the lowest tercile equals the probability of remaining in the highest tercile when we correct MRPKs for utilization. Firms hit by negative profitability shocks do not downsize, but hold their capital and decrease the intensity of utilization. Hence, their measured MRPK—based only on the size of the

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13See Appendix A.1 for details on the construction of firm-level depreciation and Appendix B.5 for the empirical results.

14See Appendix B.6 for a more detailed description of the construction of this variable and empirical results.

15Table B4 in Appendix B.6 reports the autocorrelation of MRPK, both unconditional and conditional on the current tercile of MRPK after the utilization adjustment (first column), and compares to baseline estimates (reproduced in the second column to facilitate comparison). We also perform this analysis using materials instead of energy consumption to proxy for utilization and find similar results.
capital stock—remains persistently low, whereas their adjusted MRPK—which accounts for energy consumption—increases faster, as the effective capital input shrinks through underutilization.\footnote{We discuss potential alternative explanations for asymmetric persistence in MRPK in Appendix B.7. We also perform a variance decomposition of MRPK to understand whether the persistence of MRPK is due to capital adjustment or profitability shocks. We find that for the bottom tercile, most of the changes in MRPK come from shocks to their value-added, rather than from capital adjustment, consistent with the importance of investment irreversibility. We also discuss the role of other distortions such as employment subsidies.}

### 3.3 Fact 3: Capital predicts survival, conditional on productivity

We now show that conditional on productivity, firms with higher capital are more likely to survive in their industry. 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,

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

(3)

and

$$z^*_j = \alpha + \beta_1 TFPR_j + \beta_2 k_j + \gamma_n + \gamma_t + \epsilon_{jnt}$$

(4)

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.\footnote{We use TFPR because we do not observe firm-level prices. Nonetheless, this regression gives as an informative reduced-form moment that we will match in our model (Section 5). Moreover, this specification is consistent with firm decision rules in our model: Under our assumptions, in particular CES demand, this regression is equivalent to a regression on capital and TFPQ, up to a constant multiplicative term.} 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.\footnote{Lee and Mukoyama (2015) provide evidence of an unconditional relationship between size (measured by employment) and exit in US manufacturing.} Conditional on capital level, unproductive firms are more likely to exit.

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 have a higher option value of staying in business. Thus, they are more likely to survive, conditional on their level of productivity. In contrast, many models of trade imply that
productivity is a sufficient statistic for survival.\footnote{Consistent with this literature, in Section 6 we demonstrate 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.}

Figure 2: Selection Effects of TFP and Capital Stock.

Notes: This figure represents a heat map of survival probabilities as a function of (log) capital stock on the x-axis and (log) TFPR on the y-axis. Darker colors denote higher survival probabilities.

**Capital composition, depreciation, and the role of capital for selection.** In order to link our findings on selection to investment irreversibility more directly, we leverage again our constructed measure of firm-level depreciation rates. If, conditional on productivity, firm size matters for survival due to investment irreversibility, the effect of capital on survival, relative to TFPR, should be more critical for low-capital depreciation firms. Firms holding fixed assets with high depreciation, in contrast, could downsize by letting their capital depreciate. Therefore, their option value of staying on the market should depend less on their capital stock.

We operationalize this intuition by estimating our prediction model for survival, now fully interacted with firm-level depreciation. Figure B9 in Appendix B.8 shows that there
is a negative relationship between the relative effect of capital stock on survival and firm-level depreciation rates. For firms holding high-depreciation assets, TFPR is relatively more important than capital stock in understanding selection. These results provide support for the role of investment irreversibility in explaining the negative slope of the isoprobabilities estimated in Figure 2. The complete set of results is in Table B7 in Appendix B.8.

3.4 Labor Reallocation

To conclude this section, we analyze the properties of labor reallocation. First, we compute the standard deviation of the (log) marginal revenue product of labor (MRPN). When we consider the whole sample and 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 literature, we find that returns from labor are substantially less dispersed than returns from capital.

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.9, we report the estimated transition matrix for the whole sample. We find evidence of the 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 suggest that firms face smaller frictions in the reallocation of labor than in the reallocation of capital, and the frictions that affect 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 Capital Reallocation

In this section, we present empirical evidence on how frictions in capital-reallocation shape the effects of trade shocks on domestic firms. First, we introduce China’s accession to the WTO as a significant 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/disinvestment), thus complementing the literature that focuses on labor-market effects of trade shocks (e.g., Autor, Dorn, and
Importantly, we find that firms’ responses depend crucially on their position in the distribution of capital and productivity.

We emphasize that the estimates in this section rely on cross-industry variation, as well as time variation, in import intensity, as is standard in the literature on trade shocks. Reflecting this feature, and different from our use of the evidence in Section 3, we will not be able to quantitatively compare the effects of trade shocks in the data and in our model of Section 5, which features a single manufacturing industry, hit by a single permanent shock. Nonetheless, the estimates of this section are consistent with the key mechanisms of the model along the intensive and extensive margins, and thus provide validation for our model results.

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. Since then, China’s exports of manufacturing products have grown more than sixfold.

This export expansion affected many destinations around the world, including Peru. From 1998 to 2008, Chinese import value increased by a factor of 15 and went from 3% to 15% of total Peruvian imports, with substantial heterogeneity across industries. By 2010, China effectively became Peru’s leading import partner.

At the same time, we find that China’s accession to the WTO did not immediately represent a significant exporting opportunity for the Peruvian manufacturing sector. As shown in Figure C1 of Appendix C.1, commodity-producing sectors in Peru, such as Forestry, Fishing, and Metal Ores, were the only ones that derived the most significant benefits of China’s trade liberalization. Meanwhile, most manufacturing industries—including our six selected ones—did not show any increase in exporting activity to China.

Moreover, in the short run, the shock did not significantly affect imports of raw materials or intermediate goods. For raw materials, even by 2010, China only represented 0.2% of total imports. In the case of intermediate goods, the leading import partner remained the...

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20 We do not observe such a massive inflow of Chinese goods in other Latin American countries that share a border with Peru. While these countries experience a substantial increase in Chinese import competition, this is less stark compared to the Peruvian economy.

21 Accension to the WTO also decreased tariffs on imports into China, given the requirements imposed on China by WTO members.
United States for all of the 2000s, while China only became one of the top five partners in 2006.\footnote{See Appendix C.2 for a detailed discussion.}

Considering these facts, we view China’s impact on Peruvian manufacturing as primarily an import competition shock. In particular, it represents a significantly negative profitability shock to Peruvian manufacturing firms, which may induce firm selection and factor reallocation, because of increased import competition.\footnote{While this is consistent with our empirical reading of how China’s accession to the WTO affected Peruvian firms, in other empirical settings, other channels, previously explored in the literature, could also be operative. In particular, trade shocks may enhance the export intensity of some industries, as it did with the soy, steel, and aluminum industries in the United States. The implications of a positive export shock are also worth exploring, but do not seem empirically relevant in the manufacturing industries of interest in Peru. We leave an exploration of the role of capital reallocation frictions for exporter dynamics for future research.}

Therefore, as introduced in Section 2, we will use the measure $ChComp_{nt}$ to capture import competition shocks to domestic manufacturing firms. Appendix C.3 contains the main summary statistics for this variable.

### 4.2 Effects of Trade Shocks on Selection and Investment

To understand the effects of a trade shock on firms’ decisions on exit and investment, we proceed in two steps. First, we examine the importance of Chinese competition for survival. Second, for continuing firms, we analyze the effect on firms’ investment decisions.

**Selection.** Conditional on productivity, does the level of capital matter for firm selection after a trade shock? To address this question, we re-estimate our prediction model for survival, fully interacted with our $ChComp_{nt}$ measure of import competition.

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 3. There, we plot a line corresponding to the set of levels of capital and productivity that give a probability of survival equal to 50% on average (solid line) and when firms face a 1 standard deviation import competition shock (dashed line).\footnote{Appendix C.4 presents the full specification, estimates used to generate these graphs, and specifications with alternative measures of import competition.}

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 the 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, but at odds with a model featuring free capital adjustment.

\[ z_{jnt} = \theta_0 + \theta_1 ChComp_{nt} + \eta X_{jnt} + \gamma_n + \gamma_t + \epsilon_{jnt} \]  

where \( z_{jnt} \) is only observed when

\[ z^*_{jnt} = \alpha_0 + \alpha_1 ChComp_{nt} + \sigma Y_{jnt} + \gamma_j + \gamma_t + \nu_{jnt} > 0. \]  

In equation 5, \( z_{jnt} \) are outcome variables such as the investment rate, \( X_{jnt} \) are controls such as employment, and \( \gamma_t \) and \( \gamma_n \) represent year and industry fixed effects, respectively.
In this specification, $Y_{jnt}$ are controls that include 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 2, 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).\(^{25}\)

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, an increase of 1 standard deviation in our trade shock measure approximately decreases the average growth rate of capital from 7.4% to 7.1%. This, in turn, drives a sizable response in the mobility of this set of firms in the MRPK distribution. In the second column, an increase of 1 standard deviation in our trade shock measure leads to a decrease in the average probability that a firm that starts in the first tercile will stay in the first tercile going into the next year from 82.4% to 79.4%. In contrast, firms in the other two terciles (third and fourth rows) do not exhibit any meaningful responses to the trade shock. Thus, when we estimate the effect of the import shock on the entire sample (as in the first row), the result becomes muted because the significant responses of the low-MPRK firms are countered by the weak responses of higher-MRPK firms.

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

$$z_{jnt} = \delta_0 + \delta_1 ChComp_{nt} + \delta_2 TFPR_{jnt} + \delta_3 k_{jnt} + \gamma_n + \epsilon_{jnt} \tag{7}$$

where $z_{jnt}$ are outcomes such as the size of the inaction region (probability of firms’ investment absolute value less than 10%), fraction of positive investment (probability of firms’ investment value larger than 10%), and negative investment (probability of firms’ investment value lower than -10%).\(^{25}\)

\[^{25}\text{In Appendix C.5, we present these regressions using alternative measures of import competition.}\]
Table 2: The Effect of a Trade Shock on Investment.

Results using our IV strategy are shown in Table 3. Consistent with our findings of weak effects of the trade shock on capital reallocation, the first column of Table 3 shows that the import competition shock increases the inaction region in the short run. This effect, in turn, comes entirely from a decrease in the positive investment region (second column), rather than from significant effects on the negative investment region (third column).

Table 3: The Effect of a Trade Shock on Investment (continued).

Similar to what we did in Section 3, we also use our firm-level depreciation measure to understand which type of firm accounts for these effects, as we interact \( ChComp_{nt} \) on equation 7 with firm-level depreciation rates. Consistent with the relevance of partial investment irreversibility, we find that results in Table 3 are mostly accounted for by firms with low depreciation rates. In particular, the effects on inaction and investment are considerably more muted for firms with fixed assets that depreciate faster. The full set of results is in Appendix C.6.
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. The model accounts for the key empirical patterns described above. We thus use it to study quantitatively the aggregate implications of a trade shock. We begin by describing the model in the 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:

\[ U_0 = \sum_{t=0}^{\infty} \beta^t (\log C_t - \chi N_t) \]  

(8)

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

\[ C_t = \left( \int_0^{M_t} c_{jt}^\theta d\theta \right)^\frac{1}{\theta} \]  

(9)

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

\[ \int_0^{M_t} p_{jt} c_{jt} d\theta = N_t + \Pi_t \]  

(10)

where we are normalizing the wage to 1, i.e. labor is the numeraire of our economy, and \( \Pi_t \) are aggregate dividends from ownership of all the firms in the economy.\(^{26}\)

\(^{26}\)We could also explicitly assume that the household can trade shares in 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.
We can define the CES price index associated with the consumption bundle $C_t$ as $P_t \equiv \left( \int_0^M p_j^{1-\epsilon} \right)^{1/\epsilon}$. Using this definition, we obtain the cost-minimizing demand schedule for each variety as

$$p_{jt} = c_{jt} \frac{1}{\epsilon} P_t C_t^{1/\epsilon}$$

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

The optimality condition for the consumption-leisure margin is $\chi C_t = \frac{1}{P_t}$, 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 $y_{jt} = s_{jt} k_{jt}^{\alpha} n_{jt}^{1-\alpha}$, 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 $F(s_{jt}, s_{jt+1})$.

Firms internalize the demand function (11) 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 the absence of international trade of manufacturing varieties), we get that for a given level of productivity and inputs, revenues are given by

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

We now introduce our key assumptions on capital adjustment. 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).\footnote{This assumption is motivated by the fact that Peru imports a substantial share of the investment goods employed in domestic production.} We assume that the domestic economy is small, in the sense that it takes the price of capital goods as given and 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.\footnote{We verify in our numerical solutions that there is never an excess supply of domestic used capital at price $q$, that is, demand for capital goods from investing firms is larger than the supply of used capital, implying that part of the investment takes place thanks to imports of new capital goods.}

Capital stock at the firm level evolves according to the following accumulation equation:

$$k_{j,t+1} = (1 - \delta) k_{j,t} + i_{j,t}$$ (13)

where $\delta \in (0, 1)$ is the constant depreciation parameter and $i_{j,t}$ 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 summarize the marginal cost of investment as follows

$$Q(i_{j,t}) = \begin{cases} Q, & \text{if } i_{j,t} \geq 0 \\ q, & \text{if } i_{j,t} < 0 \end{cases}$$ (14)

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.

$$\theta(1 - \alpha)P_t C_i^\frac{1}{\epsilon} s_j^{\theta} h_j^{\theta(1-\alpha)-1} = 1$$ (15)

This labor decision, for a given value of the state vector, determines the firm’s level of production through the production function and the firm’s output price through (11).

Each firm incurs an idiosyncratic fixed cost of operations $f_{j,t}$, denominated in units of labor, iid across time and firms, with distribution $G(f; s)$.\footnote{We allow the distribution of the fixed continuation cost to vary depending on productivity. As we discuss later, this assumption improves the model fit in our calibration exercise, but does not affect our key results.} 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 $Z$ be the aggregate state of the economy, to be fully specified below. Sales net of labor cost, after choosing the optimal level of labor input, are given by $\pi(k, s, Z) \equiv \max_n P(Z) C'(Z)^{\frac{1}{\epsilon}} s^{\theta} k^{\theta \alpha} n^{\theta(1-\alpha)} - n$. 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.

$$V^c(k, s, f, Z) = \max_{i,k'} \pi(k, s, Z) - f - Q(i) i + \beta \mathbb{E} \left[ \frac{C(Z)}{C(Z')} V(k', s', f', Z') | s, Z \right]$$ (16)
subject to the capital accumulation equation (13), $k' = (1 - \delta)k + i$, and the transition law for the aggregate state $Z' = \Gamma(Z)$. Notice that the continuation value in equation (16) discounts the future value using the household’s discount factor, because households own all manufacturing firms.

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

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

(17)

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,

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

(18)

The investment decision of continuing firms can be characterized by 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 distribution $G(f; s^e)$, 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

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

(19)

### 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 with 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: \( X_t = A^X N_t^X \), where \( A^X \) is a constant productivity parameter and \( N_t^X \) is labor employed in the commodity sector.\(^{30}\) These firms are also owned by the representative household. In equilibrium, we will have 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

We abstract from fully modeling the production structure of the foreign economy, as this does not appear to affect the key insights of the paper. In our initial stationary equilibrium, the foreign economy 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: 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

Our definition of recursive stationary equilibrium is standard. An equilibrium consists of a collection of household choices, firm value functions, aggregate price level, and a joint distribution of firm capital and productivity, such that households maximize utility, firms’ decisions are consistent with the Bellman equations introduced above, and the distribution of firms over individual state variables perpetuates itself. In the interest of space, we relegate a more detailed and formal definition to Appendix D.1.

\(^{30}\)It is possible to extend the model and allow for productive capital in this sector. However, we stress that many capital goods, especially equipment, are specific at the industry level. Moreover, production of commodities is geographically constrained, thus limiting reallocation of structures as well. Overall, reallocation of capital away from manufacturing industries, such as textile and apparel, and toward commodities production is unlikely to be a quantitatively important phenomenon, and for simplicity we abstract from it.
5.6 Trade Shock and Aggregate Dynamics

After the trade shock, the foreign economy sells varieties \([M_t, M^F_t]\) in the domestic market at exogenous price \(p^F_t\). We model this shock as an unexpected change that hits the economy in its stationary equilibrium. After the shock, the key aggregates move over time along a transition path that brings the economy to a different stationary equilibrium with manufacturing imports.

Along this 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, Bellman equations (16), (17), (18), (19) 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:

\[
C_t = \left( \int_0^{M_t} y^\theta j_{it} dj + \int_{M_t}^{M^F_t} c^\theta j_{it} dj \right)^{\frac{1}{\theta}}.
\]

(20)

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

\[
\int_0^{M_t} Q(i_{jt})i_{jt} dj + p^F_t \int_{M_t}^{M^F_t} c_{jt} dj = p^X X_t.
\]

(21)

6 Quantitative Analysis

In this section, we first discuss our calibration strategy. We then use the calibrated model to study the aggregate effects of a trade shock.

6.1 Calibration

We now describe our choices for parameter values, reported in Table 4. A period in our model coincides with a year, reflecting the frequency of our data. Our strategy is to impose standard values for preference parameters and to leverage our micro evidence on Peru’s manufacturing firms to inform a method-of-moments procedure that delivers the values of parameters related to technology and firm dynamics, using the stationary equilibrium of our model.
Preferences. We set the discount factor to induce a 4% interest rate, a standard value in the investment literature. The labor disutility parameter is chosen to obtain a level of aggregate hours worked approximately equal to one-third. We also borrow the value of the elasticity of substitution across varieties from the literature (e.g., Asker, Collard-Wexler, and De Loecker, 2014).

Technology and reallocation frictions. We 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 $\alpha$. Next, we set $\delta$ equal to the median firm-level depreciation rate. We set the price of new investment $Q$ goods equal to the aggregate manufacturing price level in the stationary equilibrium, consistent with the standard assumption in the real-business-cycles literature, and we normalize productivity in the commodity sector $A^X = 1$.

We parameterize idiosyncratic productivity as an AR(1) process in logs, and assume that the distribution of the fixed continuation (and entry) cost is uniform over the interval $[0, \eta_0(1 + (1 + s)^{\eta_1} - (1 + s)^{\eta_2})]$, where $s$ is the current realization of idiosyncratic productivity.\(^{31}\) Next, we use a method-of-moments procedure to jointly determine the values of $(\rho, \sigma, q, \zeta, \eta_0, \eta_1, \eta_2)$ to match the following key moments: (i) autocorrelation of TFPR; (ii) standard deviation of TFPR; (iii) frequency of negative investment; (iv) slope of survival isoprobability lines; (v) exit rate; (vi) average capital stock of exiting firms (relative to continuing firms); and (vii) average TFPR of exiting firms (relative to continuing firms).\(^{32}\) This procedure ensures that the stationary equilibrium of the model is aligned with the key empirical facts about capital reallocation on both the intensive and extensive margins. The numerical targets we match are reported in Table D1 in Appendix D.2.

The estimated degree of irreversibility for continuing firms, $1 - \frac{Q}{Q}$, is 0.58, meaning that firms lose over half of the value of their used capital when they downsize. When firms exit, they lose an additional 17%. These values for the resale loss are somewhat larger than existing estimates of irreversibility for the U.S. (e.g., Bloom, 2009), and are thus consistent

\(^{31}\)The flexible and non linear dependence of the upper bound of the distribution on productivity $s$ helps us match the slope of the survival isoprobability lines jointly with the key characteristics of exiting firms. However, we emphasize that this functional form is not key for the mechanisms described below. Indeed, in Appendix D.7, we report the key results from a simplified version of the model, in which the distribution of $f$ is independent of $s$.

\(^{32}\)As far as the idiosyncratic productivity process is concerned, we target the properties of residualized TFPR after controlling for industry and time fixed effects. We include these moments in our method-of-moments procedure, to account for the effect of endogenous firm selection on the distribution of measured productivity. We thank Yan Bai for this helpful suggestion.
with the presence of large frictions in our empirical setting.

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Table 4: Parameter Values.

6.2 Key Properties of the Stationary Equilibrium

We now describe the key properties of the stationary equilibrium. First, we illustrate firms’ decision rules and then report the key statistics implied by the equilibrium of the model. In Figure 4a, 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 threshold, 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 the fact 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 the presence of this friction, firms with larger capital stock find it more costly to downsize and exit. Furthermore, the option value of staying in business, hoping for a positive idiosyncratic shock, is larger for firms with a high level of capital. For the purpose of comparison, Figure 4b 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, the 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.

![Figure 4: Thresholds for Investment, Disinvestment, and Exit.](image)

Notes: The left panel (a) displays the thresholds for exit (solid blue line), positive investment (dashed red), and negative investment (dashed-dotted yellow) as functions of capital (x-axis) and productivity (y-axis) in the baseline model. The right panel (b) displays the exit threshold (solid blue) and investment/disinvestment threshold in the frictionless model.

We now move to a brief discussion of the key statistics implied by the model and compare them with 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 5 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.\footnote{The overall degree of persistence of MRPK is somewhat lower in the model than in the data. In Section 6.6 we discuss an extension that deals with this issue by adding further reallocation frictions.} 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, 1.28 in the baseline, and 1.09 in the comparison).

<table>
<thead>
<tr>
<th>Tercile at $t$</th>
<th>Tercile at $t + 1$</th>
<th>Tercile at $t + 1$</th>
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<tr>
<td>3</td>
<td>0.16 0.35 0.50</td>
<td>3 0.33 0.33 0.33</td>
</tr>
</tbody>
</table>

(a) Baseline Model (b) Frictionless Model

Table 5: 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 and asymmetrically persistent, and selection is driven by both productivity and capital level. All of these properties are induced by partial investment irreversibility.\footnote{In Appendix D.4, we compare the key aggregate variables in our model with their counterpart in the frictionless model without irreversibility (Table D2). We find that the degree of irreversibility consistent with our calibration strategy induces large differences between the two economies considered. In particular, the aggregate capital stock in our baseline model is less than half of its frictionless counterpart, largely because firms are afraid to expand and later lose a large fraction of their value if they need to downsize.}

6.3 Long-run Effects of Import Competition

We parameterize the trade shock (i.e., the number of additional varieties $M^F - M$ and their price $p^F$) to match the (long-term) import penetration of Chinese goods in Peru and the relative price of Chinese imports (relative to domestic goods). The 2014 import penetration of China in Peru is approximately 10%. Over the period 2001-2014, the price index of Chinese manufacturing goods in Peru averages approximately one half the price of domestically produced manufacturing goods.\footnote{We use Peruvian firms’ export prices to proxy for the price of domestic goods.}
We first compute the final steady state with trade and compare key aggregates of interest in Table 6. The first column lists the key aggregate variables: consumption, capital, hours worked in manufacturing, the mass of active firms, and average TFPQ. The second column reports the percentage change in the steady-state after the trade shock, relative to the initial steady state. Consumption increases by 0.68%, which—given our assumed preferences—implies an equal decline in the price level. Capital stock, hours in manufacturing, and mass of domestic active firms decrease by approximately 10%. This large decline is primarily driven by increased competition for domestic manufacturers and substitution toward imported varieties. Because of improved selection, the average productivity of firms increases. This selection effect arises because in the long run, the fall in the price level leads primarily to the exit of lower-productivity firms.

<table>
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<th>Variable</th>
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<tr>
<td>$C$</td>
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</tr>
<tr>
<td>$K$</td>
<td>-10.8%</td>
</tr>
<tr>
<td>$N$ (manuf.)</td>
<td>-9.96%</td>
</tr>
<tr>
<td>$M$</td>
<td>-9.45%</td>
</tr>
<tr>
<td>$TFPQ$ (average)</td>
<td>1.28%</td>
</tr>
</tbody>
</table>

Table 6: Steady-state Comparison: Before and After Trade Shock.

6.4 Aggregate Transitional Dynamics

We now study the equilibrium transition path that takes the economy from the initial steady state to the final one. Appendix D.3 describes our solution method, which explicitly keeps track of the joint distribution of firm capital and productivity. We find that convergence to the final steady state takes approximately 20 years. Although the shock is a sudden and permanent change in the set of varieties available to domestic consumers, and the price of imported varieties is constant over time, import penetration is increasing over time, from around 8% on impact to around 10% when the economy converges to its new steady state.

General-equilibrium forces (i.e., consumption smoothing) slow the investment and real-location response of domestic manufacturing.\textsuperscript{36} Figure 5 displays the transitional dynamics.

\textsuperscript{36}The path of import penetration over time is displayed in Figure D1 in Appendix D.4.
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 overshoots its long-run value, and then gradually recovers as the domestic industry downsizes to adjust to the new competitive environment. At the same time, investment falls, leading to a decline in the aggregate level of capital. Accordingly, both the labor input employed in manufacturing and the mass of active firms decline as workers reallocate toward the commodity sector.

6.5 Selection, Reallocation, and Productivity

Next, we focus on the effects of the trade shock on firm dynamics and aggregate productivity. In Figure 6, we show the exit thresholds associated with drawing an average value of the fixed cost, under both 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. Some productive but small firms, that did not grow because of their fear of incurring a largely irreversible investment, choose to exit the industry. In contrast, productivity is the only determinant of exit in the comparison model.
Figure 5: Aggregate Dynamics After the Trade Shock.

Notes: This figure displays the transitional dynamics of the price index of manufacturing varieties (a), aggregate capital stock (b), labor employed in manufacturing (c), and mass of active manufacturing firms (d). The trade shock hits the economy in period 1. The y-axes of all panels report percentage changes relative to the initial stationary equilibrium.
These patterns of selection are consistent with our empirical findings (see Figure 2) and affect the short-term response of aggregate productivity to the trade shock. In Figure 7, we plot the dynamic response of the average productivity of active firms (i.e., average firm TFPQ), in both the baseline model (solid blue line) and in the comparison model (dashed red line). Especially in the short and medium run, the model with partial irreversibility induces a lower gain in average TFPQ relative to the comparison model. This slow adjustment of average productivity arises because the trade shock drives out smaller but highly productive firms in our baseline model, whereas these firms would survive in the frictionless model. Furthermore, we show that in the frictionless model the convergence of average productivity is nearly immediate. On the other hand, in the presence of capital-reallocation frictions, the half-life of the transition of this variable is approximately equal to 5 years. In the long run, we find that average productivity increases by 1.2%, and the initial effect is less than one half the long-run effect.
Figure 7: Average Firm Productivity After the Trade Shock.

Notes: This figure displays the transitional dynamics of average firm productivity \( s \) in the baseline model (solid blue line) and in the frictionless model (dashed red). The trade shock hits the economy in period 1. The y-axis reports percentage changes relative to the initial stationary equilibrium.

Moving on to the response of the intensive margin of capital reallocation, Figure 8 displays the thresholds for positive and negative investment before and immediately after the trade shock hits the economy (solid and dashed lines, respectively). The large drop in the price level for manufacturing goods, combined with expectations of its increase as the economy adjusts, implies that even relatively productive firms decide to postpone their investment decisions; this leads to a wider inaction region after the shock hits the economy. Consistent with our empirical evidence, this shift is more pronounced on the positive investment margin.\(^{37}\)

\[\text{Footnote 37: Our assumption of a constant resale price of capital is likely to understate the magnitude of this effect of the trade shock on the size of the inaction region. In a model with an equilibrium price of used capital, Lanteri (2018) shows that a negative aggregate (productivity) shock leads to a widening of the inaction region because the relative price of used capital drops. This renders investment endogenously more irreversible, because many firms desire to downsize at the same time.}\]
Figure 8: Thresholds for Investment and Disinvestment Before the Trade Shock and on Impact.

Notes: This figure displays the effect of the trade shock on investment and disinvestment thresholds in the baseline model. The solid lines refer to the initial stationary equilibrium \((t = 0)\). The dashed lines refer to the period in which the trade shock hits \((t = 1)\). The x-axis reports capital and the y-axis reports productivity.

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; we illustrate these in Figure 9 by reporting the dynamic responses of two measures of “misallocation”. In Figure 9a, we report the change in the cross-sectional standard deviation of MRPK, while in Figure 9b we plot the ratio of aggregate TFPQ in our baseline model to that in the frictionless model, i.e., an inverse measure of the aggregate efficiency wedge induced by capital-reallocation frictions.

Figure 9a 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, equal to approximately 0.5 percentage points; in contrast, the dispersion of MRPK is almost unaffected by the shock in the frictionless model.

Figure 9b shows that aggregate TFPQ rises faster in the frictionless model than in the baseline model, especially in the short run, which leads to an initial fall in the ratio (equal to approximately 0.5 percentage points). Hence, we find that the trade shock increases the
efficiency wedge between the two models in the short run. In the long run, however, we find that the ratio actually rises above the initial steady state.

![Image](image_url)

(a) Standard deviation of MRPK
(b) Aggregate TFPQ: ratio between baseline and frictionless model

Figure 9: MRPK Dispersion and Aggregate Productivity.

*Notes:* The left panel (a) displays the path of the dispersion of MRPK over time, in the baseline model (solid blue line) and in the frictionless model (dashed red). The right panel (b) displays the path of the ratio between aggregate productivity (TFPQ) in the baseline model and in the frictionless model. The y-axes report percentage changes relative to the initial stationary equilibrium.

We conclude this section by briefly discussing the welfare effects of the trade shock in our model.\(^{38}\) We find that accounting for transitional dynamics leads to welfare gains from trade equal to approximately 0.4% of permanent consumption. A simple steady-state comparison, in our dynamic model with capital, would misleadingly suggest welfare losses. To better understand the importance of accounting for the transition, recall that after the trade shock, consumption initially overshoots its long-term value as consumers benefit from the favorable terms of trade induced by cheap manufacturing and a constant price of exported commodities.\(^{39}\) However, we also find that this short-term gain is more muted under our baseline calibration relative to a frictionless model, because of the sluggish productivity gains. Quantitatively, capital-reallocation frictions decrease the welfare gain from the trade shock by approximately 25%.

\(^{38}\)These results are reported in more detail in Appendix D.4.

\(^{39}\)The overshooting result and its welfare implications appear to be consistent with the recent analysis of Alessandria, Choi, and Ruhl (2018).
6.6 Further Analyses and Sensitivity

We now briefly describe some counterfactuals and extensions of our quantitative analysis. In the interest of space, we relegate a more detailed presentation of these results to the appendix.

Decomposition of GE forces. To assess the role of general-equilibrium forces, we also compute the transitional dynamics assuming that firms discount profits with a constant interest rate, while still imposing market clearing in the output market. This analysis may also be useful for thinking about import competition in a small-open-economy benchmark. We find qualitatively similar patterns, with some noticeable differences. First, in the absence of an equilibrium response (decline) of the interest rate, the selection effect and widening of the inaction region are even more pronounced. Second, convergence of the aggregate capital stock to the new stationary equilibrium is faster, consistent with standard results on neoclassical growth models (see Appendix D.5).

Convex adjustment costs and MRPK persistence. Our baseline calibration did not target the transition matrix of MRPK. Instead, we used the asymmetric persistence of MRPK as an untargeted moment and argued that our model is broadly consistent with the empirical patterns, although it understates the overall persistence of MRPK. We investigate the possibility that additional frictions in capital reallocation may contribute to explain the gap in MRPK persistence between data and baseline model. Specifically, we solve a version of our model with convex (quadratic) capital adjustment costs, as well as partial irreversibility. We find that convex costs can substantially increase overall MRPK persistence. For instance, we get that the probability of staying in the bottom tercile increases from 0.61 to 0.73. However, we cannot account for the whole degree of persistence in the data. We also verify that additional frictions in capital adjustment increase the persistence of MRPK, without affecting the key role of partial irreversibility in delivering asymmetry in persistence (see Appendix D.6). Finally, we simulate the trade shock in this version of the model and obtain qualitative patterns similar to our baseline calibration.

Restriction on the fixed-cost distribution. Our baseline parameterization assumed that the distribution of the fixed continuation cost $f$ depended on the level of firm productivity $s$. We now investigate a version of the model in which the distribution of $f$ is independent of $s$. In order to do so, we maintain our estimated parameters, but restrict $\eta_1 = \eta_2 = 0$. We find that the model fit worsens, particularly as far as the moments related

\footnote{For simplicity, we do not recalibrate the other frictions and maintain our estimated parameter values.}
to exiting firms (see Appendix D.7). Nonetheless, the effects of the trade shock are similar to those that we obtain with our baseline calibration. Specifically, we obtain a slow convergence of average productivity, as well as an initial spike in inaction and thus in dispersion of MRPK.

7 Conclusions

This paper takes a first step in bridging the quantitative macro literature on investment and firm heterogeneity with the empirical literature on the effects of international trade. We focus on the short- and medium-term effects of import competition shocks, and combine micro data and a model to show that capital-reallocation frictions play a key role in shaping the equilibrium dynamics.

Capital reallocation is costly, particularly in manufacturing, where capital is more likely to be specific at the firm and industry levels. This friction induces dispersion in MRPK and slows 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 several years to reach a new stationary equilibrium with higher aggregate productivity. Meanwhile, short-run dynamics feature sluggish improvements in the selection of active firms, a spike in inaction, increased dispersion in returns from capital, and a larger efficiency wedge relative to a frictionless economy.
References


BROOKS, W., AND A. DOVIS (Forthcoming): “Credit Market Frictions and Trade Liberalization,” *Journal of Monetary Economics*.


A Data and Measurement

A.1 Firm-level Depreciation

To construct firm-level depreciation rates we proceed as follows. First, for each firm $i$ and year $t$, we construct the share $S_{i,t,l}$ 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:

$$\delta_{i,t} = \sum_l S_{i,t,l} \delta_{l,t} \quad (A1)$$

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 A1 provides further details on the distribution of average depreciation rates.
Figure A1: Distribution of Imputed Firm-level Depreciation Rates.

Notes: This figure is a histogram of firm-level depreciation rates.
B Additional Evidence on MRPKs

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. 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 of 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 with associated MRPK dispersions and TFPR volatility. The solid line is generated by a (weighted) OLS regression with a slope of 0.48 (0.01).
B.2 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 B2 and Table B1. 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 \( \delta \) to 11%, which corresponds to the average depreciation rate faced by firms in the survey. Section 2 in the main text and Appendix A.1 provide more details on how the firm level depreciation rates are constructed, and report the distribution and characteristics of our constructed depreciation rates.

![Distribution of Investment Rates](image)

Figure B2: Distribution of Investment Rates.

*Notes: This figure is a histogram of firm-level investment rates. The distribution is winsorized at the 5th and 95th percentile.*
<table>
<thead>
<tr>
<th>Industry</th>
<th>Food</th>
<th>Textiles</th>
<th>Apparel</th>
<th>Recorded media</th>
<th>Chemical</th>
<th>Machinery</th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.429</td>
<td>0.389</td>
<td>0.487</td>
<td>0.435</td>
<td>0.336</td>
<td>0.501</td>
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<td>Median</td>
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<td>0.159</td>
<td>0.188</td>
<td>0.169</td>
<td>0.158</td>
<td>0.170</td>
</tr>
<tr>
<td>s.d.</td>
<td>0.868</td>
<td>0.778</td>
<td>0.917</td>
<td>0.870</td>
<td>0.685</td>
<td>0.941</td>
</tr>
<tr>
<td>Fraction ≤ 0</td>
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<td>0.085</td>
<td>0.121</td>
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<td>0.110</td>
<td>0.123</td>
</tr>
<tr>
<td>$E[I^L/I^K &lt; 0]$</td>
<td>-0.214</td>
<td>-0.164</td>
<td>-0.207</td>
<td>-0.213</td>
<td>-0.179</td>
<td>-0.208</td>
</tr>
<tr>
<td>Inaction (5%)</td>
<td>0.054</td>
<td>0.052</td>
<td>0.044</td>
<td>0.045</td>
<td>0.083</td>
<td>0.073</td>
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<td>Inaction (10%)</td>
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<td>0.188</td>
<td>0.175</td>
<td>0.142</td>
<td>0.227</td>
<td>0.196</td>
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<tr>
<td>Inaction (20%)</td>
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<td>0.573</td>
<td>0.467</td>
<td>0.495</td>
<td>0.558</td>
<td>0.482</td>
</tr>
</tbody>
</table>

Table B1: Summary Statistics of the Distribution of Investment Rates.
B.3 Dynamics of MRPK: Non-Parametric Estimation

In this section, we report the non-parametric estimation of MRPK mobility described in the main text, at the industry level.

![Persistence of Relative Rankings of MRPK Distribution](image)

Figure B3: Persistence of Relative Rankings of MRPK Distribution.

*Notes:* This figure shows the probabilities of staying in the same origin tercile by industry. Circles represent probability of staying conditional on being on the first tercile, and diamonds conditional on being on the third tercile of MRPK distribution. Confidence intervals are shown at the 95% significance.

B.4 Dynamics of MRPK: Transition Matrices

In this section, we report the full transition matrices of MRPK by industry, and also allowing for exit as an additional transition.
### B.4.1 MRPK Transitions: Benchmark

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<th>3</th>
<th></th>
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<th>2</th>
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<tr>
<td>(a) Food</td>
<td></td>
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<td>(b) Textiles</td>
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<td></td>
</tr>
<tr>
<td>(c) Apparel</td>
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<td>(d) Printing</td>
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Table B2: Transition Matrices of MRPK.
B.4.2 MRPK Transitions: Including exit

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<tr>
<td></td>
<td>(0.00)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td></td>
</tr>
</tbody>
</table>

Table B3: Transition probabilities of MRPK. Standard errors in parentheses.

B.5 Firm-level Depreciation and Persistence

We estimate the impact of capital depreciation rates on the persistence of a firm’s MRPKs by estimating the following probit model:

\[
I_{i,j,t}(q' = q) = \begin{cases} 
0 & \text{if } Y_{i,j,t} < 0 \\
1 & \text{if } Y_{i,j,t} \geq 0
\end{cases}
\]  

(B1)

\[
Y_{i,j,t} = a + \eta \delta_{i,t} + \theta X_{i,t} + \gamma_j + \gamma_t + \epsilon_{i,j,t}
\]  

(B2)

where \(I_{i,j,t}(q' = q)\) 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 \(t + 1\), \(\eta\) 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), \(\gamma_j\) is an industry fixed effect, and \(\gamma_t\) 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 the Persistence of Low MRPKs.

Notes: This figure shows the average marginal effect of firm-level depreciation rates on the probability of staying on the current rank for firms on the first tercile of the MRPK distribution.

B.6 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 estimate the following equation with the corrected measure of MRPK.

$$\log MRPK_{jnt} = \alpha + \sum_{q \in \{1,2,3\}} (\rho_q \log MRPK_{jnt-1} \times \mathcal{I}_{jnt-1,q}) + \gamma_n + \gamma_t + \epsilon_{jnt} \quad (B3)$$

Table B4 shows the results.
<table>
<thead>
<tr>
<th>Variables</th>
<th>MPRK (utilization adjusted)</th>
<th>MRPK</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho$ (no interaction)</td>
<td>0.744</td>
<td>0.742</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>$\rho_1$ (1st tercile MRPK)</td>
<td>0.619</td>
<td>0.843</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>$\rho_2$ (2nd tercile MRPK)</td>
<td>0.731</td>
<td>0.641</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.025)</td>
</tr>
<tr>
<td>$\rho_3$ (3rd tercile MRPK)</td>
<td>0.735</td>
<td>0.546</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.050)</td>
</tr>
</tbody>
</table>

Table B4: Persistence of MRPK and Capital Utilization.

We also compute the MRPK transition matrices by industry using the corrected measure of MRPK and we found no evidence of higher persistence on the first tercile.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.690</td>
<td>0.211</td>
<td>0.060</td>
<td>1</td>
<td>0.680</td>
</tr>
<tr>
<td>2</td>
<td>0.244</td>
<td>0.626</td>
<td>0.206</td>
<td>2</td>
<td>0.267</td>
</tr>
<tr>
<td>3</td>
<td>0.065</td>
<td>0.162</td>
<td>0.733</td>
<td>3</td>
<td>0.053</td>
</tr>
</tbody>
</table>

(a) Food

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.658</td>
<td>0.232</td>
<td>0.042</td>
<td>1</td>
<td>0.708</td>
</tr>
<tr>
<td>2</td>
<td>0.264</td>
<td>0.515</td>
<td>0.233</td>
<td>2</td>
<td>0.249</td>
</tr>
<tr>
<td>3</td>
<td>0.078</td>
<td>0.253</td>
<td>0.725</td>
<td>3</td>
<td>0.043</td>
</tr>
</tbody>
</table>

(b) Textiles

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.770</td>
<td>0.151</td>
<td>0.023</td>
<td>1</td>
<td>0.725</td>
</tr>
<tr>
<td>2</td>
<td>0.205</td>
<td>0.688</td>
<td>0.146</td>
<td>2</td>
<td>0.210</td>
</tr>
<tr>
<td>3</td>
<td>0.026</td>
<td>0.161</td>
<td>0.831</td>
<td>3</td>
<td>0.065</td>
</tr>
</tbody>
</table>

(c) Apparel

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.670</td>
<td>0.274</td>
<td>0.052</td>
<td>1</td>
<td>0.685</td>
</tr>
<tr>
<td>2</td>
<td>0.247</td>
<td>0.613</td>
<td>0.140</td>
<td>2</td>
<td>0.257</td>
</tr>
<tr>
<td>3</td>
<td>0.083</td>
<td>0.155</td>
<td>0.762</td>
<td>3</td>
<td>0.065</td>
</tr>
</tbody>
</table>

(d) Printing

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.725</td>
<td>0.168</td>
<td>0.029</td>
<td>1</td>
<td>0.725</td>
</tr>
<tr>
<td>2</td>
<td>0.210</td>
<td>0.687</td>
<td>0.202</td>
<td>2</td>
<td>0.210</td>
</tr>
<tr>
<td>3</td>
<td>0.065</td>
<td>0.145</td>
<td>0.769</td>
<td>3</td>
<td>0.065</td>
</tr>
</tbody>
</table>

(e) Chemicals

Table B5: Transition Matrices of Utilization Correction MRPK.
B.7 Drivers of MRPK Persistence

B.7.1 Variance Decomposition of MRPK Changes

Here, we first provide further evidence that the asymmetric persistence of MRPK is driven by a small disinvestment response to negative profitability shocks. We do this via a simple variance decomposition approach.

Recall that under our assumptions,

\[
\log MRPK_t = \log(\alpha \theta) - \log(k_t) + \log(p_t y_t) \tag{B4}
\]

\[
\Rightarrow \log(\frac{MRPK_{t+1}}{MRPK_t}) = \log(\frac{k_{t+1}}{k_t}) + \log(\frac{p_{t+1}y_{t+1}}{p_t y_t}) \tag{B5}
\]

\[
\Rightarrow \text{var}(\log(\frac{MRPK_{t+1}}{MRPK_t})) = \text{var}(\log(\frac{k_{t+1}}{k_t})) + \text{var}(\log(\frac{p_{t+1}y_{t+1}}{p_t y_t})) + \text{cov}(\log(\frac{k_{t+1}}{k_t}), \log(\frac{p_{t+1}y_{t+1}}{p_t y_t})) \tag{B6}
\]

That is, the growth rate of MRPK can be decomposed into a component that comes from the choice of capital (i.e. \(k_{t+1}\)), and a component that arises from a shock to value added tomorrow (i.e. \(p_{t+1}y_{t+1}\)). This decomposition is reflected in Table B6. Moreover, this also implies that \textit{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.

<table>
<thead>
<tr>
<th></th>
<th>First Tercile</th>
<th>Third Tercile</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{var}(\log(\frac{k_{t+1}}{k_t})))</td>
<td>0.13</td>
<td>0.85</td>
</tr>
<tr>
<td>(\text{var}(\log(\frac{p_{t+1}y_{t+1}}{p_t y_t})))</td>
<td>0.53</td>
<td>0.43</td>
</tr>
<tr>
<td>(\text{cov}(\log(\frac{k_{t+1}}{k_t}), \log(\frac{p_{t+1}y_{t+1}}{p_t y_t})))</td>
<td>0.05</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Table B6: 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). 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 plot the kernel density estimates of the growth rates of capital and TFPR for firms that stayed in their current tercile, or switched out of their current tercile. For low-MRPK firms, we see in Panel (a) of Figure B5 that there is almost 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.

Figure B5: Distribution of $\log(\frac{k_{t+1}}{k_t})$ for First and Third Terciles.

Notes: This figure shows the estimated kernel density of (log) growth rates of capital for firms in the first- and third-tercile of the MRPK distribution. Solid lines represent the growth rates of those who stay in the same tercile next year, while dashed lines refer to capital growth rate of firms switching terciles. Dashed black vertical line refers to the mean of the distribution.
Figure B6: Distribution of $\log(\frac{TFPR_{t+1}}{TFPR_t})$ for First and Third Terciles

Notes: This figure shows the estimated kernel density of (log) growth rates of TFPR for firms in the first- and third-tercile of the MRPK distribution. Solid lines represent the growth rates of those who stay in the same tercile next year, while dashed lines refer to TFPR growth rate of firms switching terciles. Dashed black vertical line refers to the mean of the distribution.

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 Asymmetric TFPR Persistence?**

One natural question is whether the asymmetric persistence of MRPK is driven by asymmetric TFP shocks. It is worth highlighting that the persistence of TFPR has no impact on the persistence of MRPK if firms can easily adjust their capital stock.\(^{41}\) However, given that we argue that reallocation frictions are likely to be sizable, we also estimate 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 more persistent in the right tail.

\(^{41}\)Tan (2018) proves this result.
Figure B7: Left and Right Tail Persistence of TFPR.

Notes: This figure shows the probabilities of staying in the same tercile, by industry. Circles represent probability of staying conditional on being on the first tercile, and diamonds conditional on being on the third tercile of TFPR distribution. Confidence intervals are shown at the 95% significance.

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 employment subsidies are unlikely to explain our findings.
Figure B8: Effect of Firm Size by Employment on Tail Persistence.

Notes: This figure shows the elasticity of staying in the same tercile of MRPK with respect to employment, by firm size. Circles represent probability of staying conditional on being on the first tercile, and diamonds conditional on being on the third tercile of MRPK distribution. Confidence intervals are shown at the 95% significance.

B.8 Capital Composition, Depreciation and the Selection

We estimate the following specification,

$$ Survival_{jnt,t+1} = \begin{cases} 1 & \text{if } z^*_{jnt} > 0 \\ 0 & \text{otherwise} \end{cases} $$  \hspace{1cm} (B7)$$

and

$$ z^*_{jnt} = \alpha + \beta_1 TFPR_{jnt} + \beta_2 k_{jnt} + \beta_3 \delta_{jnt} + \beta_4 TFPR_{jnt} \times \delta_{jnt} + \beta_5 k_{jnt} \times \delta_{jnt} + \gamma_n + \gamma_t + \epsilon_{jnt} $$ \hspace{1cm} (B8)

with the results presented in Table B7. While the additional effect of firm-level depreciation rates on capital is negative and statistically-significant, the one on TFPR is not statistically different from zero. Moreover, the average marginal effect of capital level on the probability of staying is plotted in Figure B9.
<table>
<thead>
<tr>
<th></th>
<th>Prob Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFPR&lt;sub&gt;jt&lt;/sub&gt;</td>
<td>0.304***</td>
</tr>
<tr>
<td></td>
<td>(0.039)</td>
</tr>
<tr>
<td>K&lt;sub&gt;jt&lt;/sub&gt;</td>
<td>0.216***</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
</tr>
<tr>
<td>δ&lt;sub&gt;jt&lt;/sub&gt;</td>
<td>3.981</td>
</tr>
<tr>
<td></td>
<td>(3.346)</td>
</tr>
<tr>
<td>TFPR&lt;sub&gt;jt&lt;/sub&gt; * δ&lt;sub&gt;jt&lt;/sub&gt;</td>
<td>-0.076</td>
</tr>
<tr>
<td></td>
<td>(0.328)</td>
</tr>
<tr>
<td>K&lt;sub&gt;jt&lt;/sub&gt; * δ&lt;sub&gt;jt&lt;/sub&gt;</td>
<td>-0.246*</td>
</tr>
<tr>
<td></td>
<td>(0.145)</td>
</tr>
<tr>
<td>Pseudo R-Squared</td>
<td>0.19</td>
</tr>
<tr>
<td>N. Obs</td>
<td>12393</td>
</tr>
</tbody>
</table>

Table B7: The Effect of Capital on Survival by Depreciation Rates.
Figure B9: The Effect of Capital on Survival by Depreciation Rates.

Notes: This figure shows the average marginal effect of (log) capital stock on the probability of staying on the current rank for firms on with bundles of capital of different depreciation rates.

B.9 Labor Reallocation

In Table B8, we show our estimated transition probabilities for terciles of MRPN. We find no evidence of asymmetry in the persistence of MRPN.
<table>
<thead>
<tr>
<th>Tercile at t</th>
<th>at t + 1</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.71</td>
<td>0.22</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.00)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.25</td>
<td>0.59</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.06</td>
<td>0.24</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td></td>
</tr>
</tbody>
</table>

Table B8: Transition Probabilities of MRPN. Standard Errors in Parentheses.
C Effect of Trade Shock: Details and Robustness

C.1 Export Behavior

One potential effect of China’s WTO accession on the Peruvian manufacturing industry is the increase in market access. To understand this impact, Figure C1 shows the share of Peruvian exports to China relative to total Peruvian exports at the 2-digit industry level during the period 1998-2016. As shown, China opened a big market but only to some industries. The industries that substantially expanded their exports to China are mostly in the commodity sector. In particular, these are forestry, fishing, metal ores. It is not the case for out manufacturing industries of interest. Most of them did not see any increase in exports to China.

These facts inform our modeling decisions in Section 5. In particular, the assumptions by which the manufacturing sector does not export while the outside-good sector will be produced domestically and only exported, as Peruvian commodities.

Figure C1: Export Intensity to China.

Notes: This figure shows the export intensity of Peruvian goods to China by 2-digit industries.
C.2 Import of Raw Materials and Intermediate Goods

Another potential channel through which China’s WTO accession could benefit domestic firms is the access to cheaper raw materials or intermediate goods. We use data from WITS to examine what are the main import partners of Peru of these product groups and show the share of Chinese imports by product group and the ranking of China as an import partner.

Table C1 shows this. As shown, for raw materials, China only represents 0.2% of total imports by 2010 and occupies the 18th place in the import partner ranking. In the case of intermediate goods, China does gain more room over the years, but the increase in importance is not immediate. Table C1 shows that in 2002, China was 7th on the ranking, with only 4.4% of import shares. By 2005, this percentage increased to 7.0% and China rose as the sixth leading import partner. However, it is only by 2011, that China becomes the leading import partner of Peru in this product group. While important, in the short-run, the impact of the increase in imported inputs is relatively muted compared to the fast increase in imports of final goods.

<table>
<thead>
<tr>
<th>Year</th>
<th>Raw Materials</th>
<th>China</th>
<th>Ranking</th>
<th>Intermediate Goods</th>
<th>China</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>0.9%</td>
<td>10</td>
<td>10</td>
<td>3.0%</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>2002</td>
<td>0.1%</td>
<td>17</td>
<td>7</td>
<td>4.4%</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>2005</td>
<td>0.1%</td>
<td>19</td>
<td>6</td>
<td>7.0%</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>2010</td>
<td>0.3%</td>
<td>18</td>
<td>2</td>
<td>15.0%</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2015</td>
<td>0.5%</td>
<td>16</td>
<td>1</td>
<td>21.0%</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Table C1: Import Intensity in Raw Materials and Intermediate Goods.

C.3 Import Competition Shock

In table C2, we summarize the two main measures of the trade shock, previously described in Section 2. \( \text{ImpInt}_{nt} \) is the share on total imports of goods originated in China, by 4-digit CIIU Rev 3 industry codes. \( \text{ChComp}_{nt} \) is our preferred measure and refers to the deviation from import intensity trends by 2-digit industry.
<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChComp(_{nt})</td>
<td>0.00</td>
<td>0.12</td>
<td>-0.59</td>
<td>0.39</td>
</tr>
<tr>
<td>ImpPen(_{nt})</td>
<td>0.21</td>
<td>0.23</td>
<td>0.00</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Table C2: Import Competition Shock.

C.4 Extensive Margin Effects

In this section, we estimate the following probit specification,

\[
Survival_{jnt,t+1} = \begin{cases} 
1 & \text{if } z_{jnt}^* > 0 \\
0 & \text{otherwise}
\end{cases}
\]  

(C1)

and

\[
z_{jnt}^* = \beta_0 + \beta_1 ChComp_{nt} + \beta_2 TFPR_{jnt} + \beta_3 ChComp_{nt} \ast TFPR_{jnt} \\
+ \beta_4 k_{jnt} + \beta_5 ChComp_{nt} \ast k_{jnt} + \eta X_{jnt} + \gamma_n + \gamma_t + \epsilon_{jnt}
\]  

(C2)

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, \( k_{jnt} \). \( \gamma_t \) and \( \gamma_n \), represent year and industry fixed effects, respectively. \( \beta_1 \) gives the direct impact of an import competition shock on survival, while \( \beta_3 \text{ and } \beta_5 \) allow for the differentiated effects of the shock by level of productivity and capital stock.

We provide the point estimates for equation C2. Columns 1 and 2 use as import competition shock the level of Chinese import penetration by industry, \( ImpInt_{nt} \), while Columns 3 and 4 use as import competition shock the deviations from trend of import penetration, \( ChComp_{nt} \). Columns 1 and 3 report the OLS estimates while Columns 2 and 4 correspond to the IV results. Our benchmark specification is Column 4.
<table>
<thead>
<tr>
<th></th>
<th>$P(surv_{jnt})$ (1)</th>
<th>$P(surv_{jnt})$ (2)</th>
<th>$P(surv_{jnt})$ (3)</th>
<th>$P(surv_{jnt})$ (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ChComp_{jnt}$</td>
<td>-3.419</td>
<td>-4.079</td>
<td>-3.426</td>
<td>-6.474</td>
</tr>
<tr>
<td></td>
<td>(0.539)</td>
<td>(0.598)</td>
<td>(1.103)</td>
<td>(1.544)</td>
</tr>
<tr>
<td>$TFPR_{jnt}$</td>
<td>0.224</td>
<td>0.221</td>
<td>0.251</td>
<td>0.247</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.020)</td>
<td>(0.014)</td>
<td>(0.015)</td>
</tr>
<tr>
<td>$K_{jnt}$</td>
<td>0.143</td>
<td>0.137</td>
<td>0.169</td>
<td>0.167</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.009)</td>
<td>(0.006)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>$ChComp_{jnt}^*TFPR_{jnt}$</td>
<td>0.152</td>
<td>0.158</td>
<td>0.250</td>
<td>0.472</td>
</tr>
<tr>
<td></td>
<td>(0.057)</td>
<td>(0.062)</td>
<td>(0.125)</td>
<td>(0.173)</td>
</tr>
<tr>
<td>$ChComp_{jnt}^*K_{jnt}$</td>
<td>0.126</td>
<td>0.149</td>
<td>0.083</td>
<td>0.156</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.027)</td>
<td>(0.048)</td>
<td>(0.067)</td>
</tr>
</tbody>
</table>

N. Observations 12,014 11,559 12,014 11,559

Table C3: Effect of Trade Shock on Survival.

In addition, we present the equivalent graphs to Figure 3 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.

![Figure C2: Effects of Trade Shock on Survival Probabilities. ImpInt and OLS.](image)

Notes: This figure is a map of isoprobabilities. The solid line represents the isoprobability line at 50% without a trade shock. The dashed line refers to the isoprobability of 50% survival when firms face and increase in one standard deviation trade shock.
Figure C3: Effects of Trade Shock on Survival Probabilities. $ImpInt_{nt}$ and IV.

Notes: This figure is a map of isoprobabilities. The solid line represents the isoprobability line at 50% without a trade shock. The dashed line refers to the isoprobability of 50% survival when firms face an increase in one standard deviation trade shock.

Figure C4: Effects of Trade Shock on Survival Probabilities. $ChComp_{nt}$ and OLS.

Notes: This figure is a map of isoprobabilities. The solid line represents the isoprobability line at 50% without a trade shock. The dashed line refers to the isoprobability of 50% survival when firms face an increase in one standard deviation trade shock.
C.5 Intensive Margin Effects

We now perform the same analysis as in Table 2, but considering different measures of trade shocks and by OLS and IV.

<table>
<thead>
<tr>
<th></th>
<th>Growth Rate of K</th>
<th>Prob of Staying in Current Tercile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pooled</td>
<td>0.049</td>
<td>-0.082</td>
</tr>
<tr>
<td></td>
<td>(0.066)</td>
<td>(0.046)</td>
</tr>
<tr>
<td>First Tercile MRPK</td>
<td>-0.217</td>
<td>-0.151</td>
</tr>
<tr>
<td></td>
<td>(0.072)</td>
<td>(0.077)</td>
</tr>
<tr>
<td>Second Tercile MPRK</td>
<td>0.100</td>
<td>-0.037</td>
</tr>
<tr>
<td></td>
<td>(0.075)</td>
<td>(0.085)</td>
</tr>
<tr>
<td>Third Tercile MRPK</td>
<td>0.055</td>
<td>-0.019</td>
</tr>
<tr>
<td></td>
<td>(0.192)</td>
<td>(0.086)</td>
</tr>
</tbody>
</table>

Table C4: The Effect of a Trade Shock on Investment. $ImpInt_{nt}$ and OLS.

<table>
<thead>
<tr>
<th></th>
<th>Growth Rate of K</th>
<th>Prob of Staying in Current Tercile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pooled</td>
<td>0.009</td>
<td>-0.098</td>
</tr>
<tr>
<td></td>
<td>(0.088)</td>
<td>(0.062)</td>
</tr>
<tr>
<td>First Tercile MRPK</td>
<td>-0.284</td>
<td>-0.194</td>
</tr>
<tr>
<td></td>
<td>(0.095)</td>
<td>(0.101)</td>
</tr>
<tr>
<td>Second Tercile MPRK</td>
<td>0.119</td>
<td>-0.049</td>
</tr>
<tr>
<td></td>
<td>(0.099)</td>
<td>(0.113)</td>
</tr>
<tr>
<td>Third Tercile MRPK</td>
<td>-0.184</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>(0.267)</td>
<td>(0.120)</td>
</tr>
</tbody>
</table>

Table C5: The Effect of a Trade Shock on Investment. $ImpInt_{nt}$ and IV.
Table C6: The Effect of a Trade Shock on Investment. ChComp_{nt} and IV.

C.6 Intensive Margin Effects: Inaction and Firm-level depreciation

To understand the effects of firm-level depreciation on inaction and investment dynamics, we run the following specification,

\[ z_{jnt} = \alpha_0 + \alpha_1 ChComp_{nt} + \beta ChComp_{nt} \times I[DepQuantile]_{jnt} + \alpha_3 TFP_{R_{jnt}} \]
\[ + \alpha_4 I[DepQuantile]_{jnt} + \alpha_5 k_{jnt} + \gamma_n + \epsilon_{jnt} \] (C3)

where \( I[DepQuantile]_{jnt} \) refers to dummy variables for quantiles of firm-level depreciation rates. Quantile 1 represents the lowest capital depreciation firms, whereas quantile 4 consists on the highest ones.

Results are shown in Table C7. We have only included the \( \beta \) coefficients; the effect of the shock by each quartile of the firm-level depreciation distribution relative to the first one. The first row refers to the impact of the competition shock on the base category. The second row refers to the additional impact, relative to base category, of the second quartile; and so on.

As shown, the competition shock increases the probability of inaction for firms in the first quartile of the distribution. However, the effect becomes more muted for firms in the upper quartiles. The same pattern exists for the probability of positive (negative) investment, where firms in the first quartiles are more negatively (positively) affected than
firms in the upper quartiles. These results show that firms with lower firm-level depreciation rates are the ones responsible for the aggregate effects seen in Table 3.

<table>
<thead>
<tr>
<th></th>
<th>Inaction</th>
<th>Positive Investment</th>
<th>Negative Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChComp(_{nt})</td>
<td>0.277</td>
<td>-0.330</td>
<td>0.053</td>
</tr>
<tr>
<td></td>
<td>(0.121)</td>
<td>(0.132)</td>
<td>(0.080)</td>
</tr>
<tr>
<td>ChComp(<em>{nt}) + δq(</em>{2jnt})</td>
<td>-0.282</td>
<td>0.314</td>
<td>-0.033</td>
</tr>
<tr>
<td></td>
<td>(0.147)</td>
<td>(0.162)</td>
<td>(0.097)</td>
</tr>
<tr>
<td>ChComp(<em>{nt}) + δq(</em>{3jnt})</td>
<td>-0.095</td>
<td>0.179</td>
<td>-0.085</td>
</tr>
<tr>
<td></td>
<td>(0.148)</td>
<td>(0.168)</td>
<td>(0.103)</td>
</tr>
<tr>
<td>ChComp(<em>{nt}) + δq(</em>{4jnt})</td>
<td>-0.210</td>
<td>0.344</td>
<td>-0.135</td>
</tr>
<tr>
<td></td>
<td>(0.151)</td>
<td>(0.177)</td>
<td>(0.112)</td>
</tr>
</tbody>
</table>

Table C7: The Effect of a Trade Shock on Investment (continued).
D Additional Model Material

D.1 Definition of 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 \( G(f; s) \)), a recursive stationary equilibrium is defined as:

- Household’s decision for consumption \( C \) and labor \( N \);
- Value functions:
  \[
  V(k, s, f), V^c(k, s, f), V^x(k, s);
  \]
- 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 the first order condition for labor supply;
- Firms’ value functions and decision rules solve the dynamic program (16), (17), (18), (19);
- Output market and labor market clear, that is

\[
C = \left( \sum_k \sum_s (sk^\alpha n(k, s)^{1-\alpha})^{\theta} \lambda(k, s) \right)^{\frac{1}{\theta}} \tag{D1}
\]

\[
N = \sum_k \sum_s n(k, s) \lambda(k, s) + N^X + 1^e + \bar{f} \tag{D2}
\]
where \( \bar{f} \) 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:

\[
\sum_k \sum_s Q(i(k, s))i(k, s)\lambda(k, s) = p^X X; \quad (D3)
\]

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

\[
\mu(k, s) = \sum_k \sum_s \sum_f \lambda(k, s)G(f; s) (1 - x(k, s, f)) \quad (D4)
\]

\[
\lambda(k', s') = \sum_k \sum_s \mu(k, s)F(s, s')I(k' = g(k, s))
+ \sum_{s^e} F^e(s^e)F^{es'}(s^e, s')e(s^e)I(k' = g^e(s^e)). \quad (D5)
\]

Notice that this definition also implies market-clearing in each manufacturing variety.
D.2 Empirical Calibration Targets

<table>
<thead>
<tr>
<th>Moment</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq. of negative investment</td>
<td>10.1%</td>
</tr>
<tr>
<td>Slope of exit thresholds</td>
<td>0.754</td>
</tr>
<tr>
<td>Autocorrelation of TFPR</td>
<td>0.742</td>
</tr>
<tr>
<td>Unconditional std dev of TFPR</td>
<td>1.13</td>
</tr>
<tr>
<td>Exit rate</td>
<td>18.4%</td>
</tr>
<tr>
<td>Relative capital at exit</td>
<td>0.345</td>
</tr>
<tr>
<td>Relative TFPR at exit</td>
<td>0.756</td>
</tr>
</tbody>
</table>

Table D1: Calibration Targets

D.3 Solution Method for Transitional Dynamics

We now briefly describe how we solve for the transitional dynamics. First, we compute the initial and final stationary equilibrium, using standard methods. We assume that the trade shock unexpectedly hits the economy in its initial stationary equilibrium, at $t = 1$, and that the new stationary equilibrium is then reached by $T = 40$ (we verify that we obtain convergence in a shorter horizon).

We then need to compute a sequence of aggregate price levels $\{P_t\}_{t=1}^{T-1}$ as well as sequences of firm value functions and decision rules (household choices are easily pinned down given the price level). To do so, we iterate between the following two steps until convergence:

- For a given guess for $\{P_t\}_{t=1}^{T-1}$, we solve for firms value function by iterating backward on the Bellman equations, starting from $t = T - 1$ and until $t = 1$.

- Given the decision rules obtained, we iterate forward on the transition equation for the distribution of firms over individual states $\lambda_t(k, s)$, starting from $t = 1$ and until $t = T - 1$. In so doing, we compute excess demand in the goods markets and update the aggregate price level accordingly, thus obtaining a new guess for the price sequence.

More details on this algorithm can be found in Ríos-Rull (1998).
D.4 Additional Results for the Baseline Model

Figure D1: Import Penetration After the Trade Shock.

*Notes:* The figure displays the path of import penetration, as a percentage of expenditures on consumption goods.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>BASELINE</th>
<th>FRICTIONLESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C$</td>
<td>1.43</td>
<td>2.30</td>
</tr>
<tr>
<td>$K$</td>
<td>1.93</td>
<td>4.68</td>
</tr>
<tr>
<td>$N$ (MANUF.)</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>$M$</td>
<td>0.72</td>
<td>0.60</td>
</tr>
<tr>
<td>$TFPQ$ (AVERAGE)</td>
<td>2.41</td>
<td>2.61</td>
</tr>
</tbody>
</table>

Table D2: Steady-state Comparison: Baseline and Frictionless Model.

<table>
<thead>
<tr>
<th>MODEL</th>
<th>STEADY-STATE</th>
<th>TRANSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>-0.54%</td>
<td>0.39 %</td>
</tr>
<tr>
<td>Frictionless</td>
<td>-0.71%</td>
<td>0.53 %</td>
</tr>
</tbody>
</table>

Table D3: Welfare (Consumption Equivalent Variation).
D.5 Decomposition of GE 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. 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 D2a, 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 6), 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. This in turn leads to a quicker convergence of average firm TFPQ to the new long run steady-state, i.e. the gains from trade are realized faster (figure D3a). In contrast, the equilibrium fall in the real rate dampens this selection effect in our benchmark GE model.

In Figure D2b, we do the same decomposition for the positive and negative investment thresholds. We find that the shock would lead to a larger decline in the fraction of firms doing positive investment, but it also spurs disinvestment by large firms with low productivity.

\footnote{To see this, recall that the labor supply equation states that consumption is inversely proportional to the aggregate price level.}
Figure D2: Thresholds with Fixed Interest Rate.

Notes: The left panel (a) displays the exit threshold, in the baseline before the shock (solid blue line), after the shock in GE (dashed blue), and after the shock with a constant interest rate (dashed-dotted black). The right panel (b) displays the investment and disinvestment thresholds.

Figure D3: Transition of Average TFPQ (left) and Dispersion of MRPK (right).

Notes: The left panel (a) displays the transition path of average firm productivity in GE (solid blue line) and with a constant interest rate (dashed-dotted black). The right panel (b) displays the dispersion of MRPK. The y-axes report percentage changes relative to the initial stationary equilibrium.
In Figure D4, 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 D4: Aggregate Capital.](image)

Notes: The figure displays the transition path of the aggregate capital stock in GE (solid blue line) and with a constant interest rate (dashed-dotted black). The y-axis reports percentage changes relative to the initial stationary equilibrium.

D.6 Convex adjustment costs and MRPK persistence

In this extension of our model, we assume the following convex cost of adjustment in addition to the prevailing adjustment costs in our baseline model:

\[
C(k', k) = c \left( \frac{k' - (1 - \delta) k}{k} \right)^2 k
\]

Holding fixed our baseline parameters, we vary \(c\) to increase persistence in MRPK. We report the transition matrix of MRPK in Table 1. The addition of a convex adjustment cost function substantially improves the fit of our model to the data (contrasting the case in table 5 where the persistence of MRPK was not explicitly targeted). However, the addition of convex costs is not sufficient to fully account for MRPK persistence, consistent with the
findings of David and Venkateswaran (2019).

<table>
<thead>
<tr>
<th>Tercile at $t+1$</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.73</td>
<td>0.25</td>
<td>0.02</td>
</tr>
<tr>
<td>2</td>
<td>0.27</td>
<td>0.52</td>
<td>0.20</td>
</tr>
<tr>
<td>3</td>
<td>0.04</td>
<td>0.34</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Table D4: Mobility (Transition Probabilities) of MRPK in Stationary Equilibrium.

D.7 Restriction on the fixed-cost distribution

In this section, we show that our headline results are not driven by our assumptions on the distribution of fixed costs. Here, we set $\eta_1 = \eta_2 = 0$, which reduces the function to a uniform distribution common across all firm productivity. We then use the reduced set of parameters to target the same seven moments from the data. We report in table D5 the corresponding model moments. While the model fit is less precise than our baseline calibration, we see that the capital irreversibility is still crucial in allowing us to qualitatively match our empirical findings, that is, the asymmetric persistence of MRPK, and the exit thresholds.

<table>
<thead>
<tr>
<th>Moments</th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq of negative investment</td>
<td>10.1%</td>
<td>8.6%</td>
</tr>
<tr>
<td>Slope of exit thresholds</td>
<td>0.754</td>
<td>0.352</td>
</tr>
<tr>
<td>Autocorrelation of TFPR</td>
<td>0.742</td>
<td>0.730</td>
</tr>
<tr>
<td>Unconditional std dev of TFPR</td>
<td>1.13</td>
<td>0.94</td>
</tr>
<tr>
<td>Exit rate</td>
<td>18.4%</td>
<td>26.1%</td>
</tr>
<tr>
<td>Relative size at exit</td>
<td>0.345</td>
<td>0.277</td>
</tr>
<tr>
<td>Relative productivity at exit</td>
<td>0.756</td>
<td>0.332</td>
</tr>
</tbody>
</table>

Table D5: Model Fit with $\eta_1 = \eta_2 = 0$. 

78
<table>
<thead>
<tr>
<th>Tercile at $t$</th>
<th>Tercile at $t + 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0.65</td>
</tr>
<tr>
<td>2</td>
<td>0.39</td>
</tr>
<tr>
<td>3</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Table D6: Mobility (Transition Probabilities) of MRPK in Stationary Equilibrium.

In figure D5, we report the transitional dynamics of average firm productivity and capital misallocation, similar to that in figures 7, 9a, and 9b. As we can see, the transitional dynamics are qualitatively and quantitatively similar to our baseline calibration. Average firm productivity converges to the new long run level at a lower speed than in the frictionless economy; there is a short-run increase in MRPK dispersion arising from the widening of the inaction region, leading to a wider gap with respect to the allocation of capital in the frictionless economy.
Figure D5: Average Productivity, MRPK Dispersion, TFPQ ratio.

Notes: Panel (a) displays the transition path of average firm productivity under this alternative calibration in the model with frictions (solid blue line) and frictionless (dashed red). Panel (b) displays the dispersion of MRPK. Panel (c) displays the ratio of aggregate TFPQ between model with frictions and frictionless. The y-axes report percentage changes relative to the initial stationary equilibrium.