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Keywords: capital reallocation, Investment Irreversibility, Trade Shocks, Firm Dynamics

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Capital-Reallocation Frictions and Trade Shocks*

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July 2020

Abstract

What are the short- and medium-term effects of an import-competition shock on firm dynamics and aggregate productivity? We address this question by combining detailed data on investment dynamics of Peruvian manufacturing firms, data on trade flows from 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, by rendering disinvestment and firm exit costly. In our model, these frictions shape the transitional dynamics after a trade shock. On impact, a drop in output prices due to import competition induces a spike in inaction, and exit of some productive firms, consistent with our empirical evidence. These effects expand the aggregate productivity wedge relative to a frictionless benchmark. Overall, productivity gains materialize slowly over time, whereas welfare gains emerge early in the transition.

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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 import-competition shock on firm dynamics and productivity in the domestic economy? 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 a trade 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 substantial 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 dispersed 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. 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 quantify the role of capital-reallocation frictions in the response of the economy to 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 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. We compare these results to a counterfactual scenario, in which we remove capital-reallocation frictions. In this case, we find that there are significantly larger productivity gains as soon as the shock hits.

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 the frictionless counterfactual. In terms of welfare, trade is overall beneficial. While productivity improves slowly over time, welfare gains materialize early in the transition because of a drop in output prices.

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:

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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 (2020a) also finds similar results in the context of US entrepreneurial firms.

Investment is partially irreversible at the firm level. In their seminal paper, Ramey and 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; Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry, 2018; Lanteri, 2018).[3] Our paper studies the role of these frictions in the context of trade liberalization. To this end, our model combines irreversibility with three important margins: monopolistic competition; endogenous entry and exit; and an open-economy dimension.

The literature on international trade with heterogeneous firms, starting from the seminal work of Melitz (2003), often abstracts from investment dynamics and focuses on steady-state comparisons, i.e., long-term outcomes. Our paper contributes to this literature by explicitly considering investment frictions and transitional dynamics.[4] By casting a model of trade with heterogeneous firms into a macro general-equilibrium framework and computing aggregate dynamics, we build on the seminal 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 other frictions and adjustment dynamics in models of trade. In an early contribution, Chaney (2005) characterizes the transitional dynamics in a Melitz model. Several papers focus on the gradual *expansion* of exporting firms facing frictions such as sunk costs—e.g., Impulliti, Irrazabal, and Opromolla (2013), Alessandria and Choi (2014) and Alessandria, Choi, and Ruhl (2018)—or financing constraints—e.g., Caggese and Cuñat (2013), Chaney (2016), Brooks and Dovis (2020).[5] Our contribution is com-

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[3] Relatedly, Baley and Blanco (2020) emphasize the importance of irreversibility in a sample of Chilean manufacturing firms and propose a sufficient-statistic approach that relates empirical steady-state moments of the investment distribution to aggregate dynamics in response to aggregate shocks. 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 (Antràs and Caballero, 2009; Helpman, Itskhoki, and Redding, 2010; Chor and Manova, 2012; Cuñat and Melitz, 2012; Manova, 2013; Foley and Manova, 2015). A full survey can be found in Manova (2010). Relatedly, Bai, Jin, and Lu (2019) study the long-run effects of trade liberalization with heterogeneous firms and factor misallocation. Federico, Hassan, and Rappoport (2019) provide an empirical analysis of the reallocation of bank credit in response to trade shocks.

[5] Relatedly, Buera and Shin (2013) show that financial frictions also lead to gradual transitional dynamics after other types of reforms, which they model as removal of factor-markets distortions. Guren, Hemous, and Olsen (2015) study the role of sector-specific human capital for trade dynamics. Ravikumar, Santacreu, and Sposi (2019) emphasize the role of capital accumulation for gains from trade in a dynamic multi-country model. Caliendo, Dvorkin, and Parro (2019) analyze the labor-market effects of the China

plementary to this body of work: We emphasize the aggregate effects of the *downsizing* process for domestic firms induced by an import-competition shock. This motivates our focus on capital-reallocation frictions, and specifically investment irreversibility.[6] We show that the frictions we document play a crucial role in shaping the transition path of the economy in our context. To obtain this result, we apply computational tools from the literature on macro models with heterogeneous agents to explicitly keep track of the joint distribution of capital and productivity, the key aggregate state variable (as in Khan and Thomas, 2008), along the general-equilibrium transition path of the economy.

Our results on the effects of capital-reallocation frictions on the gains from trade appear consistent with the recent analysis of Berthou, Chung, Manova, and Charlotte (2019), who analyze the role of factor misallocation for the calculation of the gains (or losses) from trade in response to the "China shock". Furthermore, 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 and Measurement

In this section, we describe our main data sources on firm dynamics and trade and present our measurement strategy.

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trade shock in a spatial general-equilibrium model of the US economy. Collard and Licandro (2020) study the role of selection and investment irreversibility for welfare in the transitional dynamics of a neoclassical model of firm dynamics.

[6] While financial constraints are likely to be binding for growing exporters, they would not necessarily prevent downsizing for domestic firms when they become less profitable after a trade shock.

2.1 Data Sources

Our analysis combines three main data sources. The first source is the *Encuesta Economica Nacional* (EEA) for the period between 2000 and 2014. This is an annual firm-level survey administered nationally by the Peruvian Statistical Agency (INEI). 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. For our analysis, we consider the six largest manufacturing industries in Peru according to 2-digit CIIU Rev.3: Food and Beverages, Apparel, Textiles, Chemicals, Printing, and Machinery and Equipment n.e.c. (not elsewhere classified). Overall, the number of firm-year observations equals 17,427.[7]

As is often the case with non-census administrative data, while the EEA is representative of the overall Peruvian manufacturing industry, and is effectively a census for large and medium-sized firms, it only represents a sample for smaller firms.[8] Thus, to compute entry and exit rates, we complement the EEA with the Peruvian firms' registry *(Padrón RUC)*, which is available for the period 2007-2017. This dataset lists all firms registered with the Peruvian Tax Authority in each of these years, as well as the date of the beginning of legal operations. With this additional information, we can, for instance, identify whether firms that left the survey are still active, and thus distinguish between sample attrition in the EEA and actual exit. We describe our survival measurement strategy in the next section.

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.[9]

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 productivity measures following the procedure proposed by Asker, Collard-Wexler, and De Loecker

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[7] In Appendix A.2, we report details on the number of firms by industry.

[8] Throughout our sample period, firms with annual sales above 2 million Soles, i.e., approximately 600 thousand US dollars, are always included.

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

(2014), to account for the fact that we do not separately observe output prices and quantities. We assume that 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, $y_{jt} = s_{jt} k_{jt}^{\alpha} n_{jt}^{1-\alpha}$, 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 ϵ, where B_t is an aggregate shifter.[10]

With these assumptions, revenue (net of intermediates), is

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

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

We assume a standard value for the elasticity of substitution, namely $\epsilon = 4$ (e.g., Bloom, 2009; Asker, Collard-Wexler, and De Loecker, 2014), and recover an industry-specific value for α by computing, for each industry, the median expenditure share on labor in firm's value-added, i.e., $\theta(1-\alpha)$. We then measure (revenue total factor) productivity ω_{jt} as follows:

$$\omega_{jt} \equiv \frac{p_{jt} y_{jt}}{k_{jt}^{\theta\alpha} n_{jt}^{\theta(1-\alpha)}} \tag{2}$$

where n_{jt} is the number of employees in the firm and k_{jt} is the capital stock measured as book value.[11] Notice that this measure is not equivalent to the definition of TFPR (Total Factor Productivity - Revenue) used, for instance, by Hsieh and Klenow (2009), which is instead $\tilde{\omega}_{jt} \equiv p_{jt} s_{jt} = \frac{p_{jt} y_{jt}}{k_{jt}^{\alpha} n_{jt}^{1-\alpha}}$. Under our assumptions on production and demand, which are consistent with the theoretical model of Section 5, $\omega_{jt} = B_t^{\frac{1}{\epsilon}} s_{jt}^{\theta}$ depends only on aggregate conditions common across all firms (through B_t) and firm-level physical productivity s_{jt} (often referred to as TFPQ, Total Factor Productivity - Quantity). Conversely, $\tilde{\omega}_{jt}$ is directly tied to marginal revenue products, and thus to distortions or frictions in factor demand.[12]

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

[11] All nominal variables are deflated using Peru's GDP deflator.

[12] We provide further details on this distinction in Appendix A.1. To the extent that there is model misspecification, or mismeasurement in ϵ and α in the data, our measure of productivity ω_{jt} may also be contaminated by factors other than physical productivity, such as distortions or adjustment costs. Nevertheless, following Asker, Collard-Wexler, and De Loecker (2014), we adopt this definition because it makes revenue productivity independent of capital-reallocation frictions (and exogenous to capital and labor choices) under the assumptions of our model, thus providing a more direct empirical counterpart to the exogenous idiosyncratic productivity process we calibrate.

We measure the marginal revenue product of capital (MRPK) as follows:

$$MRPK_{jt} = \frac{\partial p_{jt} y_{jt}}{\partial k_{jt}} = \theta\alpha \frac{p_{jt} y_{jt}}{k_{jt}} \tag{3}$$

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.3 provides more details on this procedure. In addition, we use the information on the consumption of energy and materials at the firm level to construct measures of capital utilization.

Exit. The EEA provides an accurate measurement of exit for medium and large firms. As far as small firms are concerned, we enhance the measurement of their survival or exit as follows. In the EEA, we define a firm's exit year as the last year the firm is present in the sample (except if it is 2014, which is the last year of our analysis). Next, using the Peruvian firms' registry, we construct the end of operation dates for all firms that are recorded between 2007 and 2017, and we merge this information with the EEA, using firms' tax ID number, whenever we observe it. If a firm "exiting" from the EEA is not observed in the registry at a later date, we keep the measure of exit based on the EEA. If a firm is instead present in the registry at a later date, we replace the exit date based on the EEA with the discharge year from the registry. This procedure leads to a sizable improvement in the measurement of exit for small firms. Overall, the average exit rates decrease from 27.4% to 18.4% for the whole sample period, and from 32.5% to 17.9% during 2007-2013. We also use the matched EEA-registry sample as a robustness check in all our specifications. Finally, for 2007 and 2011, we can match *all* EEA firms to the registry. Thus, we use these years to further verify the robustness of our results related to exit.[13]

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, n. 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

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[13] See Appendix A.2 for the complete exit summary statistics.

increases in Chinese import intensity. To construct the deviations from trends, we first regress the raw import intensity measure $ImpInt_{nt}$ on a series of dummy variables for two-digit industry and year. Then, we construct the import-competition shock as the residual 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.

Moreover, 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.[14]

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 Section 5.

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. MRPK 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 high (0.74).

The 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

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[14] To lessen the concern of similar demand trends between Latin American countries; we also consider imports from China to other upper-middle-income countries, such as Mexico, Costa Rica, and South Korea. Results are robust to these instruments and discussed in Section 4.2.

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.[15]

3.2 Fact 2: Capital Adjustment is Asymmetric

We now move to characterize the dynamic evolution of capital at the firm level. Across several 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 11% of adjustments are negative, which suggests the presence of partial investment irreversibility.[16]

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 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, a 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. Therefore, conditional on a given process for the profitability shocks, a high persistence in low MRPKs signals the presence of frictions that render disinvestment costly.

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[15] 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 productivity 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 productivity (ω) dispersion for each industry-year in our sample.

[16] 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.

To exploit this new insight, we pool our data to generate a single set of MRPK mobility estimates. To this end, 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%. In contrast, 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 productivity ω in Table B.3.3 , and find that, in contrast, high levels of ω are more persistent than low levels. This suggests that the high persistence of low MRPKs is likely due to frictions in capital reallocation rather than asymmetries in the distribution of profitability shocks.

		at $t+1$		
		1	2	3
Tercile at t	1	0.82	0.16	0.02
		(0.01)	(0.01)	(0.00)
	2	0.19	0.69	0.12
		(0.01)	(0.01)	(0.01)
	3	0.03	0.20	0.77
		(0.00)	(0.01)	(0.01)

Table 1: Transition Probabilities of MRPK.

Notes: Bootstrapped standard errors in parentheses.

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.3.1. In addition, we construct industry-specific definitions of MRPK terciles and perform this analysis separately for the six largest industries in our sample. We 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). In Appendix B.3.2, we provide our estimated probabilities of transition across all terciles of all six industry-specific MRPK distributions.[17]

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[17] 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.

MRPK and capital adjustment. Our results corroborate the notion that capital adjustment frictions 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 present the distribution of growth rates of capital for firms in the bottom tercile of MRPK (solid blue line) and contrast it with the one for firms in the top tercile (dashed red line). We find a large spike of zero growth rates for firms with low MRPK, suggesting that these firms are not downsizing in response to negative shocks. On the other hand, we find a long right tail of positive growth for firms with high returns from capital.

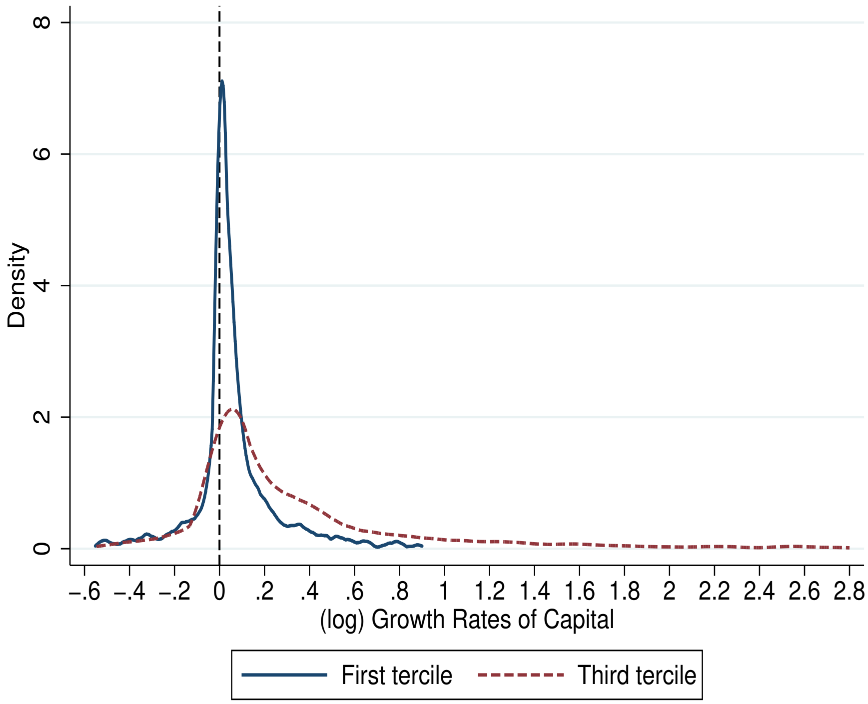

Figure 1: Density of Firm-level Growth Rates of Capital.

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

Capital composition, depreciation, and MRPK mobility. We now leverage a unique feature of our dataset in two related ways. For each firm, we observe the portfolio composition of its capital stock among the following categories: land, buildings, fixed installations, machinery, computers, furniture, and transportation equipment. First, we exploit the fact that the depreciation rate of capital goods is very heterogeneous across different types of capital, e.g., land does not depreciate, whereas transportation equipment depreciates at an annual 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 also varies at the firm level.[18]

Heterogeneity in capital depreciation has important consequences for firms' ability 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 reduce 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 the same tercile of the MRPK distribution.[19] We first focus on firms in the first tercile of the MRPK distribution, i.e., low-MRPK firms which are more likely to be directly affected by capital resale frictions. We find a statistically significant negative effect of depreciation rates on the persistence of MRPK, meaning that a higher depreciation rate makes it more likely that a firm with currently low MRPK will move to a tercile associated with higher MRPK in the following year. The estimated effect 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 trying to downsize.

Second, we also examine whether a particular type of capital drives the asymmetric persistence of the MRPK distribution. To this end, we construct marginal revenue product measures for every type of capital and estimate their autocorrelation, allowing for heterogeneity by initial tercile. The results are shown in Appendix B.5. Notably, the marginal revenue product of fixed installations and machinery features a significantly higher persistence for firms in the lowest tercile. This result is consistent with the notion that these types of capital have a higher degree of firm specificity.

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[18] Refer to Appendix A.3 for details on the construction of firm-level depreciation rates.

[19] See Appendix B.4 for the empirical results.

A caveat in interpreting these results is that the composition of firms' capital stock, even across capital goods with different depreciation rates, is an endogenous choice, and might reflect differences—including unobservable ones—across firms. Developing a theory of heterogeneous firm-level depreciation rates is beyond the scope of this paper. Our analysis takes heterogeneity in capital composition and depreciation rates as given and is thus meant to produce a further piece of suggestive evidence in favor of the importance of partial irreversibility, by exploiting our uniquely rich information about firm capital.

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.[20]

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.[21] We cannot reject that the probability of remaining in the lowest tercile equals the probability of staying 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 capital stock—remains persistently low, whereas their adjusted MRPK—which accounts for energy consumption—increases faster, as the effective capital input shrinks through underutilization.[22]

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[20] See Appendix B.6 for a more detailed description of variable construction and empirical results.

[21] Table B7 in Appendix B.6 reports the autocorrelation of MRPK, both unconditional and conditional on the current tercile of MRPK after the utilization adjustment, and compares to baseline estimates. We also perform this analysis using materials to proxy for utilization and find similar results.

[22] We discuss potential alternative explanations for asymmetric persistence in MRPK in Appendix B.7, such as the role of other distortions (e.g., employment subsidies), state-owned enterprises, asymmetric persistence of productivity shocks, among others. In Appendix B.8, 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.

3.3 Fact 3: Capital Predicts Survival, Conditional on Productivity

Using our sample 2000-2014 and the measurement of survival and exit explained in Section 2.2, 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 log productivity ω_{jnt} and log capital stock k_{jnt} at the firm level. Specifically,

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

and

$$z^*_{jnt} = \alpha + \beta_1 \log(\omega_{jnt}) + \beta_2 \log(k_{jnt}) + \gamma_n + \gamma_t + \epsilon_{jnt} \tag{5}$$

where γ_n and γ_t are industry and year fixed effects, respectively.

Figure 2 shows the contours of the probability of firm survival, with (log) capital on the x-axis and (log) ω on the y-axis. The figure shows that a firm's survival probability depends positively on both productivity and level of capital. Accordingly, the isoprobability curves are downward sloping. The estimated coefficients are $\beta_1 = 0.26$ (0.02) and $\beta_2 = 0.19$ (0.01), with standard errors in parenthesis clustered at the firm level. In particular, conditional on productivity, firms with a lower capital stock have a significantly higher probability of exiting their industry.[23] Conditional on a level of capital, unproductive firms are more likely to exit.

This result is also robust to only considering the years for which we can match all firms in the EEA to the registry, as Appendix B.9 shows.

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

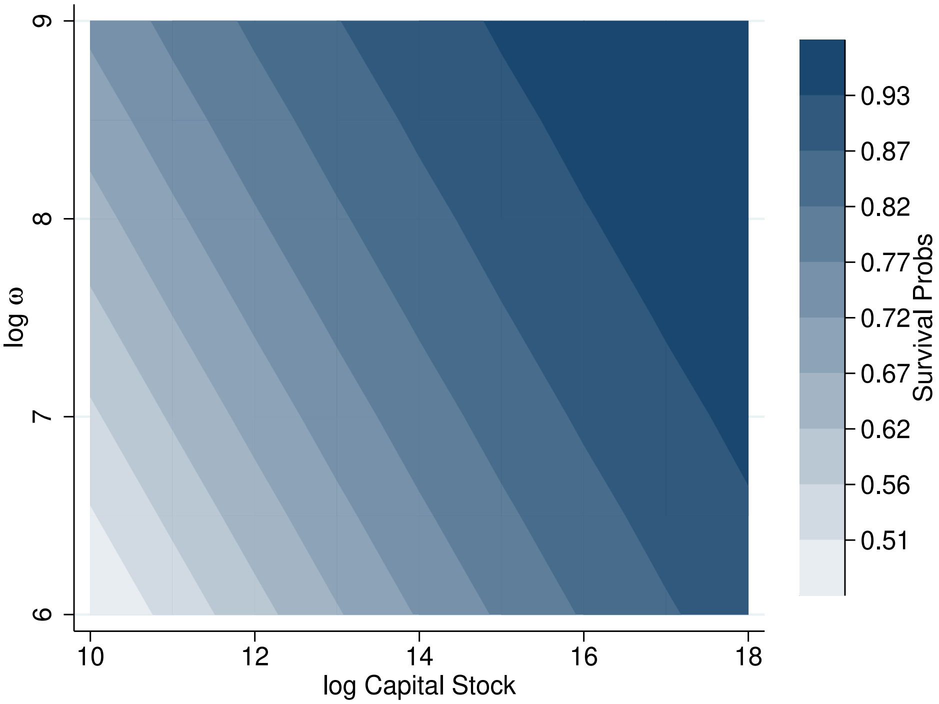

Figure 2: Selection Effects of Productivity and Capital.

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

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.[24]

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 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 productivity, should be more critical for firms operating capital with a low depreciation rate. Firms holding assets with high depreciation, in contrast, could downsize by letting their capital depreciate. Therefore, their option value of staying on the market

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[24] 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.

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 B7 in Appendix B.10 shows that there is a negative relationship between the relative effect of capital stock on survival and firm-level depreciation rates.[25] For firms holding high-depreciation assets, productivity is relatively more important than the level of capital in understanding selection. Subject again to the caveat that the composition of capital is an endogenous variable, these results provide support for the role of investment irreversibility in explaining the negative slope of the isoprobabilities estimated in Figure 2.

3.4 Labor Reallocation

To complement our analysis of capital reallocation, we also 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.11, 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.

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[25] The complete set of results is in Table B11 in Appendix B.10.

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 Hanson, 2013; Acemoglu, Autor, Dorn, Hanson, and Price, 2016).

We find that the import-competition shock induces firm exit on the extensive margin, and a spike in inaction on the intensive margin of investment. Moreover, these responses depend importantly on the location of firms in the distribution of capital and productivity.

We emphasize that the estimates in this section rely on cross-industry and time variation in import intensity, as is standard in the literature on trade shocks. This element poses serious challenges for a formal quantitative comparison of 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 empirical estimates in this section are consistent with the key mechanisms of the model along the intensive and extensive margins, thus providing validation for our model results.

4.1 Chinese Import Competition

In December 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 China's volume of goods exported. 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 became Peru's leading import partner.[26]

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.[27] As shown

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[26] 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 relative to the Peruvian economy.

[27] Accession to the WTO also decreased tariffs on imports into China, which potentially implied easier

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 the six industries we analyze—did not show any increase in exporting activity to China. Moreover, in the short run, Chinese imports were consistently focused on final goods and did not significantly increase in raw materials or intermediate goods.[28]

Considering this evidence, we view China's impact on Peruvian manufacturing as primarily an import-competition shock, which may induce firm selection and factor reallocation, because of increased import competition.[29] Therefore, as introduced in Section 2, we will use the measure $ChComp_{nt}$ to capture unanticipated 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 capital reallocation, we proceed in two steps. First, we examine the importance of Chinese competition for survival. Second, we analyze the effect on firms' investment decisions. In all the specifications, we use the measure $ChComp_{nt}$ defined in Section 2.2, instrumented using Chinese imports to border Latin American countries.[30]

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access for Peruvian exporters to this vast market.

[28] For raw materials, even by 2010, China only represented 0.3% of total imports. In the case of intermediate goods, the trend is positive over our sample period even though the leading import partner remained the United States for all of the 2000s—while China only became one of the top five partners in 2006. Access to cheaper imported intermediates could reduce the negative effect of the import-competition shock. Hence, it would make it harder for us to find effects on exit and investment inaction. Our findings can thus be interpreted as a lower bound on firm-level responses to an import-competition shock. See Appendix C.2 for a detailed discussion. Regardless, all our results hold when considering the earlier period of our sample (2000-2005), when these trends were limited, and no other trade policies, such as bilateral trade agreements, took place.

[29] 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 some industries' export intensity, 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. However, we acknowledge that import competition could lead to increase in exports to other destinations due to quality upgrading, as shown by Medina (2019). Yet, undestanding those mechanisms for each of our sample industries is out of the scope of this paper; thus, we leave an exploration of the role of capital reallocation frictions for exporter dynamics for future research.

[30] In all specifications, the instruments are relevant, with F-statistics above the rule of thumb threshold. They also pass the test of overidentifying restrictions.

Selection. How does the level of capital affect firm survival in response to a trade shock? To address this question, we re-estimate our prediction model for survival in equation (5), now 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 stock. We illustrate the results in Figure 3. 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).[31]

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. Quantitatively, in response to a one-standard-deviation trade shock, the average exit rate goes from 18.4% to 19.7%.

The result that a trade shock induces the exit of unproductive firms is consistent with the predictions of standard trade models. However, we also find that the level of capital plays an important role, 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 exit in response to 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.

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[31] Appendix C.4 presents the full specification, estimates used to generate these graphs, and specifications with alternative measures of import competition as well as instruments considering other upper-middle-income countries.

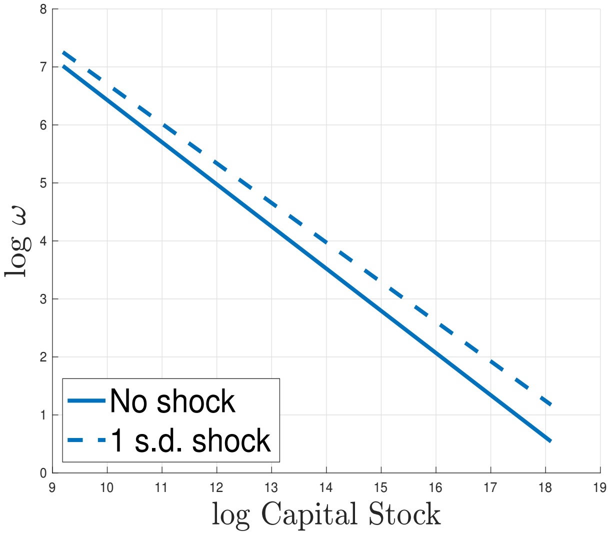

Figure 3: Effects of Trade Shock on Survival Probabilities.

Notes: This figure displays the effect of a 1-standard-deviation trade shock on survival probability. The solid line represents the isoprobability line (50% survival probability) without trade shocks. The dashed line refers to the same isoprobability line when firms face a 1-standard-deviation trade shock. The import-competition measure is $ChComp_{nt}$ and is instrumented using imports from China to border Latin American countries.

Investment. We now study the effects of import competition on firms' investment decisions, conditional on survival. How does the trade shock affect the likelihood of firms doing positive investment, negative investment, or inaction? To answer this question, we estimate the following specification:

$$z_{jnt} = \delta_0 + \delta_1 ChComp_{nt} + \delta_2 \log(\omega_{jnt}) + \delta_3 \log(k_{jnt}) + \gamma_n + \epsilon_{jnt} \tag{6}$$

where z_{jnt} are outcome variables, such as the size of the inaction region (fraction of firms for which the absolute value of the investment rate is less than 10%), fraction of positive investment (larger than 10%), and negative investment (lower than -10%), and γ_n are industry fixed effects.

We report results based on our IV strategy in Table 2. The first column shows that the import-competition shock increases the inaction region in the short run. This effect comes entirely from a decrease in the positive investment region (second column), rather than from significant effects on the negative investment region (third column). This result is explained by the fact that negative investment is a rare event to begin with, consistent with the presence of substantial irreversibility. Quantitatively, a one-standard-deviation trade shock brings the fraction of firms in the inaction region from an average value of 18.84% to 24.24%.

	Inaction	Positive Investment	Negative Investment
ChComp_{nt}	0.456	-0.537	0.081
	(0.092)	(0.107)	(0.065)

Table 2: The Effect of a Trade Shock on Investment Activity.

Notes: Standard errors clustered at the firm level in parenthesis.

Similar to what we did in Section 3, we also use our firm-level depreciation measure to investigate the role of capital composition. Specifically, we interact $ChComp_{nt}$ in equation 6 with firm-level depreciation rates. Consistent with the relevance of partial investment irreversibility, we find that the results in Table 2 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.

In Appendix C.7, we also analyze intensive-margin reallocation decisions at the firm-level, allowing for selection effects of the trade shock. We find that the shock induces a limited amount of reshuffling in the MRPK distribution, and most of the intensive-margin responses are accounted for by firms in the lowest tercile of MRPK.

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 and perform a counterfactual analysis that highlights the role of capital-reallocation frictions.

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:

$$U_0 \equiv \sum_{t=0}^{\infty} \beta^t \left(\log C_t - \chi N_t\right) \tag{7}$$

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

Aggregate consumption is a constant elasticity of substitution (CES) aggregator of a continuum of measure M_t of different varieties of goods

$$C_t = \left(\int_0^{M_t} c_{jt}^{\theta} dj\right)^{\frac{1}{\theta}} \tag{8}$$

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

The budget constraint of the household is

$$\int_0^{M_t} p_{jt} c_{jt} dj = N_t + \Pi_t \tag{9}$$

where we are normalizing the wage to 1, i.e. labor is the numeraire of our economy, and Π_t are aggregate dividends from ownership of all the firms in the economy.[32]

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

$$p_{jt} = c_{jt}^{-\frac{1}{\epsilon}} P_t C_t^{\frac{1}{\epsilon}} \tag{10}$$

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

The optimality condition for the consumption-leisure margin is $\chi C_t = \frac{1}{P_t}$, where the left-hand side reports the marginal rate of substitution between consumption and leisure and the right-hand side is the real wage.

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[32] 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.

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 $F(s_{jt}, s_{j,t+1})$.

Firms internalize the demand function (10) 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

$$p_{jt}y_{jt} = P_t C_t^{\frac{1}{\epsilon}} s_{jt}^{\theta} k_{jt}^{\theta\alpha} n_{jt}^{\theta(1-\alpha)}. \tag{11}$$

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).[33] 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.[34]

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

$$k_{j,t+1} = (1-\delta)\, k_{jt} + i_{jt} \tag{12}$$

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

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

[34] 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.

summarize the marginal cost of investment as follows

$$Q(i_{jt}) = \begin{cases} Q, & \text{if } i_{jt} \geq 0 \\ q, & \text{if } i_{jt} < 0 \end{cases} \tag{13}$$

In Section 6.6 and Appendix D.5 we present an extended model that also features convex capital adjustment costs, and delivers similar results.

We assume that the labor input is freely adjustable in every period. Hence, firms' labor choice is static: Firms optimally set the marginal revenue product of labor equal to the wage.

$$\theta(1-\alpha)P_t C_t^{\frac{1}{\epsilon}} s_{jt}^{\theta} k_{jt}^{\theta\alpha} n_{jt}^{\theta(1-\alpha)-1} = 1 \tag{14}$$

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 (10).

Each firm incurs an idiosyncratic fixed cost of operations f_{jt}, denominated in units of labor, iid across time and firms, with distribution $G(f;s)$.[35] 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 equals the present discounted value of its profits, which we express in units of the aggregate consumption goods. Thus, 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:

$$V^c(k,s,f,Z) = \max_{i,k'} P(Z)^{-1}\left[\pi(k,s,Z) - f - Q(i)i\right] + \beta\mathbb{E}\left[\frac{C(Z)}{C(Z')}V(k',s',f',Z')\,|s,Z\right] \tag{15}$$

subject to the capital accumulation equation (12), $k' = (1-\delta)k + i$, and the transition law for the aggregate state $Z' = \Gamma(Z)$. Notice that the continuation value in equation (15) discounts the future value using the household's discount factor, because households own all manufacturing firms. In other words, we explicitly allow general-equilibrium forces to shape

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[35] 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.

micro investment dynamics out of the stationary equilibrium, following the contribution of Khan and Thomas (2008).

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

$$V^{x}\left(k,s,Z\right)=P(Z)^{-1}\left[\pi(k,s,Z)+q(1-\zeta)\left(1-\delta\right)k\right] \tag{16}$$

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,

$$V\left(k,s,f,Z\right)=\max\left\{V^{c}\left(k,s,f,Z\right),V^{x}\left(k,s,Z\right)\right)\} \tag{17}$$

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

$$P(Z)^{-1}f^{e}\leq\max_{k'}-P(Z)^{-1}Qk'+\beta\mathbb{E}\left[\frac{C(Z)}{C(Z')}V\left(k',s',f',Z'\right)|s^{e},Z\right] \tag{18}$$

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.[36] 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.

5.6 Trade Shock and Aggregate Dynamics

After the trade shock, the foreign economy sells varieties $\left[M_t, M_t^F\right]$ in the domestic market at exogenous price p_t^F. We model this shock as an unexpected change that hits the economy in its stationary equilibrium. After the shock, the key aggregates move over time

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[36] 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.

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, the value functions in Bellman equations (15), (16), (17), (18) depend on the aggregate state $Z_t \equiv \lambda_t(k_{it}, s_{it})$.

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

$$C_t = \left(\int_0^{M_t} y_{j,t}^{\theta} dj + \int_{M_t}^{M_t^F} c_{j,t}^{\theta} dj \right)^{\frac{1}{\theta}}. \tag{19}$$

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

$$\int_0^{M_t} Q(i_{jt}) i_{jt} dj + p_t^F \int_{M_t}^{M_t^F} c_{j,t} dj = p^X X_t. \tag{20}$$

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 and perform our key counterfactual of interest.

6.1 Calibration

We now describe our choices for parameter values, reported in Table 3. 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. Consistent with our measurement assumptions, we set the value of the elasticity of substitution across varieties following the literature (e.g., Bloom, 2009; 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. Consistent with the procedure described in Section 2.2, given the elasticity of substitution ϵ, we measure the median labor share and use it to inform our calibration of the capital share α. Next, we set δ 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.[37] 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 revenue productivity ω; (ii) standard deviation of ω; (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 productivity of exiting firms (relative to continuing firms).[38] 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, $1 - \frac{q}{Q}$, implies that firms lose approximately 40% of the value of their used capital when they downsize. This estimate is close to the high end of existing estimates in the literature. For instance, Bloom (2009) estimates a resale loss of 34% using US data. This is consistent with the presence of large frictions in our empirical setting. When firms exit, they lose an additional 19%.

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[37] 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.6, we report the key results from a simplified version of the model, in which the distribution of f is independent of s.

[38] As far as the idiosyncratic productivity process is concerned, we target the properties of residualized revenue productivity ω, 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.

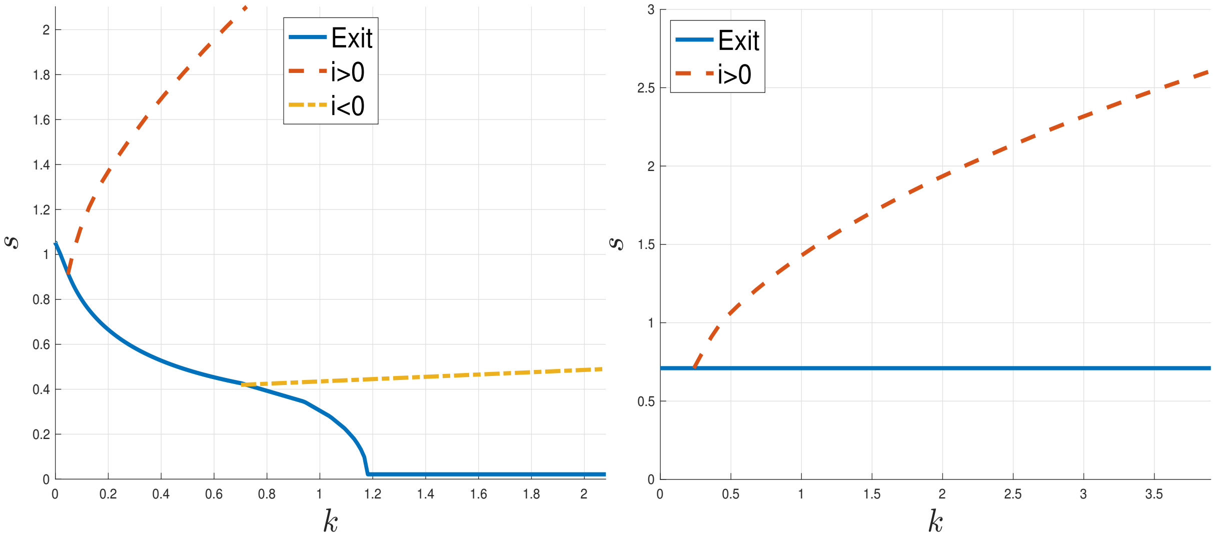
PARAMETER	VALUE	TARGET / SOURCE
β	0.96	STANDARD (ANNUAL FREQUENCY)
χ	2.15	HOURS WORKED
ϵ	4	LITERATURE
α	0.396	CAPITAL SHARE
δ	0.105	DEPRECIATION RATE
ρ	0.783	AUTOCORRELATION OF ω
σ	0.797	STANDARD DEVIATION OF ω
q/Q	0.567	FREQUENCY OF NEGATIVE INVESTMENT
ζ	0.186	SLOPE OF EXIT THRESHOLDS
η_0	0.0744	EXIT RATE
η_1	4.861	RELATIVE SIZE AT EXIT
η_2	4.864	RELATIVE PRODUCTIVITY AT EXIT

Table 3: 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.



(a) Baseline model

(b) Frictionless model

Figure 4: Thresholds for Investment, Disinvestment, and Exit.

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 4 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.[39] In contrast, a frictionless model predicts that there is no

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[39] 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.

persistence in MRPK. Moreover, partial irreversibility 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, 1.29 in the baseline model, and 1.09 in the frictionless model).

		Tercile at $t+1$		
		1	2	3
	1	0.62	0.28	0.10
Tercile at t	2	0.36	0.38	0.26
	3	0.15	0.35	0.50

(a) Baseline Model

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

(b) Frictionless Model

Table 4: Mobility (Transition Probabilities) of MRPK in Stationary Equilibrium.

Furthermore, while we directly target the *frequency* of negative investment, our model is also broadly consistent with the average *size* of negative investment episodes. This moment equals 0.175 in the model, close to its empirical counterpart of approximately 0.2 in the industries we consider in our empirical analysis (see Table B1 in Appendix B.2).

Overall, the stationary equilibrium of the model is consistent with the main facts about capital reallocation that we document 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.[40]

6.3 Long-Run Effects of Import Competition

We set the value of two parameters governing the magnitude of the trade shock (i.e., the mass of additional varieties $M^F - M$ and their price p^F) to match two targets, namely the (long-term) import penetration of Chinese goods in Peru, and the relative price of Chinese imports (relative to domestic goods). Specifically, at the end of our sample, the import penetration of China in Peru is approximately 10%. Over the period 2001-2014, the price

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[40] 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 then 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.

index of Chinese manufacturing goods in Peru averages approximately one half the price of domestically produced manufacturing goods.[41]

We first compute the final steady state with trade and compare key aggregates of interest in Table 5. The first column lists the key aggregate variables: consumption, capital, hours worked in manufacturing, the mass of active firms, and average physical total factor productivity s (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 0.73%, 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, which induces substitution of domestic demand toward imported varieties, and reallocation of labor toward the production of commodities for export. Because of improved selection in manufacturing, 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.

VARIABLE	$\Delta\%$
C	0.73
K	-10.62
$N(Manuf.)$	-9.97
M	-9.36
$TFPQ(Average)$	1.44

Table 5: 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

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[41] We use Peruvian firms' export prices to proxy for the price of domestic goods.

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 reallocation response of domestic manufacturing.[42] Figure 5 displays the transitional dynamics of the aggregate price level (top left), aggregate capital stock (top right), aggregate hours in manufacturing (bottom left), and mass of active firms (bottom right). After the trade shock hits, the increase in competition induces a drop in the price level, which 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.

The magnitude of the selection effect of import competition is close to its empirical counterpart (Section 4.2): The exit rate increases by approximately 1.7 percentage points on impact. While our calibration only targets the slope of the exit thresholds, the model also produces an empirically plausible shift in these thresholds in response to the trade shock.

Moreover, consistent with the patterns of selection in stationary equilibrium, as well as with our empirical evidence, 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.

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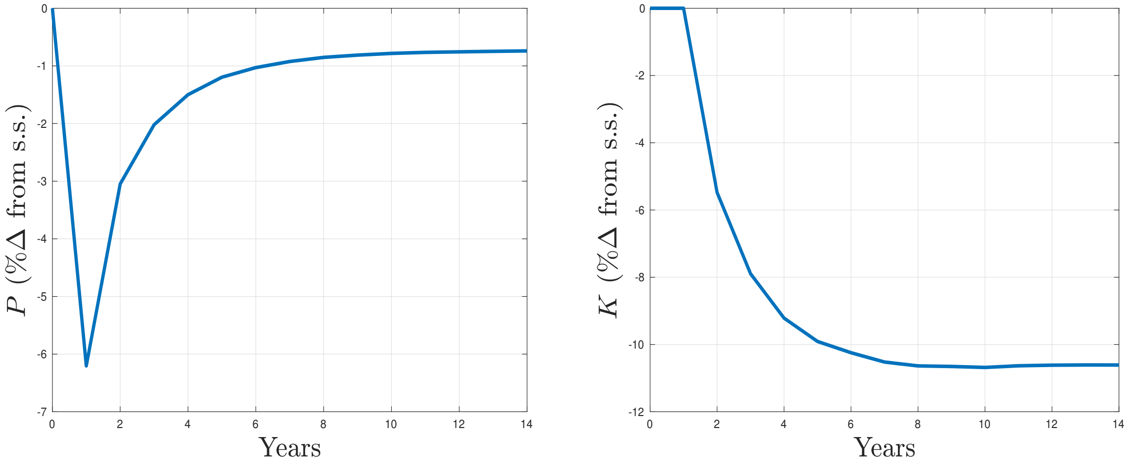
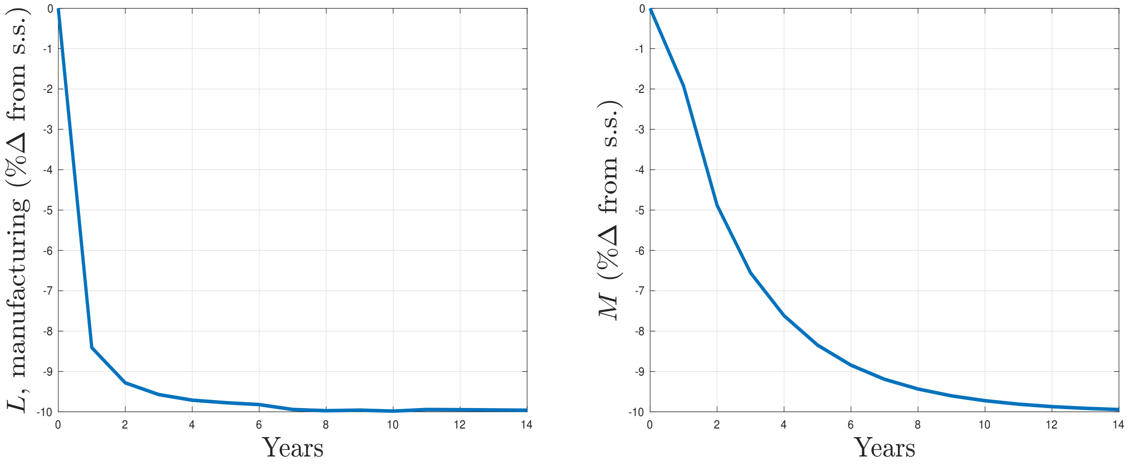
[42] The path of import penetration over time is displayed in Figure D1 in Appendix D.4.



(a) Price Index (b) Capital



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

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.

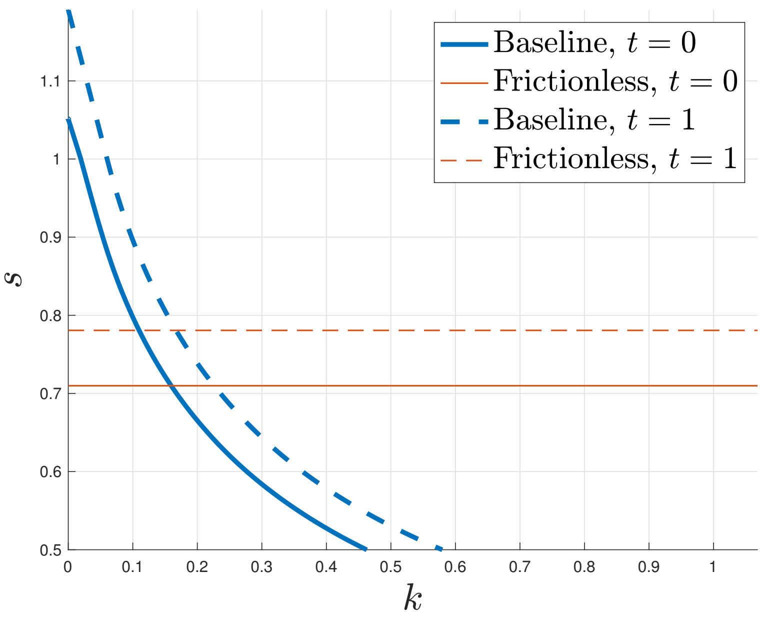


Figure 6: Exit Thresholds Before the Trade Shock and on Impact.

Notes: This figure displays the effect of the trade shock on exit thresholds in the baseline model (thick blue lines) and frictionless model (thin red lines). Solid lines refer to the initial stationary equilibrium ($t = 0$). 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.

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 significantly lower gain in average TFPQ relative to the comparison model. In the frictionless model, average productivity increases substantially faster. In fact, on impact, the sudden improvement in firm selection on productivity leads to an overshoot of average productivity.[43] On the other hand, in the presence of capital-reallocation frictions, the transition of this variable is sluggish. In the long run, we find that average productivity increases by approximately 1.5%, and the initial effect is only slightly over one half the long-run effect. 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.

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[43] This finding is consistent with the predictions of Chaney (2005) in a model without capital.

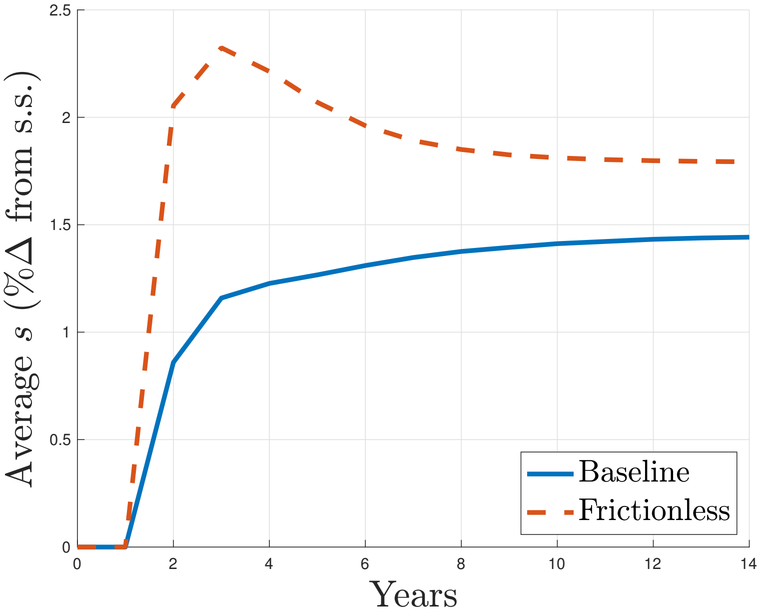

Figure 7: Average Firm Productivity After the Trade Shock.

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 (Table 2), the widening of the inaction region is accounted for by a large shift on the positive investment margin.[44]

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[44] 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.

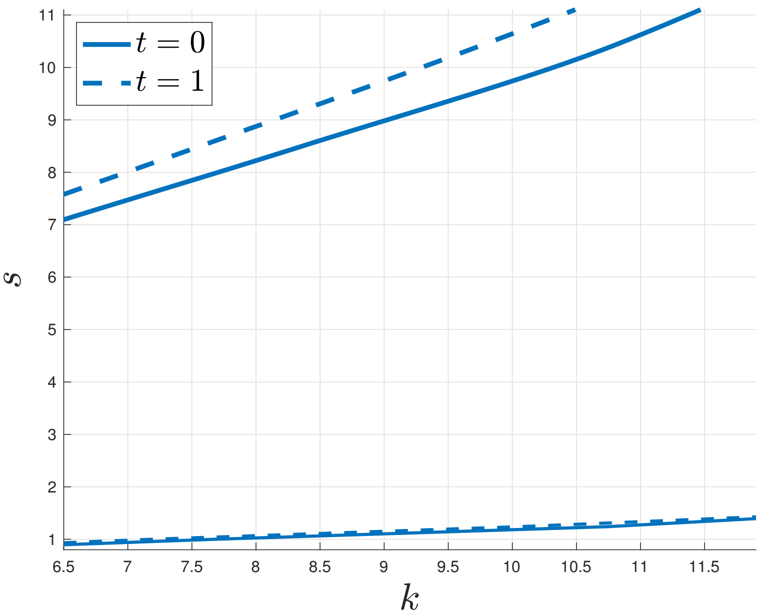


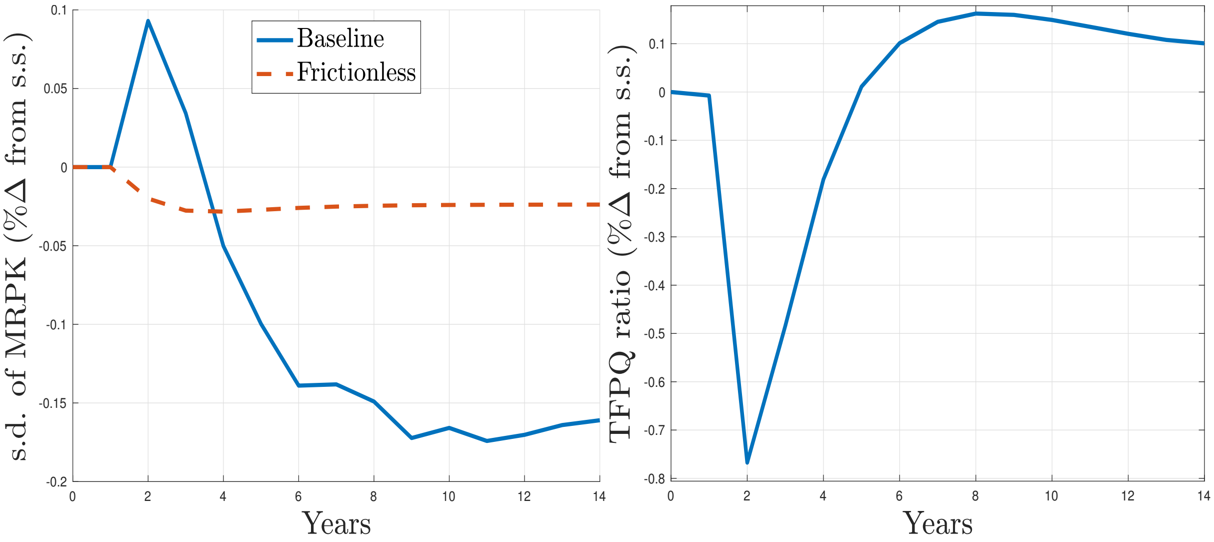
Figure 8: Thresholds for Investment and Disinvestment Before the Trade Shock and on Impact.

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, especially so in the baseline model, suggesting that the trade shock improves the allocation of capital in the long run. In the short run, the dynamic responses of the two models are quite different. In the baseline model, the increase in the size of the inaction region, coming from a decline in the fraction of investing firms, leads to an increase in the dispersion of MRPK; in contrast, the dispersion of MRPK 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 0.8 percent of the initial value). 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. Notice that the stationary equilibria (initial and final) of the baseline model differ from the respective stationary equilibria (initial and final) of the frictionless model. Figures 9a and 9b display percentage deviations of each series from its corresponding initial stationary equilibrium. Thus, our results do not imply that the long-run allocation is more efficient in the baseline model. Naturally, the opposite is true. Our results show that the long-run *improvement* in allocative efficiency is (slightly) larger in the baseline model than in the frictionless model.



(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 all variables expressed as percentage changes relative to the initial stationary equilibrium. Notice that the stationary equilibria (initial and final) of the baseline model differ from the respective stationary equilibria (initial and final) of the frictionless model.

We conclude this section by briefly discussing the welfare effects of the trade shock in our model.[45] We find that accounting for transitional dynamics leads to welfare gains from trade equal to approximately 0.3% 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

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[45] These results are reported in more detail in Appendix D.4.

from the favorable terms of trade induced by cheap manufacturing and a constant price of exported commodities.[46] Hence, while productivity gains materialize slowly over time, welfare gains materialize early in the transition. 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. Overall, welfare gains from the trade shock would thus be larger in the absence of capital reallocation frictions.

6.6 Further Analyses and Sensitivity

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

Convex adjustment costs. Our baseline calibration focuses on irreversibility as the only adjustment cost, and targets the degree of asymmetry in the investment distribution. As is typically the case in models with irreversibility, this parsimonious approach tends to overstate the degree of lumpiness of investment, implying that the overall dispersion in investment rates is larger in the model (the standard deviation equals 1.87) than in the data (0.83). We thus generalize our model to target this additional moment. To this end, we include convex (quadratic) capital adjustment costs, as well as partial irreversibility. We then jointly recalibrate all parameters, including the degree of irreversibility on the intensive and extensive margin, to match our baseline targets as well as the dispersion of investment rates. In Appendix D.5 we report all results related to this additional analysis. Here, we highlight two points. First, introducing convex adjustment costs does not alter significantly our estimated degree of irreversibility. This result suggests that our baseline estimates for reallocation frictions are robust, and necessary to account for the data, and not the result of omissions of alternative types of adjustment costs. Second, when we feed the trade shock in the generalized model with convex costs, the aggregate dynamics are remarkably similar to our baseline results. Moreover, the presence of convex costs further magnifies the increase in the dispersion of MRPK induced by the trade shock, reinforcing our mechanism. Given the similarity of results, we choose to focus on a more parsimonious model with only asymmetric reallocation frictions as a baseline for our exposition.

Furthermore, our baseline calibration does not target the transition matrix of MRPK. We thus perform a further analysis and experiment with larger convex costs to assess

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[46] The overshooting result and its welfare implications appear to be consistent with the recent analysis of Alessandria, Choi, and Ruhl (2018).

whether they can bring MRPK persistence in the model closer to the data. We find that convex costs increase overall MRPK persistence, and can increase the probability of remaining in the bottom tercile of MRPK up to 0.73 (this probability equals 0.62 in our baseline model and 0.82 in the data).

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 recalibrate our parameters, but restrict $\eta_1 = \eta_2 = 0$. We find that the model fit worsens, particularly as far as the moments related to exiting firms (see Appendix D.6). 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.

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APPENDICES

A Data and Measurement: Additional Details

A.1 Alternative Definitions of Revenue Productivity

In this section, we clarify the distinction between two definitions of revenue productivity, namely the one we adopt, as in Asker, Collard-Wexler, and De Loecker (2014), and the one used, for instance, by Hsieh and Klenow (2009).

Recall the key assumptions on technology and demand, which we use as a guide for measurement (Section 2.2) and posit in our theoretical model (Section 5). The production function is

$$y_{jt} = s_{jt} k_{jt}^{\alpha} n_{jt}^{1-\alpha} \tag{A1}$$

where s_{jt} is physical total factor productivity, or TFPQ.

Demand for firm j's output is

$$y_{jt} = B p_{jt}^{-\epsilon} \tag{A2}$$

where, for simplicity of exposition, we focus on a stationary equilibrium and thus set the aggregate component $B_t = B$ equal to a constant.

Thus, revenue can be expressed as follows:

$$p_{jt} y_{jt} = B^{\frac{1}{\epsilon}} s_{jt}^{\theta} k_{jt}^{\theta\alpha} n_{jt}^{\theta(1-\alpha)} \tag{A3}$$

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

We define (log) revenue productivity as in Asker, Collard-Wexler, and De Loecker (2014):

$$\log(\omega_{jt}) \equiv \log(p_{jt} y_{jt}) - \theta\alpha \log(k_{jt}) - \theta(1-\alpha)\log(n_{jt}) = \frac{1}{\epsilon}\log(B) + \theta \log(s_{jt}) \tag{A4}$$

Hsieh and Klenow (2009) define (log) revenue productivity as follows:

$$\begin{aligned}
\log(\tilde{\omega}_{jt}) \equiv \log(p_{jt} s_{jt}) &= \log(p_{jt} y_{jt}) - \alpha \log(k_{jt}) - (1-\alpha)\log(n_{jt}) && \text{(A5)}\\
&= \frac{1}{\epsilon}\log(B_t) + \theta \log(s_{jt}) - \frac{1}{\epsilon}\left[\log(y_{jt}) - \log(s_{jt})\right] && \text{(A6)}\\
&= \log(\omega_{jt}) - \frac{1}{\epsilon}\left[\log(y_{jt}) - \log(s_{jt})\right] && \text{(A7)}
\end{aligned}$$

Marginal revenue products of capital and labor (in logs) are defined as follows:

$$\log(MRPK_{jt}) = \log(\alpha\theta) + \log(p_{jt}y_{jt}) - \log(k_{jt}) \tag{A8}$$

$$\log(MRPN_{jt}) = \log((1-\alpha)\theta) + \log(p_{jt}y_{jt}) - \log(n_{jt}) \tag{A9}$$

Then, Hsieh and Klenow (2009) obtain the following expression:

$$\log(\tilde{\omega}_{jt}) = const + \alpha\log(MRPK_{jt}) + (1-\alpha)\log(MRPN_{jt}) \tag{A10}$$

For simplicity, assume $MRPN_{jt}$ is equalized across j, as implied by the model of Section 5. Then, $\log(\tilde{\omega}_{jt})$ has the same statistical properties of $\log(MRPK_{jt})$, which in turn depend on any distortions or adjustment frictions in capital, whereas $\log(\omega_{jt})$ has the same statistical properties of $\log(s_{jt})$, i.e., is exogenous with respect to distortions and adjustment frictions.

A.2 Number of Firms and Exit Rates

Table A1 documents the relevance of our correction in the measurement of exit, which relies on matching the EEA with the firm registry, in the aggregate and by industry. The first column shows the number of firms throughout the sample period in our EEA sample. Column 2 describes the raw exit rate of the sample. In particular, this exit rate is constructed considering that the maximum year that a firm appears on the sample correspond to the the exit year. As mentioned in Section 2.1, this approach overestimates exit due to the fact that the EEA is a sample for small firms, and thus attrition from the survey can be misinterpreted as exit. Column 3 correspond to the EEA exit rates corrected with the Peruvian firms' registry for 2007-2013. For all firms that we can match based on tax ID, we replace the EEA exit date with the exit date from the registry. As shown, exit rates in all industries decrease considerably, as well as the aggregate one.

Industry	N. Firms EEA	Exit Raw	Exit Corrected
Food-Beverages	1,058	38.96	30.80
Textiles	728	20.73	12.88
Apparel	926	32.94	23.92
Printing	881	30.70	20.93
Chemical	603	14.34	7.94
Mach-Eq nec	565	28.73	13.07
Total	4,761	27.36	18.39

Table A1: Summary Statistics of Samples and Exit Rates.

A.3 Depreciation Rates

To construct firm-level depreciation rates we proceed as follows. First, for each firm j and year t, we construct the share S_{jlt} 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 δ_{lt} for the U.S. We then use these depreciation rates to compute firm-year-specific average depreciation rates, using the following formula:

$$\delta_{jt} = \sum_{l} S_{ilt}\delta_{lt} \tag{A11}$$

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.

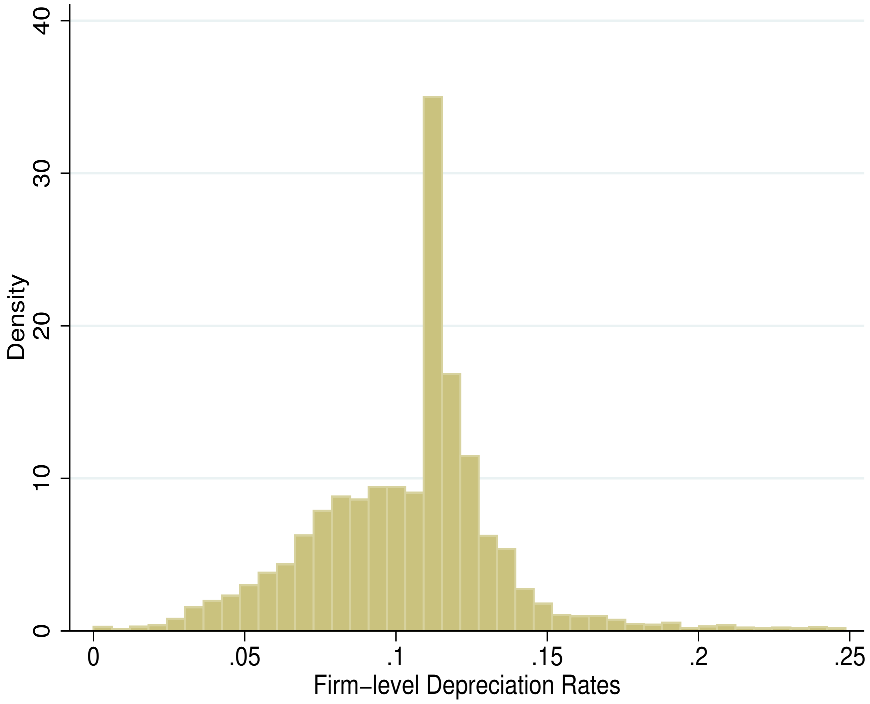

Figure A1: Distribution of Imputed Firm-level Depreciation Rates.

Notes: This figure is a histogram of firm-level depreciation rates.

B Capital-Reallocation Frictions: Additional Details and Robustness

B.1 Dispersion of MRPK and Volatility of ω

Figure B1 shows a scatter plot of the dispersion in MRPK against the volatility of revenue productivity ω 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 ω refers to the standard deviation of the innovations to ω, computed as the residual of an AR(1) process. We also overlay the implied predicted dispersion in MRPK by fitting an OLS regression line.

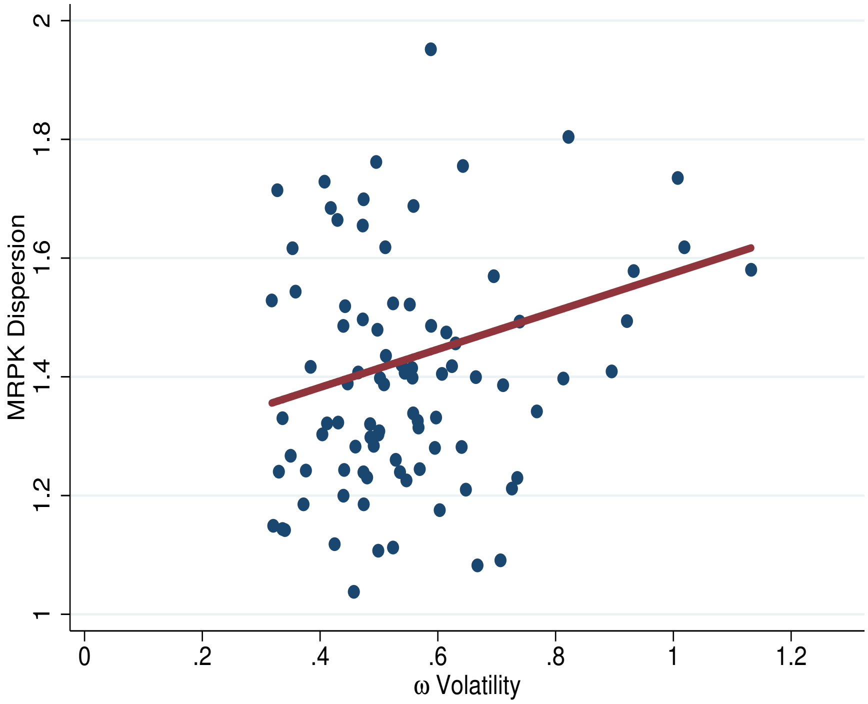

Figure B1: Dispersion of MRPK and Volatility of ω.

Notes: Each observation is a single industry-year pair with associated MRPK dispersions and ω 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 the summary statistics related to the distribution of investment rates. The investment rate of firm j in year t is constructed as $\frac{i_{jt}}{k_{jt}}$, with

$$i_{jt} \equiv k_{j,t+1} - (1-\delta_{jt})\, k_{jt}$$

where δ_{jt} is the depreciation rate. Section 2 in the main text and Appendix A.3 provide more details on how the firm level depreciation rates are constructed, and report the distribution and characteristics of our constructed depreciation rates. Notice that the key features of the distribution of investment rates that we target in the quantitative model are not significantly different if we use a constant firm depreciation rate for all firms.

As is common in firm-level data, investment is lumpy and volatile, which is reflected in Figure B2 and Table B1.

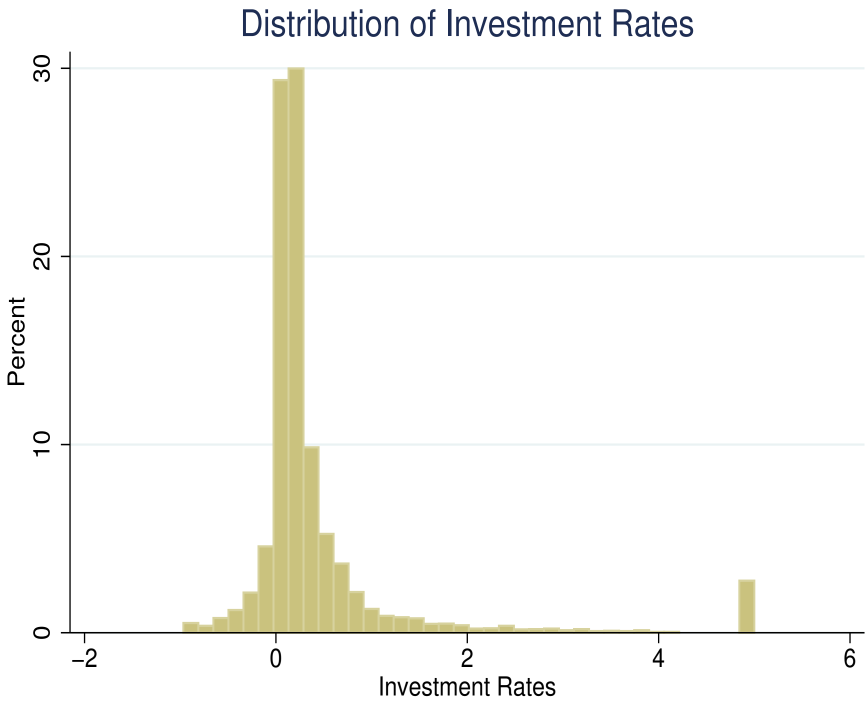

Figure B2: Distribution of Investment Rates.

Notes: This figure is a histogram of firm-level investment rates. The distribution is winsorized at the 5th and 95th percentile.

Industry	Food	Textiles	Apparel	Printing	Chemical	Machinery
Median	0.159	0.159	0.188	0.169	0.158	0.170
St. Dev.	0.868	0.778	0.917	0.870	0.685	0.941
Fraction $\frac{i}{k} < 0$	0.101	0.085	0.121	0.120	0.110	0.123
$E[\frac{i}{k} \| \frac{i}{k} < 0]$	-0.214	-0.164	-0.207	-0.213	-0.179	-0.208
Inaction (fraction $\frac{\|i\|}{k} < 10\%$)	0.186	0.188	0.175	0.142	0.227	0.196

Table B1: Summary Statistics of the Distribution of Investment Rates.

B.3 Dynamics of MRPK: Transition Matrices

In this section, we report the transition matrices for MRPK terciles, allowing for exit as an additional state, and by industry. We then report the transition matrices for terciles of productivity ω.

B.3.1 MRPK Transition Matrices: Including Exit

		at $t+1$			
		1	2	3	exit
Tercile at t	1	0.62	0.12	0.01	0.25
		(0.01)	(0.00)	(0.00)	(0.01)
	2	0.15	0.55	0.10	0.20
		(0.00)	(0.01)	(0.00)	(0.01)
	3	0.02	0.13	0.52	0.33
		(0.00)	(0.00)	(0.01)	(0.01)

Table B2: Transition Probabilities of MRPK, with Exit.

Notes: Bootstrapped standard errors in parentheses.

B.3.2 MRPK Transition Matrices: by Industry

		at $t+1$		
		1	2	3
Tercile at t	1	0.80	0.18	0.02
		(0.01)	(0.01)	(0.00)
	2	0.20	0.67	0.13
		(0.01)	(0.01)	(0.01)
	3	0.06	0.23	0.72
		(0.01)	(0.02)	(0.02)

(a) Food

		at $t+1$		
		1	2	3
Tercile at t	1	0.83	0.16	0.01
		(0.01)	(0.01)	(0.00)
	2	0.20	0.71	0.10
		(0.01)	(0.01)	(0.01)
	3	0.05	0.21	0.74
		(0.01)	(0.01)	(0.01)

(b) Textiles

		at $t+1$		
		1	2	3
Tercile at t	1	0.78	0.18	0.04
		(0.01)	(0.01)	(0.01)
	2	0.20	0.67	0.13
		(0.01)	(0.01)	(0.01)
	3	0.06	0.20	0.75
		(0.01)	(0.01)	(0.01)

(c) Apparel

		at $t+1$		
		1	2	3
Tercile at t	1	0.83	0.16	0.01
		(0.01)	(0.01)	(0.00)
	2	0.17	0.70	0.13
		(0.01)	(0.01)	(0.01)
	3	0.02	0.24	0.74
		(0.01)	(0.01)	(0.02)

(d) Printing

		at $t+1$		
		1	2	3
Tercile at t	1	0.85	0.14	0.01
		(0.01)	(0.01)	(0.00)
	2	0.16	0.70	0.14
		(0.01)	(0.01)	(0.01)
	3	0.02	0.14	0.84
		(0.00)	(0.01)	(0.01)

(e) Chemicals

		at $t+1$		
		1	2	3
Tercile at t	1	0.84	0.15	0.01
		(0.01)	(0.01)	(0.00)
	2	0.23	0.65	0.12
		(0.01)	(0.02)	(0.01)
	3	0.02	0.19	0.79
		(0.00)	(0.01)	(0.01)

(f) Machinery Eq

Table B3: Transition Matrices of MRPK, by Industry.

Notes: Bootstrapped standard errors in parentheses.

B.3.3 Transition Matrices for ω

One natural question is whether the asymmetric persistence of MRPK is driven by asymmetric ω shocks. It is worth highlighting that the persistence of ω has no impact on the persistence of MRPK if firms can easily adjust their capital stock.[47] However, given that we argue that reallocation frictions are likely to be sizable, we also estimate the transition probabilities for ω. Table B4 shows that generally ω does *not* exhibit substantial asymmetry in persistence; if anything, it appears to be more persistent in the right tail. Table B5 corroborates that notion by estimating the ω transition matrices by industry.

		at $t+1$		
		1	2	3
Tercile at t	1	0.71	0.23	0.06
		(0.01)	(0.01)	(0.00)
	2	0.23	0.60	0.17
		(0.00)	(0.01)	(0.00)
	3	0.04	0.20	0.76
		(0.00)	(0.00)	(0.00)

Table B4: Transition Probabilities of ω.

Notes: Bootstrapped standard errors in parentheses.

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[47] Tan (2020a) proves this result.

		at $t+1$		
		1	2	3
	1	0.71	0.24	0.06
Tercile at t		(0.02)	(0.02)	(0.01)
	2	0.22	0.60	0.18
		(0.01)	(0.02)	(0.01)
	3	0.04	0.20	0.76
		(0.01)	(0.01)	(0.01)

(a) Food

		at $t+1$		
		1	2	3
	1	0.71	0.19	0.09
Tercile at t		(0.01)	(0.01)	(0.01)
	2	0.25	0.61	0.14
		(0.01)	(0.01)	(0.01)
	3	0.04	0.21	0.75
		(0.00)	(0.01)	(0.01)

(b) Textiles

		at $t+1$		
		1	2	3
	1	0.72	0.25	0.04
Tercile at t		(0.02)	(0.02)	(0.01)
	2	0.23	0.59	0.18
		(0.01)	(0.01)	(0.01)
	3	0.05	0.24	0.71
		(0.01)	(0.01)	(0.01)

(c) Apparel

		at $t+1$		
		1	2	3
	1	0.68	0.24	0.08
Tercile at t		(0.02)	(0.02)	(0.01)
	2	0.25	0.59	0.16
		(0.01)	(0.01)	(0.01)
	3	0.06	0.24	0.71
		(0.01)	(0.01)	(0.01)

(d) Printing

		at $t+1$		
		1	2	3
	1	0.75	0.22	0.03
Tercile at t		(0.01)	(0.01)	(0.00)
	2	0.19	0.63	0.18
		(0.01)	(0.01)	(0.01)
	3	0.02	0.17	0.81
		(0.00)	(0.01)	(0.01)

(e) Chemicals

		at $t+1$		
		1	2	3
	1	0.61	0.28	0.11
Tercile at t		(0.02)	(0.02)	(0.02)
	2	0.26	0.58	0.16
		(0.02)	(0.02)	(0.01)
	3	0.04	0.16	0.80
		(0.01)	(0.01)	(0.01)

(f) Machinery Eq

Table B5: Transition Matrices for ω by Industry.

Notes: Bootstrapped standard errors in parentheses.

B.4 Firm-Level Depreciation and MRPK Persistence

We analyze the impact of capital depreciation rates on the persistence of a firms' MRPKs by estimating the following probit model:

$$\mathcal{I}_{jnt}\left(q'=q\right)=\begin{cases}0 & \text{if } Y_{jnt}<0\\ 1 & \text{if } Y_{jnt}\geq 0\end{cases} \tag{B1}$$

$$Y_{jnt}=a+\eta\delta_{jt}+\theta X_{jt}+\gamma_n+\gamma_t+\epsilon_{jnt} \tag{B2}$$

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

Figure B3 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.

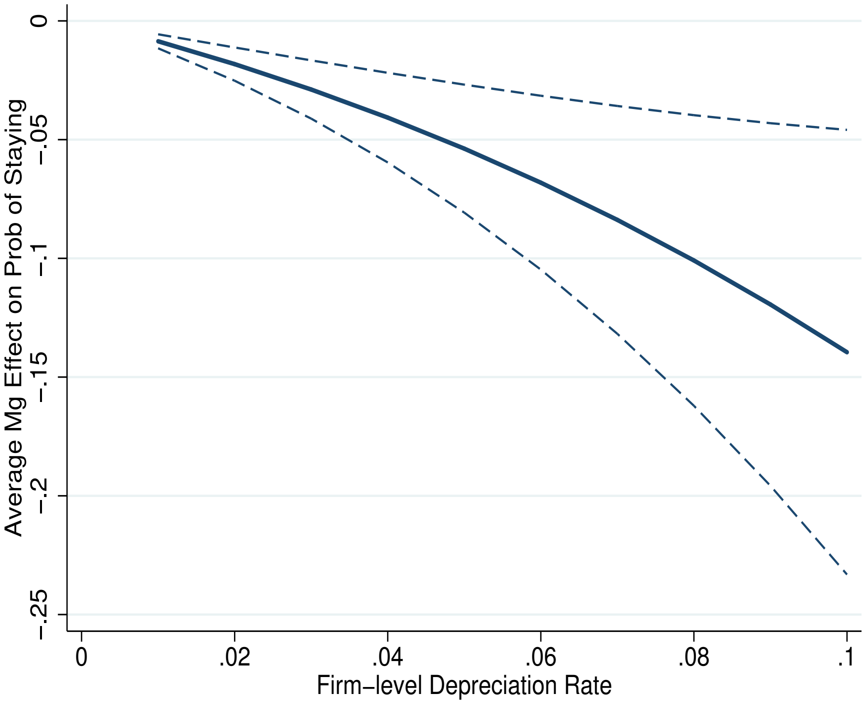


Figure B3: The Effect of Depreciation Rates on the Persistence of Low MRPKs.

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.5 Capital Type and MRPK Persistence

To examine what type of capital drives the left tail persistence of the MRPK distribution, we run the following autocorrelation specification,

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

where $\log MRPK_{jnt}$ refers to the log of the MRPK measure for firm j in industry n at time t, constructed using as a proxy for capital a particular type of fixed asset (e.g., machinery or computational equipment), and $\mathcal{I}_{jnt-1,q}$ is a dummy variable that takes value 1 if firm j in industry t belong to tercile q of the MRPK distribution at time $t-1$. γ_j is an industry fixed effect, and γ_t is a year fixed effect.

Table B6 shows the autocorrelation coefficients for two separate specifications. The first row refers to the pooled autocorrelation, while the second to fourth display the heterogenous effects.

	Buildings and Fixed Instalations	Machinery	Transport Units	Computational Equipment	Furniture
ρ (no interaction)	0.781	0.813	0.782	0.753	0.794
	(0.021)	(0.022)	(0.045)	(0.028)	(0.022)
ρ_1 (1st tercile MRPK)	0.864	0.859	0.266	0.380	0.428
	(0.027)	(0.025)	(0.057)	(0.058)	(0.036)
ρ_2 (2nd tercile MRPK)	0.244	0.608	0.587	0.631	0.693
	(0.025)	(0.047)	(0.055)	(0.042)	(0.023)
ρ_3 (3rd tercile MRPK)	0.804	0.812	0.843	0.755	0.798
	(0.021)	(0.022)	(0.027)	(0.028)	(0.019)

Table B6: Autocorrelation of MPRK by Capital Type.

B.6 Capital Utilization and MRPK 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 autocorrelation specification with the corrected measure of MRPK.

$$\log MRPK_{jnt} \;=\; \alpha + \sum_{q\in\{1,2,3\}} (\rho_q \log MRPK_{jnt-1} \times \mathcal{I}_{jnt-1,q}) + \gamma_n + \gamma_t + \epsilon_{jnt} \quad \text{(B4)}$$

where $\log MRPK_{jnt}$ refers to the log of the MRPK measure for firm j in industry n at time t, corrected and uncorrected with utilization, and $\mathcal{I}_{jnt-1,q}$ is a dummy variable that takes value 1 if firm j in industry t belong to tercile q of the MRPK distribution at time $t-1$. γ_j is an industry fixed effect, and γ_t is a year fixed effect.

Table B7 shows the results with the corrected measure (first column), and our baseline MRPK (second column). The first raw refers to the autocorrelation coefficient in a pooled specification, while the second to fourth display the heterogeneous effects.

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

Table B7: 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 persitence on the first tercile.

		at $t+1$		
		1	2	3
Tercile at t	1	0.72	0.23	0.06
		(0.02)	(0.01)	(0.01)
	2	0.16	0.64	0.20
		(0.01)	(0.02)	(0.01)
	3	0.05	0.18	0.77
		(0.01)	(0.01)	(0.01)

(a) Food

		at $t+1$		
		1	2	3
Tercile at t	1	0.79	0.17	0.03
		(0.01)	(0.01)	(0.00)
	2	0.21	0.70	0.08
		(0.01)	(0.01)	(0.01)
	3	0.04	0.17	0.79
		(0.01)	(0.01)	(0.01)

(b) Textiles

		at $t+1$		
		1	2	3
Tercile at t	1	0.72	0.21	0.07
		(0.02)	(0.01)	(0.01)
	2	0.17	0.61	0.22
		(0.01)	(0.01)	(0.01)
	3	0.05	0.23	0.72
		(0.01)	(0.01)	(0.01)

(c) Apparel

		at $t+1$		
		1	2	3
Tercile at t	1	0.70	0.25	0.05
		(0.02)	(0.01)	(0.01)
	2	0.25	0.58	0.18
		(0.01)	(0.01)	(0.01)
	3	0.05	0.21	0.74
		(0.01)	(0.01)	(0.01)

(d) Printing

		at $t+1$		
		1	2	3
Tercile at t	1	0.85	0.11	0.04
		(0.01)	(0.01)	(0.00)
	2	0.12	0.77	0.11
		(0.01)	(0.01)	(0.01)
	3	0.03	0.13	0.83
		(0.00)	(0.01)	(0.01)

(e) Chemicals

		at $t+1$		
		1	2	3
Tercile at t	1	0.78	0.18	0.04
		(0.02)	(0.02)	(0.01)
	2	0.17	0.62	0.20
		(0.01)	(0.02)	(0.01)
	3	0.05	0.22	0.74
		(0.01)	(0.01)	(0.02)

(f) Machinery Eq

Table B8: Transition Matrices of Utilization Correction MRPK, by Industry.

Notes: Bootstrapped standard errors in parentheses.

B.7 Employment Subsidies or State-Owned Enterprises

We now discuss some alternative explanations for our findings on MRPK mobility.

A possible driver for asymmetric MRPK persistence is the presence of employment subsidies for large firms; this type of distortion might lead poorly performing firms to remain large. Figure B4 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.

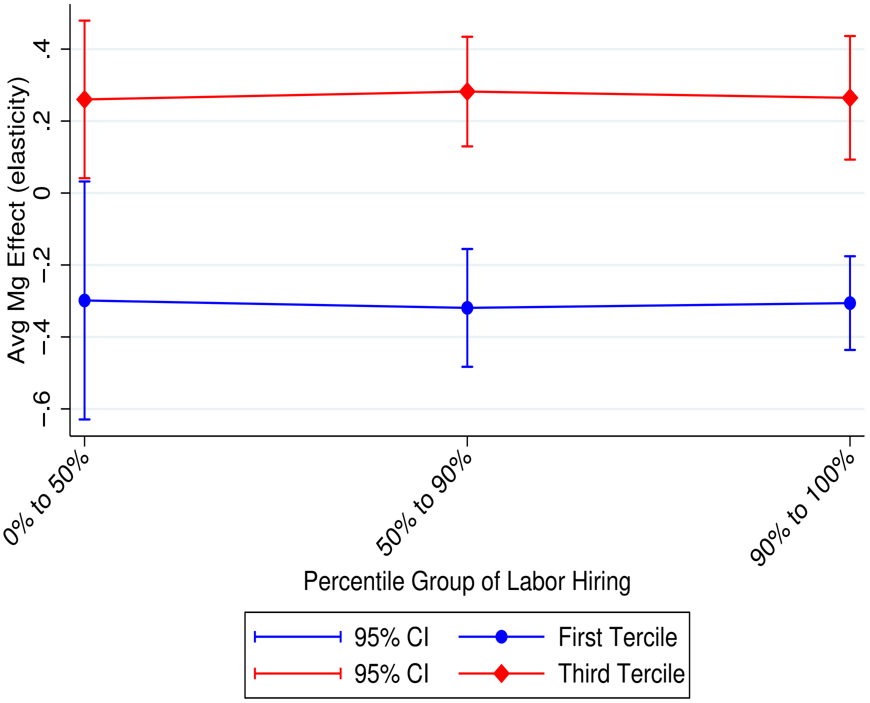


Figure B4: Effect of Firm Size by Employment on Tail Persistence.

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.

Moreover, state-owned firms could also be subsidized to stay in the market. However, there are no state-owned enterprises in any of the six industries of analysis.

B.8 Variance Decomposition of MRPK Changes

We now 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,

$$\log MRPK_t = \log(\alpha\theta) - \log(k_t) + \log(p_t y_t) \tag{B5}$$

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

$$\implies var(\log(\frac{MRPK_{t+1}}{MRPK_t})) = var(\log(\frac{k_{t+1}}{k_t})) + var(\log(\frac{p_{t+1}y_{t+1}}{p_t y_t})) + cov(\log(\frac{k_{t+1}}{k_t}), \log(\frac{p_{t+1}y_{t+1}}{p_t y_t})) \tag{B7}$$

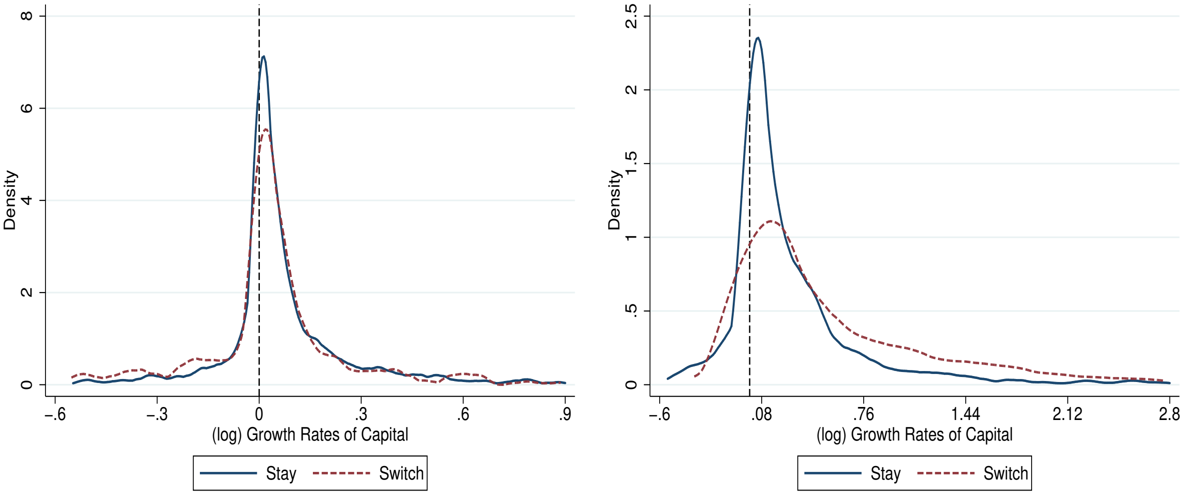
The growth rate of MRPK can be decomposed into a component that comes from the choice of capital (i.e. k_{t+1}), and a component that arises from a shock to value added in the following period (i.e. $p_{t+1}y_{t+1}$). This decomposition is reflected in Table B9. Moreover, this also implies that *mechanically*, the probability that a firm stays in a current quantile is simply a combination of the change in the firm's capital stock and the shock to profitability in the next period.

	First Tercile	Third Tercile
$var(\log(\frac{k_{t+1}}{k_t})))$	0.13	0.85
$var(\log(\frac{p_{t+1}y_{t+1}}{p_t y_t}))$	0.53	0.43
$cov(\log(\frac{k_{t+1}}{k_t}), \log(\frac{p_{t+1}y_{t+1}}{p_t y_t}))$	0.05	0.08

Table B9: Variance Decomposition of Growth Rate of MRPK

Given the decomposition above, we see that for firms in the first tercile, the majority of the variation in MRPK is 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 good productivity draws in the following 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 ω 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 ω growth rates.

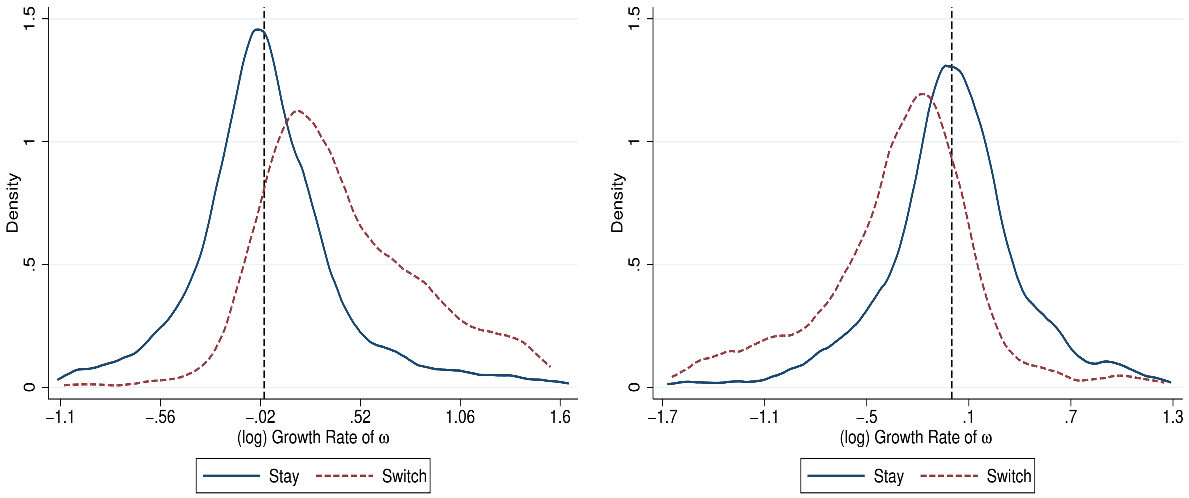


(a) First Tercile

(b) Third Tercile

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.



(a) First Tercile

(b) Third Tercile

Figure B6: Distribution of $\log(\frac{\omega_{t+1}}{\omega_t})$ for First and Third Terciles

Notes: This figure shows the estimated kernel density of (log) growth rates of ω 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 ω growth rate of firms switching terciles. Dashed black vertical line refers to the mean of the distribution.

B.9 Capital Predicts Survival: Robustness

Table B10 shows the point estimates and standard errors for equation (4). Column 1 displays the baseline estimates used in the main text and Column 2 and 3 refer to the same regression in the EEA-registry matched sample for all the sample period, and only for the years 2007 and 2011, respectively. In 2007 and 2011 we can match all firms in the EEA to the registry. In all cases, coefficients for ω_{jnt} and capital stock are positive and highly significant, leading to a downward sloping isoprobability line for survival.

	$P(surv_{jnt})$ (1)	$P(surv_{jnt})$ (2)	$P(surv_{jnt})$ (3)
log ω_{jnt}	0 .257	0.291	0.302
	(0.017)	(0.041)	(0.054)
log K_{jnt}	0.189	0.121	0.145
	(0.008)	(0.019)	(0.024)
N. Observations	12,401	6,180	2,586

Table B10: Effect of Trade Shock on Survival.

Notes: Standard errors, clustered at the firm level, in parenthesis. All the regressions are robust to using 4-digit instead of 2-digit industry fixed effects.

B.10 Capital Composition, Depreciation and Selection

We estimate the following specification,

$$Survival_{jnt,t+1} = \begin{cases} 1 & \text{if} \quad z^*_{jnt} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{B8}$$

and

$$z^*_{jnt} = \alpha + \beta_1 \log(\omega_{jnt}) + \beta_2 \log(k_{jnt}) + \beta_3 \delta_{jnt} + \beta_4 \log(\omega_{jnt}) * \delta_{jnt} + \beta_5 \log(k_{jnt}) * \delta_{jnt} + \gamma_n + \gamma_t + \epsilon_{jnt} \tag{B9}$$

with the results presented in Table B11. While the additional effect of firm-level depreciation rates on capital is negative and statistically-significant, the one on $\log(\omega)$ is not statistically different from zero. Moreover, the average marginal effect of capital level on the probability of staying is plotted in Figure B7.

	Prob Survival
log ω_{jt}	0.241
	(0.042)
log K_{jt}	0.200
	(0.018)
δ_{jt}	0.678
	(3.738)
log $\omega_{jt} * \delta_{jt}$	0.094
	(0.360)
log $K_{jt} * \delta_{jt}$	-0.045
	(0.160)
Pseudo R-Squared	0.20
N. Obs	12406

Table B11: The Effect of Capital on Survival by Depreciation Rates.

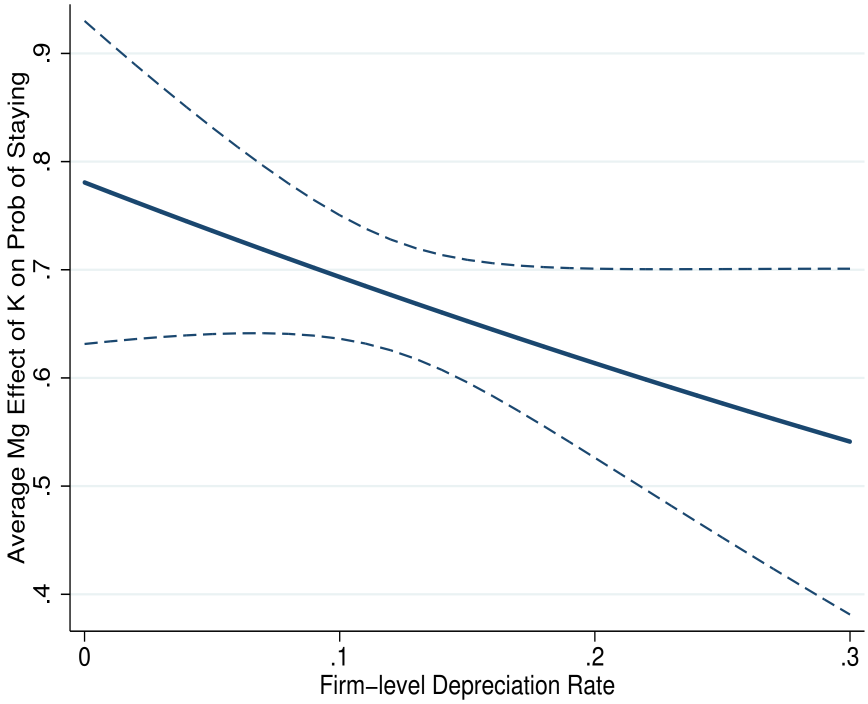


Figure B7: The Effect of Capital on Survival by Depreciation Rates.

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.11 Labor Reallocation

In Table B12, we show our estimated transition probabilities for terciles of MRPN. We find no evidence of asymmetry in the persistence of MRPN.

		at $t+1$		
		1	2	3
	1	0.71	0.23	0.06
Tercile at t		(0.01)	(0.01)	(0.01)
	2	0.25	0.59	0.17
		(0.01)	(0.01)	(0.01)
	3	0.07	0.24	0.69
		(0.01)	(0.01)	(0.01)

Table B12: Transition Probabilities of MRPN.

Notes: Bootstrapped standard errors in parentheses.

C Effects of Trade Shocks: Additional Details and Robustness

C.1 Export Dynamics

One potential effect of China's WTO accession on the Peruvian manufacturing industry is the increase in market access. To illustrate that this effect was quite limited for manufacturing, 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. China represented a large export 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. This is not the case for the manufacturing industries of interest for our analysis. Most of these industries did not see any increase in exports to China.

These facts inform our modeling choices in Section 5: in particular, the assumption that the manufacturing sector does not export, while commodity producing firms export their output.

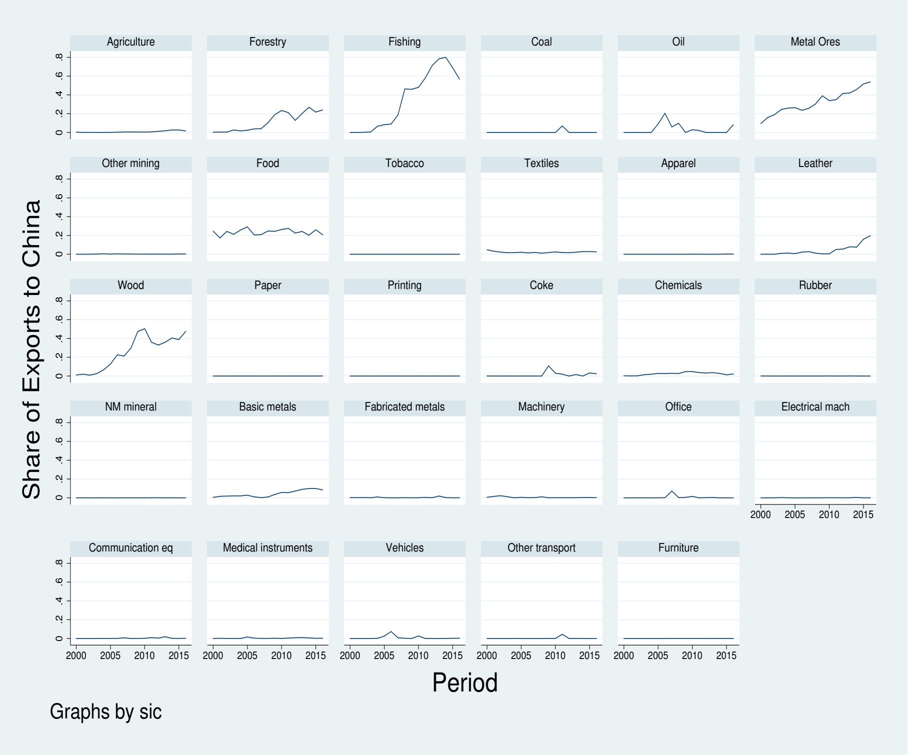


Figure C1: Export Intensity to China.

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 the World Integrated Trade Solution (WITS) to examine what are the main import partners of Peru for 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 these results. For raw materials, China only represents 0.3% 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.

	Raw Materials		Intermediate Goods	
	Share Imports China	Ranking	Share Imports China	Ranking
2000	0.9%	10	3.0%	10
2002	0.1%	17	4.4%	7
2005	0.1%	19	7.0%	6
2010	0.3%	18	15.0%	2
2015	0.5%	16	21.0%	1

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

Moreover, as discussed in Section 4.1, newly gained access to cheaper intermediate inputs should reduce the negative effect of the import-competition shock. Thus, to the extent that Peruvian firm gained access to cheaper intermediate goods, our results on the effects of trade on firm selection and reallocation can be interpreted as a lower bound for the effects of import competition.

C.3 Import-Competition Shock

In table C2, we summarize the two main measures of the trade shock, previously described in Section 2. $ImpInt_{nt}$ is the share on total imports of goods originated in China, by 4-digit CIIU Rev 3 industry codes. $ChComp_{nt}$ is our preferred measure and refers to the deviation from import intensity trends by 2-digit industry.

	Mean	Std.Dev.	Min	Max
ChComp$_{nt}$	0.00	0.12	-0.59	0.39
ImpPen$_{nt}$	0.21	0.23	0.00	0.80

Table C2: Import-Competition Shock.

C.4 Extensive Margin Effects

In this section, we estimate the following probit specification,

$$Survival_{jnt,t+1} = \begin{cases} 1 & \text{if} \quad z^*_{jnt} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{C1}$$

and

$$\begin{aligned} z^*_{jnt} = \beta_0 + \beta_1 ChComp_{nt} + \beta_2 \log(\omega_{jnt}) + \beta_3 ChComp_{nt} * \log(\omega_{jnt}) \\ + \beta_4 \log(k_{jnt}) + \beta_5 ChComp_{nt} * \log(k_{jnt}) + \eta X_{jnt} + \gamma_n + \gamma_t + \epsilon_{jnt} \end{aligned} \tag{C2}$$

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 ω_{jnt}, and firm-level capital stock, k_{jnt}. γ_t and γ_n, represent year and industry fixed effects, respectively. β_1 gives the direct impact of an import-competition shock on survival, while β_3 and β_5 allow for the differentiated effects of the shock by level of productivity and capital stock.

We 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. Column 5 reports the IV results using the additional set of instruments that consider imports from China to other upper-middle-income countries such as Mexico, Panama, and South Korea. Our benchmark specification is Column 4.

	$P(surv_{jnt})$ (1)	$P(surv_{jnt})$ (2)	$P(surv_{jnt})$ (3)	$P(surv_{jnt})$ (4)	$P(surv_{jnt})$ (5)
$ChComp_{nt}$	-3.879	-4.580	-2.756	-4.098	-5.984
	(0.729)	(0.815)	(1.260)	(1.777)	(2.459)
log ω_{jnt}	0.2156	0.224	0.253	0.254	0.252
	(0.023)	(0.024)	(0.017)	(0.018)	(0.018)
log K_{jnt}	0.160	0.149	0.188	0.184	0.183
	(0.011)	(0.011)	(0.008)	(0.008)	(0.008)
$ChComp_{nt}$* log ω_{jnt}	0.209	0.183	0.293	0.156	0.214
	(0.072)	(0.077)	(0.145)	(0.200)	(0.273)
$ChComp_{nt}$* log K_{jnt}	0 .138	0.179	0.012	0.173	0.251
	(0.033)	(0.037)	(0.054)	(0.078)	(0.108)
N. Observations	12,015	11,560	12,015	11,560	11,560

Table C3: Effect of Trade Shock on Survival.

Notes: Standard errors, clustered at the firm-level, in parenthesis. Regression is robust to using 4-digit instead of 2-digit industry fixed effects.

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.

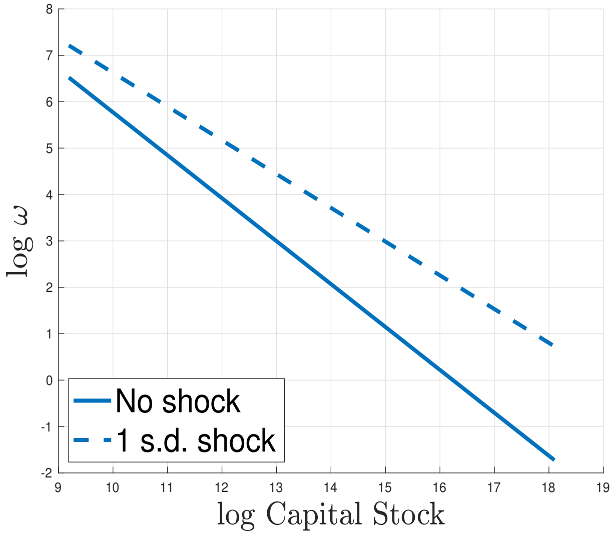


Figure C2: Effects of Trade Shock on Survival Probabilities. $ImpInt_{nt}$ and OLS.

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 and increase in one standard deviation trade shock.

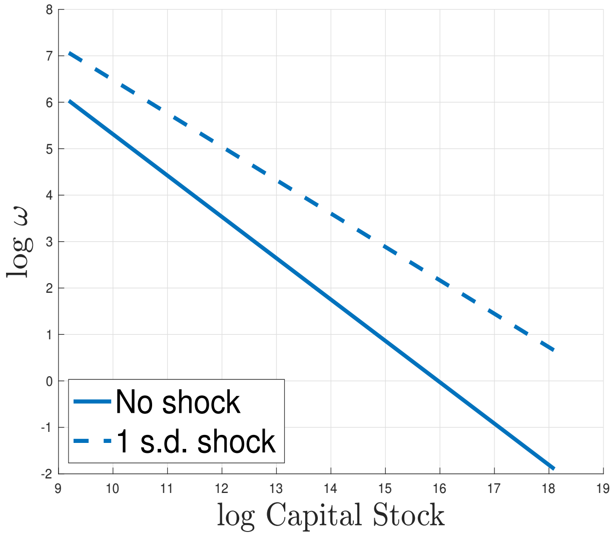


Figure C3: Effects of Trade Shock on Survival Probabilities. $ImpInt_{nt}$ and IV.

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 and increase in one standard deviation trade shock.

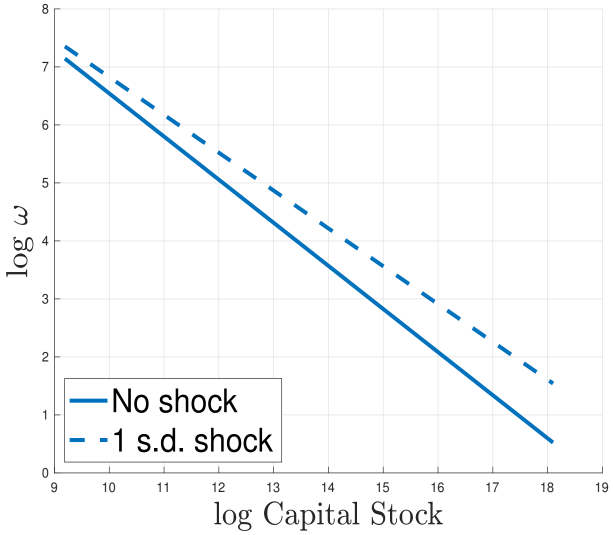


Figure C4: Effects of Trade Shock on Survival Probabilities. $ChComp_{nt}$ and OLS.

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 and increase in one standard deviation trade shock.

C.5 Intensive Margin Effects: Robustness

We provide the robustness analysis for equation (6). 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. Column 5 reports the IV results using the additional set of instruments, which use imports originated in China to other upper-middle-income countries such as Mexico, Costa Rica, and South Korea—instead of imports from China to Peru. Our benchmark specification is Column 4.

	(1)	(2)	(3)	(4)	(5)
Inaction	0.230	0.298	0.230	0.456	0.432
	(0.044)	(0.057)	(0.057)	(0.092)	(0.091)
Positive Investment	-0.401	-0.549	-0.268	-0.537	-0.468
	(0.050)	(0.066)	(0.064)	(0.107)	(0.105)
Negative Investment	0.171	0.251	0.038	0.081	0.036
	(0.044)	(0.037)	(0.037)	(0.065)	(0.058)

Table C4: Effect of Trade Shock on Investment.

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

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

$$z_{jnt} = \alpha_0 + \alpha_1 ChComp_{nt} + \beta ChComp_{nt} * I[DepQuantile]_{jnt} + \alpha_3 \log(\omega_{jnt}) \tag{C3}$$

$$+ \alpha_4 I[DepQuantile]_{jnt} + \alpha_5 \log(k_{jnt}) + \gamma_n + \epsilon_{jnt} \tag{C4}$$

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 C5. We have only included the β coefficients, i.e., 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.

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 than firms with lower firm-level depreciation rates are the ones responsible for the aggregate effects seen in Table 2.

C.7 Intensive Margin Effects: Effects by MRPK Tercile

We now perform the same analysis as in Table C6, but considering different measures of trade shocks and by OLS and IV.

We estimate the following specification, allowing for selection:

$$z_{jnt} = \theta_0 + \theta_1 ChComp_{nt} + \eta X_{jnt} + \gamma_n + \gamma_t + \epsilon_{jnt} \tag{C5}$$

	Inaction	Positive Investment	Negative Investment
ChComp_{nt}	0.627	-0.770	0.142
	(0.144)	(0.148)	(0.095)
$\text{ChComp}_{nt} * \delta q2_{jnt}$	-0.266	0.312	-0.046
	(0.153)	(0.153)	(0.100)
$\text{ChComp}_{nt} * \delta q3_{jnt}$	-0.120	0.210	-0.089
	(0.150)	(0.158)	(0.112)
$\text{ChComp}_{nt} * \delta q4_{jnt}$	-0.228	0.363	-0.135
	(0.154)	(0.169)	(0.119)

Table C5: The Effect of a Trade Shock on Investment (continued).

where z_{jnt} is only observed when

$$z^*_{jnt} = \alpha_0 + \alpha_1 ChComp_{nt} + \sigma Y_{jnt} + \gamma_j + \gamma_t + \nu_{jnt} > 0. \tag{C6}$$

In equation (C5), z_{jnt} are outcome variables such as the investment rate, X_{jnt} are controls such as employment, and γ_t and γ_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 C6, 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).

We estimate two specifications. In the first row, we show the pooled version of equation (C5). 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.

Then, we estimate equation (C5) with heterogeneous effects per MRPK tercile. 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. 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 weak responses of higher-MRPK firms counter the significant responses of the low-MPRK firms.

	Growth Rate of K	Prob of Staying in Current Tercile
Pooled	0.109	-0.117
	(0.091)	(0.064)
First Tercile MRPK	-0.111	-0.238
	(0.087)	(0.096)
Second Tercile MPRK	0.169	-0.051
	(0.105)	(0.123)
Third Tercile MRPK	-0.073	0.032
	(0.282)	(0.128)

Table C6: The Effect of a Trade Shock on Investment.

Notes: Standard errors in parenthesis. Both specifications are estimated using a Heckman regression.

D Model: Additional Details and Robustness

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 (15), (16), (17), (18);
- Output market and labor market clear, that is

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

$$N = \sum_k \sum_s n(k, s)\lambda(k, s) + N^X + \bar{f}^e + \bar{f}; \tag{D2}$$

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

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

  $$\sum_k \sum_s Q(i(k,s))i(k,s)\lambda(k,s) = p^X X; \tag{D3}$$

  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

  $$\mu(k,s) = \sum_k \sum_s \sum_f \lambda(k,s)G(f;s)\left(1 - x(k,s,f)\right) \tag{D4}$$

  $$\begin{aligned} \lambda(k',s') = &\sum_k \sum_s \mu(k,s)F(s,s')\mathcal{I}(k' = g(k,s)) \\ &+ \sum_{s^e} F^e(s^e)F^{es'}(s^e,s')e(s^e)\mathcal{I}(k' = g^e(s^e)). \end{aligned} \tag{D5}$$

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

D.2 Empirical Calibration Targets

MOMENT	VALUE
FREQ. OF NEGATIVE INVESTMENT	0.108
SLOPE OF EXIT THRESHOLDS	0.754
AUTOCORRELATION OF ω	0.742
UNCONDITIONAL STD DEV OF ω	0.848
EXIT RATE	0.184
RELATIVE CAPITAL AT EXIT	0.345
RELATIVE PRODUCTIVITY AT EXIT	0.757

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 use the method developed by Tan (2020b) to 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

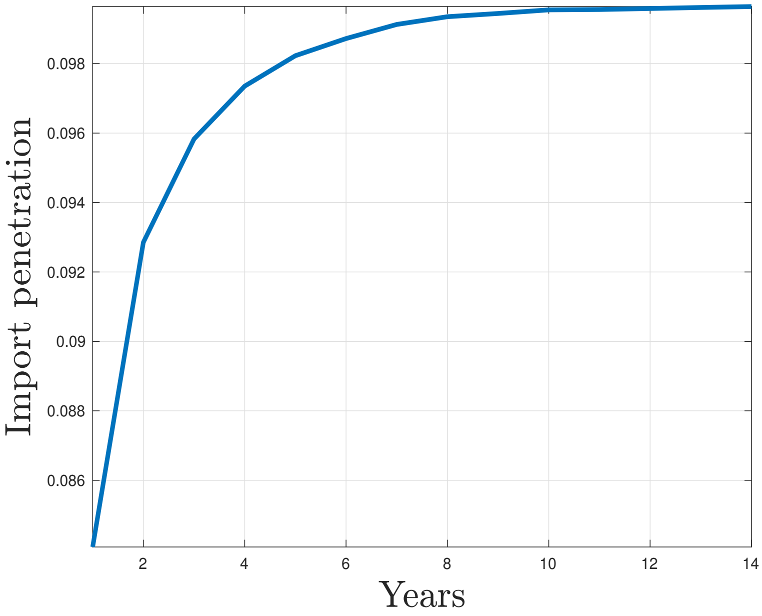


Figure D1: Import Penetration After the Trade Shock.

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

VARIABLE	BASELINE	FRICTIONLESS
C	1.40	1.98
K	2.07	4.01
$N(Manuf.)$	0.21	0.21
M	1.07	0.91
$TFPQ(Average)$	1.95	2.09

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

MODEL	STEADY-STATE	TRANSITION
BASELINE	-0.46%	0.32%
FRICTIONLESS	-0.68%	0.37%

Table D3: Welfare (Consumption Equivalent Variation).

D.5 Convex Adjustment Costs

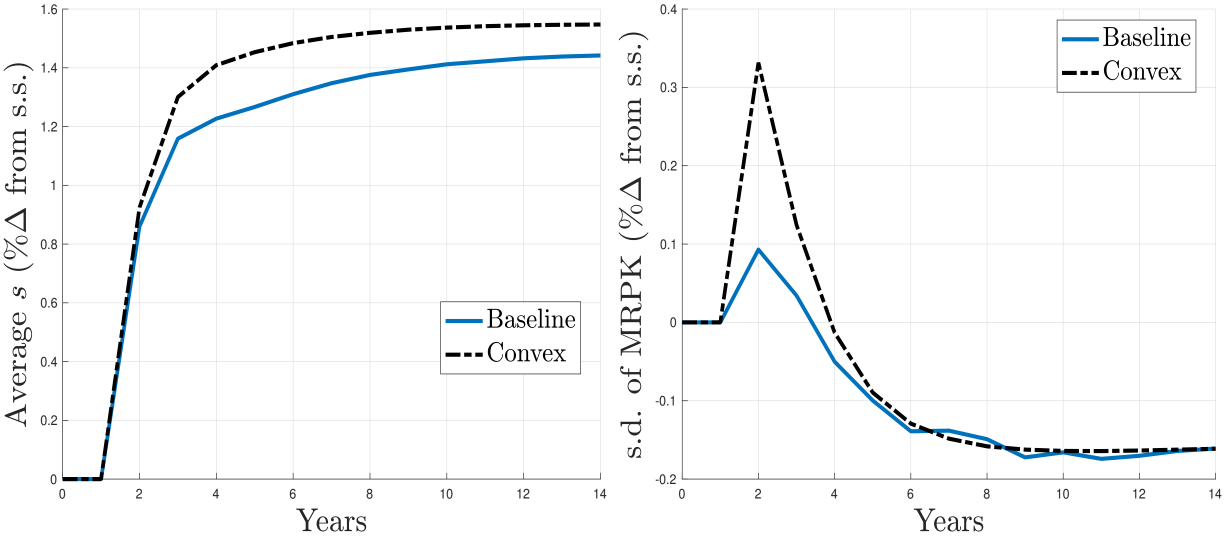
In this extension of our model, we assume the following convex cost of capital adjustment in addition to the asymmetric adjustment costs in our baseline model.

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

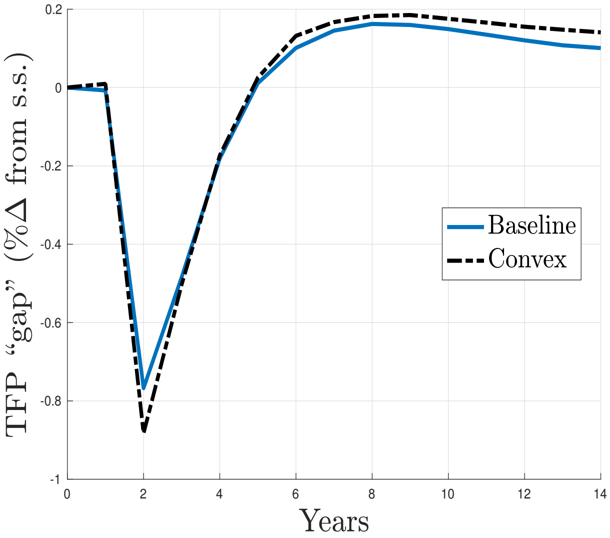
We recalibrate the model to match our baseline targets, as well as the standard deviation of investment rates. Table D4 report the parameter values. In Figures D2 and D3 we display the transitional dynamics of the model with convex costs and compare them with our baseline results.

Parameter	Value	Target / Source
ρ	0.759	Autocorrelation of ω
σ	0.790	Standard deviation of ω
q/Q	0.596	frequency of negative investment
ζ	0.170	Slope of exit thresholds
c	0.0011	Standard deviation of i/k
η_0	0.0587	Exit rate
η_1	5.201	Relative size at exit
η_2	5.202	Relative productivity at exit

Table D4: Convex Adjustment Costs: Parameter Values.



(a) Average TFPQ (b) Dispersion of MRPK



(c) TFPQ ratio

Figure D2: Convex Adjustment Costs: Average Productivity, MRPK Dispersion, TFPQ ratio.

Notes: Panel (a) displays the transition path of average firm productivity in the baseline model (solid blue line) and in the model with convex adjustment costs (dashed-dotted black). 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.

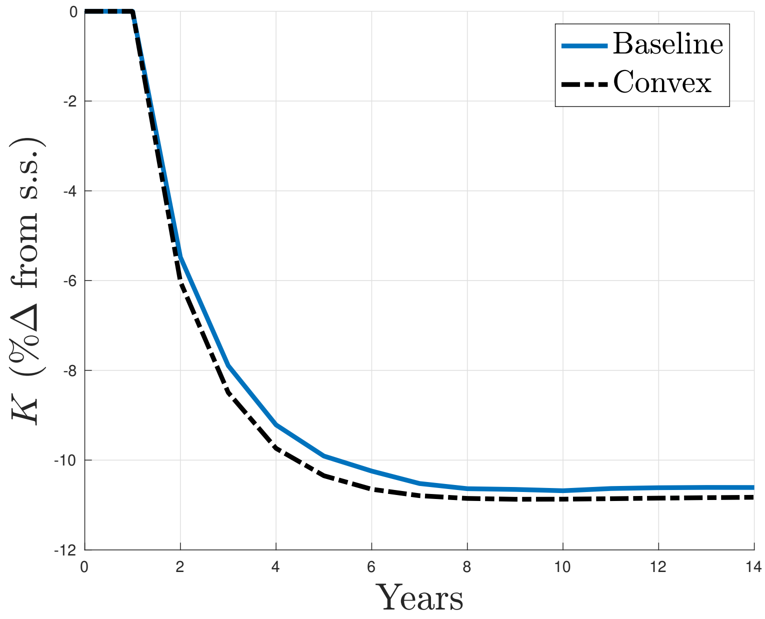


Figure D3: Convex Adjustment Costs: Aggregate Capital.

Notes: The figure displays the transition path of the aggregate capital stock in the baseline model (solid blue line) and in the model with convex adjustment costs (dashed-dotted black). The y-axis reports percentage changes relative to the initial stationary equilibrium.

D.6 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 D6 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.

Parameter	Value	Target / Source
ρ	0.744	Autocorrelation of ω
σ	0.759	Standard deviation of ω
q/Q	0.447	frequency of negative investment
ζ	0.298	Slope of exit thresholds
η_0	0.1494	Exit rate

Table D5: Parameter Values.

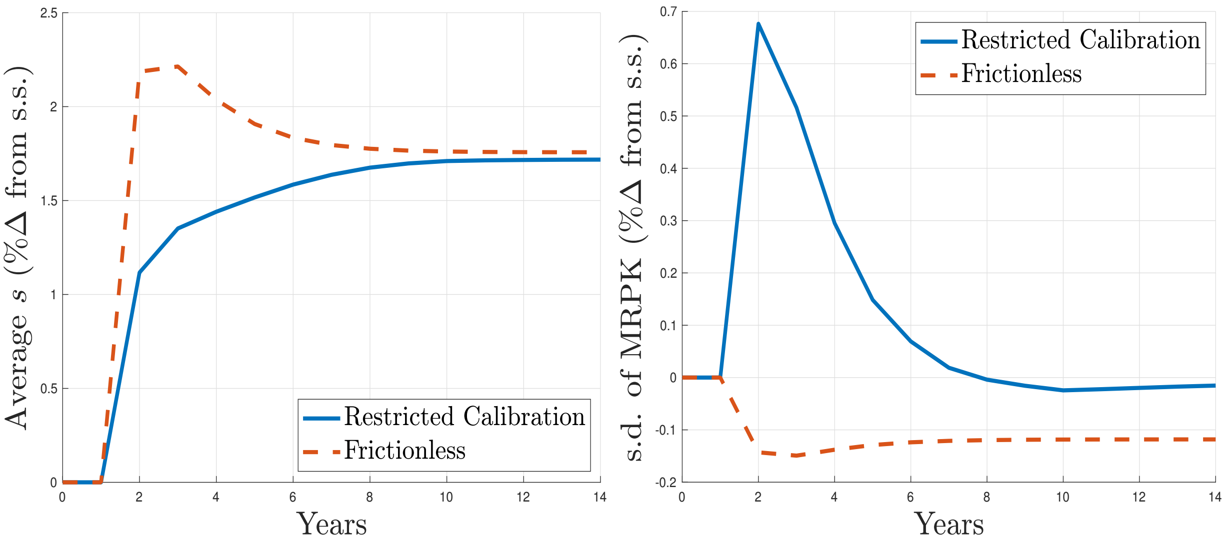
Moments	Data	Model
Freq of negative investment	0.108	0.086
Slope of exit thresholds	0.754	0.352
Autocorrelation of ω	0.742	0.730
Unconditional std dev of ω	0.848	0.705
Exit rate	0.184	0.261
Relative size at exit	0.345	0.277
Relative productivity at exit	0.757	0.332

Table D6: Model Fit with $\eta_1 = \eta_2 = 0$.

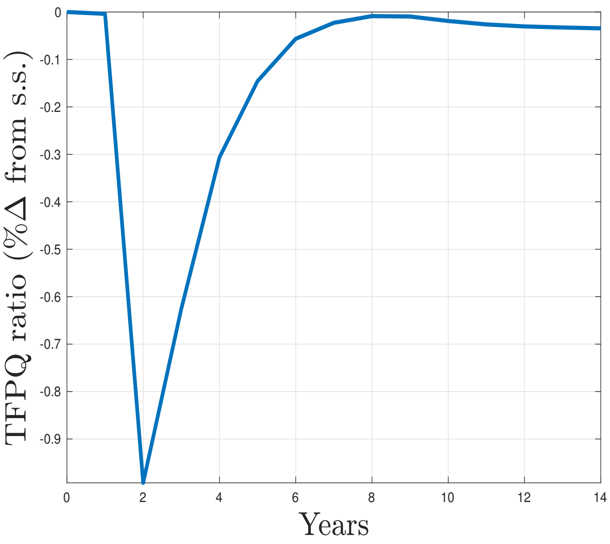
		Tercile at $t+1$		
		1	2	3
Tercile at t	1	0.65	0.27	0.08
	2	0.39	0.39	0.22
	3	0.17	0.36	0.47

Table D7: Mobility (Transition Probabilities) of MRPK in Stationary Equilibrium with $\eta_1 = \eta_2 = 0$.

In Figure D4, we report the transitional dynamics of average firm productivity and capital misallocation, similar to 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.



(a) Average TFPQ (b) Dispersion of MRPK



(c) TFPQ ratio

Figure D4: Average Productivity, MRPK Dispersion, TFPQ ratio with $\eta_1 = \eta_2 = 0$.

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.