

Slow Rockets and Fast Feathers or the Link between Exchange Rates and Exports

A Case Study for Pakistan

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Abstract

Export responses to real exchange rate (RER) depreciations in Pakistan are lower than those to appreciations. This paper empirically documents this asymmetric response using macro-level data. It then relies on a disaggregated export product-level data set for 2003–17 to test, within a panel fixed-effects framework, three hypotheses explaining the low export response to depreciations, focusing on information costs, supply constraints, and pricing to market. The analysis finds that (i) exports of differentiated products

grow more slowly when the RER depreciates than they fall when it appreciates; (ii) exports from sectors with relatively greater supply constraints—in particular related to accessing finance—respond less to depreciations than to appreciations; and (iii) dollar prices for Pakistani exports tend to fall after nominal depreciations of the Pakistani rupee, in violation of the Dominant Currency Paradigm and consistent with pricing-to-market behavior, further accounting for the low response of exports to RER depreciations.

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**Slow Rockets and Fast Feathers or the Link between Exchange Rates and Exports: A Case Study for
Pakistan**

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1. Introduction

Do exports react as fast to a depreciation of the RER as to an appreciation? A depreciation of the RER makes exports more price-competitive in international markets, while an appreciation triggers the opposite effect. But do these effects take place with the same magnitude and speed? There has been a controversy over the efficacy (or lack thereof) of competitive exchange rates for increased export competitiveness (e.g. Gopinath et al 2020). In Pakistan, the active controversy has been brought back to the forefront in the aftermath of the sharp real depreciation of the Pakistani rupee that took place during 2018 and triggered a timid export response. If appreciations depress export performance by more than depreciations boost it, it is crucial to understand why.

Exports matter. First, they can generate growth when foreign markets are demanding high-quality products, and they grow faster than the domestic economy. Second, exports in Pakistan are labor intensive, so demand for labor rises with them, contributing to the creation of jobs that typically pay better wages than jobs in inward-oriented sectors. Third, strong export growth also helps bring in foreign exchange, needed to prevent balance of payments crises. The link between exports and the RER also matters. Evidence in cross-country settings has pointed to the importance of ‘competitive currencies’ as a big push that encourages both more entries of new firms into exporting as well as export successes. As argued by Freund and Pierola (2012), real depreciations in developing countries act like a ‘grand opening sale’, and once customers start coming, “many

of the new relationships are maintained even after the sale is over”.⁴ Is that channel at work in Pakistan?

This paper combines macro and product-level analysis to document an asymmetric response to RER changes in Pakistan’s exports and then to test three different and complementary hypotheses to explain the relatively lower export response to depreciations. First, whether the response depends on the type of product that is being exported – homogeneous, traded in organized markets, versus differentiated. Second, whether it depends on supply constraints that different sectors may face, related to access to finance, structural financial dependence, and factor intensities. Third, whether export dollar-prices tend to fall when the rupee depreciates, due to some sort of pricing-to-(source)market behavior of global buyers. To the best of our knowledge, this is the first study that empirically tests asymmetric export responses to exchange rate changes in Pakistan, and that offers empirical evidence backing three plausible determinants of weak export responses to RER depreciations. The case of Pakistan is relevant. It is an example of many low-middle income country contexts in which exporters operate with imperfect capital markets, inadequate complementary services to exporting, and connect to global buyers with some degree of market power.

To measure the asymmetric export response to RER changes, this paper uses macro-level data on exports, RERs, and global income, relying on a threshold autoregressive model to test long and short-term export elasticities with respect to RERs, as well as the speed of adjustment to departures from the long-term relationship. It then relies on detailed product-destination-year-level data on exports, combined with information on bilateral real exchange rates (BRER), measures of sectoral

⁴Also, Baldwin and Krugman (1989) show persistent trade (and export) effects associated to large changes in exchange rates). More recently, Das et al (2007) show that export responses to exchange rate changes depend on entry costs, prior export experience and expectations about the real exchange rate process.

financial dependence, sectoral access to export finance schemes, sectoral factor intensities, and export dollar-prices, to test within a fixed-effects model framework the three complementary hypotheses to explain the observed relatively weak export response to depreciations.

Asymmetric export responses to RER changes have been previously discussed in the literature. Javed et al. (2016) argue that overvalued (relatively appreciated) exchange rates in Pakistan have adversely affected export competitiveness, while depreciations have failed to deliver on greater exports because they have been neutralized by loose monetary policies, leading to limited – if any – improvements in the RER. Asymmetric export responses to changes in the RER have been uncovered in other countries too. In India, Cheung and Sengupta (2013) find an asymmetric response of firm-level exports to upward and downward movements in the RER. Demian and di Mauro (2018) also look at firm-level data for a set of European countries and find larger export responses to appreciations than to depreciations. For Singapore and the Czech Republic, Bahmani-Oskooee and Harvey (2017) and Šimáková (2018) unveil similar results.

However, there is little systematic evidence on the underlying drivers of the asymmetry. Dhasmana (2015) stresses the importance of industry concentration, access to domestic finance, and foreign ownership. Demian and di Mauro (2018) propose that it responds to quantity rigidities, impeding firms from selling as much as demanded after depreciations, and price rigidities restraining exporters to lower prices enough after appreciations. Javed et al. (2016) state that real depreciations in Pakistan tend to fall short of correcting an already overvalued currency, although without formally testing the underlying drivers of the claim.

The main result of this paper is that exports react faster when the RER appreciates (behaving like fast feathers) than when it depreciates (behaving like slow rockets). Results from our threshold autoregressive model show that while 45.9 percent of the adjustment to a *negative* shock takes

place within one quarter, only 12.7 percent of the adjustment to a *positive* shock takes place within the same period. Exports fall faster than they rise. The asymmetric export response after a change in the RER unveiled at the macro level is robust to the periodicity of the data, and to its level of disaggregation. Indeed, a similar pattern is revealed when using an alternative method and data set at a higher level of disaggregation, to estimate the reaction of the export of a particular product to a particular destination after a change in the *bilateral* real exchange rate (BRER). Our results show that every 10 percent bilateral real appreciation leads to a decline in exports to that destination by 0.68 percent, while every 10 percent bilateral real depreciation leads to an increase in exports of 0.51 percent. The difference is both statistically and economically significant.

Our proposition is that this weaker export response to depreciations is related to hurdles exporters face in export markets and at home that prevent them from taking full advantage of improvement in price competitiveness – i.e. depreciations of the RER, given world income. These include information costs to enter new markets or expand shipments, supply capacity constraints – in the form of difficulties in securing credit to build up capacity or access new workers – and pricing to market, in turn linked to market power global buyers have.

Our second finding relates to the role of information frictions in determining a weak export response to depreciations. Information frictions make sales expansion after depreciations lengthier than sales contractions after appreciations. Products such as linen, trousers, and shirts, that are largely differentiated, require an active connection between buyer and seller, familiarity with market demand abroad, and pricing strategies. Products such as rice are sold instead in organized markets with reference prices. We exploit the variation in the extent of product differentiation, relying on Rauch's (1999) classification, and test whether the relatively weak export response to depreciations is more prevalent in differentiated or in homogenous products. On average and

ceteris paribus, the export response to bilateral depreciations among differentiated products is 27 percent lower than to bilateral appreciations. Instead, there is no difference in export responses to appreciations or depreciations for homogenous products.

Our third finding relates to the role of supply constraints in limiting the ability of exporters to fully react to improved relative price conditions. We look at supply constraints through three sector-specific angles. First, by exploiting sectoral differences in access to Pakistan's largest export finance schemes run by the State Bank of Pakistan (the export finance scheme (EFS), and the long-term finance facility (LTFF)), and second, by exploiting sectoral structural differences in terms of financial dependence. We rely on Rajan and Zingales (1998) measures on external finance needs of U.S. firms, which due to size and access to a deep capital market isolate needs derived from the sectoral technological production process. Third, by exploiting sectoral variation in the extent to which a sector intensively uses the country's most abundant factor – labor. We find that responses to bilateral exchange rate depreciations vary alongside sectoral characteristics. Sectors with higher access to finance, lower structural financial dependence, and higher labor intensity are associated with larger exchange rate elasticities to depreciations, relative to those sectors with lower access to finance, and higher structural financial dependence or capital intensity. We estimate that, on average, an additional 10 percent value of loans per export is related to a 5 percent larger export elasticity with respect to the BRER. The other two structural characteristics appear to cut sectors' responses more sharply. We find that a 10 percent rise in finance dependence implies a 22 percent decline in the responsiveness of exports to BRER depreciations, while a 10 percent increase in labor intensiveness is associated with a 30 percent increase, respectively. These two channels – information costs and supply constraints – are not only statistically significant but also economically significant. A back-of-the-envelope calculation using our estimates suggests that if

differentiated products reacted to depreciations as much as they do to appreciations, and if all sectors had the same access to finance as the sector with the highest level (electrical machinery), after the real depreciation observed between December 2017 and June 2019, exports would have grown by an additional 1.5 percentage points.

Our fourth finding relates to the role of pricing to market in determining the asymmetric response to the BRER. International buyers could be reaping part of the potential benefits of bilateral depreciations by adjusting the dollar price offered to local sellers, after the domestic currency depreciates substantially if they have some market power. We test this hypothesis following the method introduced in Knetter (1989). We analyze differences in Pakistani exporting prices by selling destination. Markup adjustments tend to stabilize export prices in rupees, and the stabilization is amplified during depreciations. On average, dollar export prices react by 15 percent more to Pakistan's currency depreciations than to appreciations. This asymmetric response of export dollar prices is more pronounced, the larger the change in the exchange rate is, suggesting global buyers to some extent smooth prices in rupees rather than in dollars. Again, this result is economically significant. Back-of-the-envelope calculations suggest that in the absence of pricing to sourcing market in Pakistan, Pakistani exports would have grown by an additional US\$150 million, which accounts for an additional 0.6 percentage points.

The remainder of the paper is structured as follows. Section 2 reviews the related literature. Section 3 presents the data and empirical strategy. Section 4 discusses the results. Section 5 concludes.

2. Literature Review

The RER is a key indicator of a country's price competitiveness with its trading partners. When it depreciates, production costs for domestic firms fall relative to foreign competitors. This enables

local firms to be more competitive in other markets and increase their participation. And while the link between RERs and exports has been widely analyzed, the empirical literature is not conclusive on the degree, timing, and symmetry involved in that relationship.

Freund and Pierola (2012) provide evidence on the role of what they call ‘export surges’ – rapid increases in exports. In contrast, Colacelli (2009) finds, with annual data from 136 countries, that export exchange rate elasticity is low in developing countries and high in developed ones, in line with earlier results of Hooper and Marquez (1995) and Reinhart (1994). Bayoumi (1999) focuses on developed countries and analyzes the timing of the impact of exchange rate changes in exports. Results point towards a delayed realization of the maximum effect, up to the fourth year. Bernard and Jensen (2004) find that the increase in U.S. exports between 1987 and 1992 due to exchange rate changes was not widespread, but concentrated mostly in firms already exporting, with timid effects on the extensive margin – new firms starting to export. In contrast, Albinowski et al. (2016) find, in the context of Polish firms, that exchange rate depreciations affect the decision to start exporting rather than the intensity with which they export and that it is dependent on how many imported inputs firms use, in line with results previously unveiled by Amiti et al. (2014). Because exporters also need to import inputs to produce exportable goods, effects of exchange rate depreciations on exports are dampened.

For Pakistan, Abbas and Waheed (2015) uncover a negative impact of RER appreciations on the ratio of exports to total sales for a reduced set of Pakistani firms for the period 1998 to 2010. Kemal and Qadir (2005) find that the exchange rate in Pakistan is associated with exports, but that in the short-term, exports adjust slowly towards equilibrium when there is a need to expand capacity to fulfill increased export orders. Ahmad et al. (2017) look at the link between exports, the RER, and world income for the period 1970 to 2015 and find no export response to exchange rate changes.

More recently, Pirzada (2019) uses a structural VAR model, and argues that the fact that devaluations have only had limited effects on export growth is related to a delayed effect, with exchange rate devaluations taking around a year and a half to positively affect the value of exports. The author estimates that by the sixth quarter, the elasticity of exports to the RER is 1.33.

Recent studies have documented that exports react asymmetrically to exchange rate changes.⁵ Cheung and Sengupta (2013) estimate that appreciations had stronger effects on Indian exports than depreciations during 2000-2010, using firm-level data. Also examining data at the firm-level, Demian and di Mauro (2018) find that exports of 10 European countries reacted mostly to appreciations rather than depreciations in 2000-2012 – and that it is large changes in the exchange rates that appear to matter. Bahmani-Oskooee and Harvey (2017) and Šimáková (2018) also document differing impacts in Singapore and the Czech Republic. Bussiere (2013) focuses on the pass through of the RER to export and import price reaction for appreciations and depreciations in G7 economies between 1980 and 2006, uncovering different responses to appreciation and depreciations although with noticeable variation across countries. However, there is little evidence on the underlying drivers of the asymmetry. Dhasmana (2015) finds that the degree of industry concentration, access to domestic finance, and foreign ownership determine the impact of exchange rate changes on Indian firms' performance. Demian and di Mauro (2018) propose that the asymmetric response they find is theoretically underpinned in quantity and price rigidities. Quantity rigidity impedes firms selling as much as demanded after depreciations, particularly in the case of differentiated products. Price rigidity restrains exporters to lower prices enough after appreciations to not lose demand. This proposition, however, is not tested empirically. Two

⁵ Models incorporating asymmetric responses have been common in the literature of market integration and price transmission. A classical reference is that of Peltzman (2000) in which the author shows that output prices rise faster than they fall after a change in input prices, introducing the analogy of prices rising like rockets but falling like feathers. Tappata (2009) builds a model that explains that behavior without the need for market power.

aforementioned studies for Pakistan also hint to the asymmetries and potential drivers. Javed et al. (2016) show that nominal depreciations tend to fail to impact exports positively as they fall short of correcting currency overvaluation and are neutralized by increased domestic production costs, while Abbas and Waheed (2015) argue that, even considering RER depreciations, exports take so long to respond because of supply constraints.

Structural characteristics of products, or the conditions under which they are produced, may affect responses to similar contexts. In this paper, we focus on three complementary explanations for asymmetric and heterogeneous responses of exports to exchange rate changes.

The first hypothesis relates to information barriers in international trade that may delay supply responses to changes in the RER. We rely on Rauch (1999), who provides a systematic classification of products into different categories, depending on how easy it is for matching of buyers and sellers to happen. The argument is that, for differentiated products, the relationship between buyers and sellers (and the embedded existing information in that relationship) matters more – and therefore it is costly to build it. For commodities – homogenous goods or goods traded in organized markets – prices provide all necessary information, so supply is less likely to be affected by the search processes to which the differentiated goods trade is subject.⁶ Empirical studies have characterized differentiated products, in comparison with homogenous goods, as more reliable on proximity and common language or colonial links (Rauch 1999), less frequent trade in U.S. dollars (Goldberg and Tille 2008), with lower price elasticities (Erkel-Rousse and Mirza 2002; Broda and Weinstein 2004) and higher markups (Feenstra and Hanson 2004).

⁶ Rauch (1999) divides products into three separate categories: (i) traded in organized exchanges; (ii) traded with reference prices; and (iii) differentiated. For example, products traded in organized exchanges include rice and cotton yarn; products traded with reference prices cover cement and fabric; and differentiated products include linen, shirts, and cloths.

The second approach focuses on supply constraints that hurdle beneficial production expansions. An argument often cited by policy makers and industrial leaders alike to explain the timid export responses to exchange rate depreciations in Pakistan is the ‘lack of export surplus’. This argument implies that firms struggle to ramp up production when conditions improve. One source of the difficulty lies in shallow credit markets. The fact that exporters are more dependent on external finance than domestic firms is well documented (Amiti and Weinstein 2011; Manova 2013). The need for financing working capital lies in the fact that there is a substantially longer lag between production and payment for exports than for domestic transactions. This is due to the longer transit and customs clearance times and implies that exporters are more reliant than domestic firms on working-capital finance. Exporters also require greater access to external finance to cover the larger costs associated with international transactions. Similarly, long-term finance is also crucial due to the needs of exporters to invest in technology to remain competitive. Pakistani exporters are no exception. When we interviewed an apparel firm that had re-purposed production into personal protective equipment in the context of the COVID-19 pandemic, the manager claimed that to scale up production, they needed to switch from manual to automatic stitching. The stitching machine enabled workers to stitch 100,000 masks per day, while the manual process only allowed for 20,000. The technology could be sourced from China for US\$60,000. Yet, even though the investment project had a positive net present value, there was no credit available to carry it out. The extent to which this anecdote is representative of the reality of exporters is to be tested. During 2003-2017, the ratio of credit to private sector to GDP was 21.7 percent, suggesting credit tends to be scarce and is a plausible and important supply constraint.⁷

⁷ Domestic credit to GDP ratio is obtained from World Development Indicators, World Bank.

We look at supply constraints through three different and complementary angles: (i) the extent to which different sectors have different access to finance, (ii) the extent to which different sectors are structurally dependent on financing to produce, and (iii) the factor intensity of the sector, in the assumption that labor-intensive sectors will react better to depreciations of the RER, as it is easier to secure additional labor in a labor-abundant country. On the one hand, the functioning of financial institutions appears as a determinant in firms' performance in foreign trade. Chor and Mayora (2012) find that trade flows adjusted more to the financial tightening during the 2008-09 crisis than GDP. Countries with stronger financial institutions have been found to export more successfully in sectors that need more external capital (Svaleryd and Vlachos 2005; Hur et al. 2006). Manova (2013) determines, for a panel of 107 countries from 1985-1995, that around a quarter of the effect of credit constraints on trade is driven by output reduction. Most of the impact is centered on exporting firms, both in the extensive and intensive margins. Paravisini et al. (2015) state that credit constraints reduce exports mostly by raising the variable cost of production, rather than by limiting long-term investments. Minetti et al. (2018) look at how financial structures affect export sector dynamics, showing that domestic banks tend to promote expansions of exports by reducing exit rates, rather than by promoting entry. On the other hand, Pakistan is relatively abundant in labor, as opposed to capital (Mayer and Wood 1999; Abbas and Waheed 2017). Related literature documents the structural advantages that labor intensity provides for certain exports. Mayer and Wood (1999) measure resource availability for South Asia and provide evidence of the concentration of exports in labor-intensive manufactures. Hua (2007) connects labor intensiveness with RER variations in 29 Chinese provinces. RER depreciations favor labor use in production over capital. Cheung and Sengupta (2013) find, for Indian firms, that exports' increase due to currency depreciations is lower when labor costs are higher.

The third explanation proposed is that of pricing-to-market (PTM) behavior. If global buyers have market power, they could extract some of the gains a depreciation brings to Pakistani exporters, by paying lower dollar-prices when the rupee depreciates against the dollar, if Pakistani sellers do not have attractive fallback options. Indeed, when we interviewed textile and apparel exporters on why their exports did not react more strongly to the depreciation of the rupee in 2018-19, their answer was that part of the benefits had been passed on to foreign buyers. It was also mentioned that ‘every time (the) rupee depreciates those overseas buyers demand discount(s) that is (are) at least 50 percent of the depreciation’.⁸ If client search costs are relatively high, exporters may be willing to take that cut. This would violate one of the propositions of the ‘Dominant Currency Paradigm’ (DCP) proposed in Gopinath et al. (2020), namely, that terms of trade are in the short and medium term, independent of exchange rate fluctuations, and instead are in line with some sort of ‘pricing-to-(source)market’ argument pioneered by Krugman (1987). Krugman documents that after a strong depreciation of the U.S. dollar, prices from a set of German imports diverged from those charged to other trading partners, absorbing more than 30 percent of the appreciation in the currency. Knetter (1993) uncovers further evidence on PTM for U.S., U.K., German, and Japanese industries, highlighting the wide variation across products. Gagnon and Knetter (1995) estimated different markup for auto-makers against exchange rate changes from foreign buyers, from around 70 percent for Japanese firms to 0 percent for U.S. companies. Nakamura and Zerom (2010) and Goldberg and Hellerstein (2013) find evidence of PTM behavior for the coffee and beer industries in the United States, respectively.

⁸ For a report on this matter, see <https://www.thenews.com.pk/print/497025-how-exporters-handed-the-benefit-of-devaluation-to-buyers>. Accessed June 1, 2020.

3. Data and Empirical Strategy

Data

To test the existence of an asymmetric response to exchange rates and explore three complementary explanations, we use data sets at the macro and product-destination levels.

We use macro-level data for assessing export adjustment to changes in the RER from 1996 to 2019 – the choice of the period being of the maximum length the data allow. Pakistan’s exports at the quarterly level are obtained from the International Monetary Fund’s (IMF) International Financial Statistics - until end-2002 - and from the State Bank of Pakistan (SBP) starting from 2003; annual export data for robustness are obtained from the World Bank; the RER is obtained from Bruegel’s data set (Darvas 2012). Because quarterly data for global income for the period of analysis were not available, we proxy them by using the combined GDP of China, the United States, Japan, and the EU-28, which, altogether, account for 68 percent of the world’s income.⁹ GDP for China is obtained from the Bureau of Statistics of China, the United States’ from the U.S. Bureau of Economic Analysis, Japan’s from the Economic and Social Research Institute, Cabinet Office of Japan, and the EU’s from Eurostat; exchange rates used to convert foreign GDPs to U.S. dollars are from the IMF.

We use product-destination-year level data for checking robustness of our macro-level results and testing our proposed hypotheses on the drivers of the asymmetric export response. We obtain product-destination level exports from UN Comtrade at HS6 level for 2003 to 2017. The choice of the period is again determined by data availability. We compute BRERs based on nominal exchange rates taken from the Bank of International Settlement (BIS) and price indices taken from

⁹ The sum of these economies represents 67.9 percent of total GDP and 53.0 percent of total Pakistani exports in 2003-2017.

World Development Indicators of the World Bank. We also take trading partners' GDP from World Development Indicators.

To test our hypothesis, we collect additional information at sector and product level. First, we use Rauch's (1999) classification of export products into differentiated and homogenous products. Second, we use data on outstanding loans by sector, for the period 2015-2017 from the two largest export finance schemes run on a concessional basis by the SBP: Export Finance Scheme (EFS) and Long-Term Finance Facility (LTFF), to proxy sectoral access to finance. Because these schemes target specific sectors and are by far the country's largest export financing schemes, the outstanding loans by sector is a good indicator of the sectoral access to finance.¹⁰ Third, we use sectoral measures of finance dependence as presented in Rajan and Zingales (1998). The indicators signal the reliance on external funds to cover long-term investments and dependence from banks, as the fraction of capital expenditures not funded by internal funds. Fourth, we use data on labor intensity estimated for 63 sectors of the economy, based on a Social Accounting Matrix for 2013-14, constructed by the International Food Policy Research Institute (IFPRI) for Pakistan. Fifth, we proxy dollar export prices with unit values, by calculating the ratio of export values and quantities at a six-digit disaggregation of the HS classification, from UN Comtrade.

Empirical Strategy

We start analyzing the link between exports and the RER at aggregate levels. We model exports as a function of the RER and global income and use an error correction model (ECM) to analyze

¹⁰ The EFS was put in motion in 1973 and provides short-term financing to exporters. The LTFF started in 2008 and provides long-term financing for investments in plant and machinery for export purposes.

the short-run dynamics and the adjustments toward the long-run equilibrium. The model is specified as follows¹¹:

$$\ln X_t = \alpha_1 + \beta_1 \ln RER_t + \gamma_1 \ln Y_t^W + \sum_{i=1}^4 \lambda_i + u_t \quad (1)$$

$$\Delta \ln X_t = \alpha_2 + \sum_{k=1}^K \phi_{2,k} \Delta \ln X_{t-k} + \sum_{k=0}^K \beta_{2,k} \Delta \ln RER_{t-k} + \sum_{k=0}^K \gamma_{2,k} \Delta \ln Y_{t-k}^W + \theta_2 \hat{u}_{t-1} \quad (2)$$

4

where X_t is the total real exports (deflated by U.S. GDP implicit price deflator); RER_t is the real effective exchange rate (with $RER_t = (NEER_t \times P_t^L) / P_t^F$, which implies that a rise in RER_t accounts for a decrease of Pakistani price-competitiveness)¹²; Y_t^W is the world income, proxied by the GDP of the United States, Japan, the EU, and China; λ_i are quarterly dummies for $i = (1, \dots, 4)$, accounting for specific effects for each quarter in quarterly data; Δ refers to the first difference of the variables; K is the maximum number of lags in the model; and \hat{u}_{t-1} is the estimated one-lagged residuals from equation (1). The coefficient θ is the speed of adjustment, showing how exports adjust to the long-run equilibrium: when $\theta \in (-1, 0)$, lagged residuals are gradually corrected, and trade flows converge to the equilibrium. We estimate the model with quarterly data, spanning from 1996-Q1 to 2019-Q3. As a robustness check, we estimate the model with annual data, from 1996 to 2018.

¹¹ Thorbecke and Kato (2012), Bayoumi et al. (2011), Chen et al. (2012), and Allard et al. (2005).

¹² Where $NEER_t = \prod_{i=1}^N NEER(i)_t^{w(i)}$ is the nominal effective exchange rate of Pakistan, constructed as the geometrically weighted average of the nominal bilateral exchange rate between Pakistan and its trading partners i (expressed as foreign currency price of one unit of Pakistani rupee); P_t^L is the Consumer Price Index of Pakistan, and $P_t^F = \prod_{i=1}^N P(i)_t^{w(i)}$ is the geometrically weighted average of the Consumer Price Indices of Pakistan's trading partners.

We test whether export, RERs, and world income have unit roots, using Augmented Dickey-Fuller tests. We find evidence of all three series being I(1), and their first differences being I(0). Similarly, we test for cointegration of the long-run relationship in equation (1) relying on a two-step Engle-Granger test, finding evidence of cointegration, further validated by the statistical significance of the speed-of-adjustment coefficient in the error correction model specified in equation (2).

We test the asymmetric adjustment of exports by following a threshold autoregressive (TAR) model, in which we split estimated one-lagged deviations (\hat{u}_{t-1}) above and below the long-run equilibrium. We obtain two variables: positive deviations (\hat{u}_{t-1}^-) and negative deviations (\hat{u}_{t-1}^+), for which we estimate the effects over exports. Positive deviations (\hat{u}_{t-1}^-) imply that exports are above the equilibrium (yielding a negative estimated one-lagged residual), so the adjustment requires a decrease in exports (downward adjustment). Negative deviations (\hat{u}_{t-1}^+) imply exports are below the equilibrium, so adjustment requires an increase (upward adjustment). The resulting model is specified as follows:

$$\begin{aligned} \Delta \ln X_t = & \alpha_2 + \sum_{k=1}^K \phi_{2,k} \Delta \ln X_{t-k} + \sum_{k=0}^K \beta_{2,k} \Delta \ln RER_{t-k} + \sum_{k=0}^K \gamma_{2,k} \Delta \ln Y_{t-k}^W + \theta_2^- \hat{u}_{t-1}^- \\ & + \theta_2^+ \hat{u}_{t-1}^+ + \sum_{i=i}^4 \lambda_i + \varepsilon_t \end{aligned} \quad (2')$$

To test for asymmetric export responses to RER changes – that is if the speed of adjustment implying an upward change in exports is lower than that implying a downward change – we use a one-tailed F-test, based on the priors that the speed of adjustment to equilibrium after depreciations

of the RER is lower than that after appreciations.¹³ We also conduct a more agnostic two-tailed test to check robustness.

We then test robustness of this result by using product-destination-year level data for Pakistan's exports over the period 2003-2017. Product-destination-year level allows us to exploit additional sources of heterogeneity in exports to test the three hypotheses regarding the underlying causes of the asymmetric export response to changes in the RER. Also, because Pakistan's export levels by product are substantially small in global markets, it is reasonable to assume exogeneity of world income and BRER (particularly considering the nominal exchange rate of the PKR to the dollar has been managed during the period).

Our baseline model using product-destination level data is specified as follows:

$$\ln X_{jit} = \alpha_3 + \beta_3 \ln BRER_{it} + \phi_3 \ln BRER_{it} \times d_{it} + \gamma_3 \ln Y_{it}^* + \theta_t + \mu_j + \varepsilon_{it} \quad (3)$$

where X_{jit} is export volumes of product j to partner i in year t ; $BRER_{it}$ is the bilateral real exchange rate expressed (with $BRER_{it} = (NER_{it} \times P_t^L) / P_t^i$, which implies that a rise $BRER_{it}$ means a decrease of Pakistani price-competitiveness)¹⁴; d_{it} is a dummy that takes value 1 if the BRER movements correspond to a real depreciation and 0 otherwise; Y_{it}^* is the GDP of the trading partner i at time t ; θ_t are time fixed-effects for $t = (1, \dots, T)$; μ_j are product fixed-effects at HS6 level; and ε_{jit} is the error in the model.

¹³ This is in turn based on the international empirical evidence and on Pakistan's conventional wisdom.

¹⁴ Where NER_{it} is the bilateral nominal exchange rate between Pakistan and trading partner i (expressed as foreign currency price of one unit of Pakistani rupee); P_t^L is the Consumer Price Index of Pakistan, and P_t^i is the Consumer Price Indices of Pakistan's trading partner i .

The main parameter of interest is ϕ_3 , which represents the differential impact that depreciations have on exports, relative to the baseline effect captured by β_3 . If ϕ_3 is zero, then bilateral depreciations and appreciations have symmetric effects on exports, while if it is positive, bilateral depreciations have a relatively smaller effect on exports than bilateral appreciations. The expected relationship between exports and BRER is negative: exports shift to a particular destination when price competitiveness with that destination increases (the BRER rate falls).

To test the information frictions hypothesis, we exploit the cross-product differences in the extent to which market information matters for increasing sales, and leverage the classification of products presented by Rauch (1999). We replicate equation (3) in two separate categories: (i) differentiated products, and (ii) homogenous products.¹⁵ Categories differ in the available information in the market to export, thus differential impacts could suggest that information costs play a role in the effect of exchange rate change over exports. We also allow for different effects in the intensive and the extensive margin.¹⁶ The analysis enables us to see if RER changes differently impact changes in shipment sizes relative to the set-up of new export relationships (at the product-destination level).

To test the supply (or borrowing) constraints hypothesis, we exploit differences across sectors in finance access. It is possible, however, that sectors that, for reasons other than access to finance, respond faster to exchange rate depreciations have access to more financing than sectors that respond more slowly. This would introduce endogeneity in our specification. Hence, we rely on two alternative measures that are more exogenously determined in the Pakistani context: finance

¹⁵ For simplicity, we aggregate products (i) traded in organized exchanges, and (ii) traded with reference prices into a single category: homogenous products.

¹⁶ Intensive margin is estimated by considering only combinations of products and trading partners active in the previous period. Extensive margin is estimated by converting equation (3) into a Linear Probability Model (LPM) that measures as dependent variable whether the combination of product and trading partner is active.

dependence of the sector as measured by internationally defined indicators, and differences in labor intensity. We expand equation (3) separately for each factor as follows:

$$\begin{aligned} \ln X_{jit} = & \alpha_4 + \beta_4 \ln BRER_{it} + \delta_4 \ln BRER_{it} \times Ratio_j + \phi_4 \ln BRER_{it} \times d_{it} \\ & + \psi_4 \ln BRER_{it} \times Ratio_j \times d_{it} + \gamma_4 \ln Y_{it}^* + \theta_t + \mu_j + \varepsilon_{it} \end{aligned} \quad (4)$$

where $Ratio_j$ corresponds in each case to: (i) access to finance, (ii) structural financial dependence, and (iii) labor intensity. The remaining variables and parameters are as in equation (3).

The main parameters of interest is ψ_4 , which represents the differential impact of an additional point in $Ratio_j$ for the change on exports in depreciations. This effect is added up to δ_4 , which accounts for the differential for both depreciations and appreciations. Year effects control for economy-wide changes that may affect both the dependent and main explanatory variables.

To test PTM behavior impact, we follow Knetter (1989), under the logic that firms may change their prices depending on the selling destination.¹⁷ Marginal costs for production are common for all destinations, but markups can vary depending on country-specific factors, such as their income and bilateral exchange rate.

We model product export price as follows:

$$\ln P_{jit} = \beta_5 \ln NER_{it} + \phi_5 \ln NER_{it} \times d_{it} + \gamma_5 \ln Y_{it}^* + \theta_t + \lambda_i + \mu_j + \varepsilon_{it} \quad (5)$$

where P_{jit} is the unit value of destination-specific HS6 product in current U.S. dollars; NER_{it} is the nominal exchange rate expressed as Pakistani rupees per trading-partner currency; d_{it} is a

¹⁷ Recent examples include Goldberg and Verboven (2001), Gil-Pareja (2003), and Gaulier, Lahrèche-Révil and Méjean (2008).

dummy that identifies movements in the BRER corresponding to a real depreciation; Y_{it}^* is the GDP of the trading partner; θ_t are time fixed-effects for $t = (1, \dots, T)$; λ_i are trading-partner fixed-effects for $i = (1, \dots, N)$ that should reflect cost arising from geography, trade policy, and other institutional frameworks; μ_j are product fixed-effects at HS6 level that capture ; and ε_{it} is the error in the model.

The parameter β_5 shows the impact of nominal exchange rates in export unit values. A value of zero implies that prices in current dollars are orthogonal to the movements in the nominal exchange rate. The expected negative values reflect situations in which markup adjustment tends to stabilize prices in rupees, while positive values account for amplifications in the export prices. The main parameter of interest is ϕ_5 , which represents the additional impact for depreciations. A value of zero implies that there are no significant differences between appreciations and depreciations. When the value is of the same sign as the β_5 , the observed effect amplifies in depreciations. When the sign is the opposite, the effect is moderated in depreciations.

4. Results

Macro-Level Baseline

We begin with a simple log-log specification linking Pakistan's merchandise exports at the macro level with the RER, and world income, to estimate long-run elasticities. Results are reported in Table 1, reporting results relying on quarterly data for the period 1996-Q1 to 2019-Q3. As expected, exports are responsive to RER changes and to the world's income. A 10 percent depreciation of the RER is associated with a 4.92 percent increase in exports in the long run. A 10 percent growth of world income is associated with a 10.46 percent expansion of exports in the long run. These results are in line with those reported by Pirzada (2019) when using an Autoregressive

Distributed Lag model (ARDL) for the period 1994-2018. Results using annual data are in line with those using quarterly data, although the RER coefficient is poorly determined due to the small sample size (see Table A.1 in the Appendix).

Table 1: Long-run relationships for Pakistani exports

VARIABLES	Quarterly (1)
$\ln REER_t$	-0.492*** (0.165)
$\ln Y_t^*$	1.046*** (0.076)
Quarterly dummies	Yes
Observations	95
R ²	0.881

***, **, * imply significance at the 1%, 5% and 10% respectively.
Newey-West SE are reported in parenthesis.

In column 1 of Table 2, we present the results for the error correction model. The estimated speed of adjustment is significant and negative for both quarterly and annual data. For quarterly data, about 28 percent of the disequilibrium from the long-term relationship is corrected in one quarter. Annual data estimates show that 73.5 percent is corrected within the year, in line with quarterly estimates (see Table A.2 in the Appendix). The significance of the coefficient implies that, as expected, deviations from equilibrium conditions are corrected, and its absolute value below one shows corrections are gradual. This provides further evidence for the finding of cointegration when using the two-step Engle-Granger test.¹⁸ In Column 2 we present results when we separate deviations from the long-run equilibrium into positive and negative, allowing for different speed of adjustments to new equilibria when exports are above or below the long-run equilibrium modeled by equation (1). This parameterization of the ECM model is analogous to a Threshold

¹⁸ For robustness, we test cointegration of exports, real exchange rates, and world income using a VECM, finding evidence aligned with that reported here. Results from the VECM are presented in Table A.7 in the Appendix.

Autoregressive Model (TAR) commonly used in the literature to examine asymmetric responses of given variables to its determinants.¹⁹ The lag structure for this ECM is determined by maximizing the Akaike Information Criteria (see Table A.3 in the Appendix for results).²⁰ The speed of adjustment is only significantly different from zero for lagged positive residuals, which implies that, when the RER appreciates, exports respond downward. The speed of adjustment for lagged negative residuals is not statistically different from zero indicating that when the RER depreciates, exports do not react.²¹

Table 2: Error correction model for Pakistani exports

VARIABLES	Quarterly (1)	Quarterly (2)
Speed of Adjustment	-0.281*** (0.062)	
Speed of Adjustment (upward)		-0.127 (0.095)
Speed of Adjustment (downward)		-0.459*** (0.137)
$\Delta \ln X_{t-1}$	-0.324*** (0.102)	-0.287*** (0.098)
$\Delta \ln REER_t$	0.096 (0.362)	0.103 (0.370)
$\Delta \ln REER_{t-1}$	1.164*** (0.335)	1.030*** (0.355)
$\Delta \ln Y_t^*$	0.868** (0.420)	0.871** (0.412)
$\Delta \ln Y_{t-1}^*$	1.279** (0.570)	1.147* (0.580)

¹⁹ For alternative specifications of a TAR model, and M-TAR model, see the Appendix.

²⁰ The stability of the coefficients is tested using a CUSUM, and the null of no structural break cannot be rejected at standard significance levels (see Figure A.2 in the Appendix).

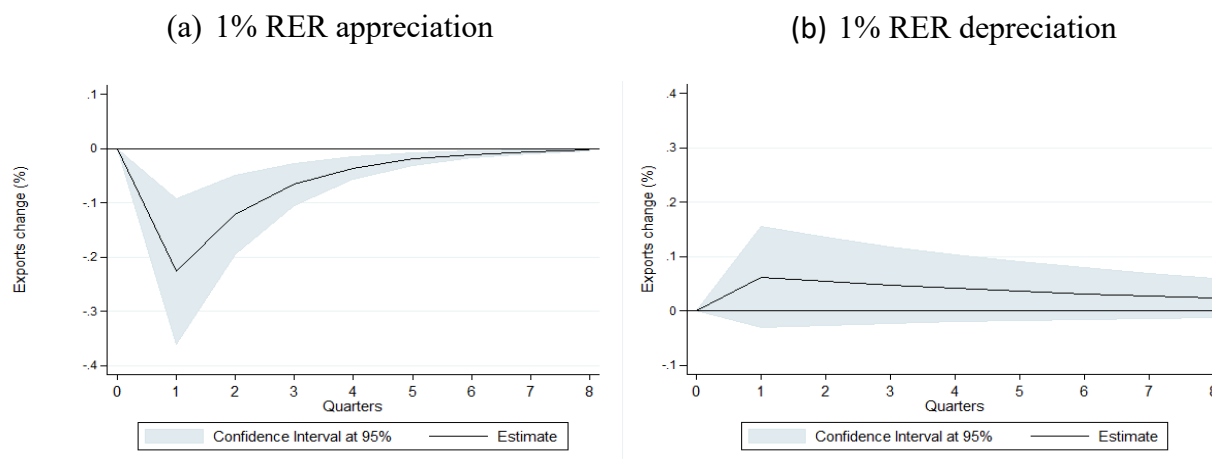
²¹ We also check another form of asymmetry in the export response. Namely, if exports respond more to large changes in the RER than to small ones. If there are lumpy investments needed to increase export capacity, then only large improvements in price competitiveness will induce export adjustments, in line with Ss models. Also, large changes may reduce risks of reversals in the RER, hence encouraging investments in export capacity. To test that hypothesis, we split the error correction term into large deviations (above 75th percentile, above the 90th), and small ones. We find that large changes in the RER induce a larger export response than small ones, but the difference is not statistically significant. Results are reported in Table A.3 in the Appendix.

Quarterly dummies	Yes	Yes
Observations	93	93
R ²	0.488	0.499
F-statistic		2.80
<hr/>		
<i>p-value</i>		
H0: upward = downward		0.098
H0: upward <= downward		0.953

***, **, * imply significance at the 1%, 5% and 10% respectively.
Newey-West SE are reported in parentheses

Figure 1 illustrates these results (panel a for appreciations, and b for depreciations), uncovering the asymmetric nature of the adjustment process of Pakistani exports to changes in the RER, given world income.

Figure 1: Exports' response due to 1% change in the RER



Note: The figures show the quarterly adjustment based on the estimated speed of adjustment for appreciations (panel a) and depreciations (panel b).

We test the hypothesis of the upward adjustment being slower than or equal to the downward adjustment, against the alternative that the upward adjustment is faster than the downward adjustment, using a one-tailed F-test. A one-tailed test is valid in case there are strong priors (based on international evidence) suggesting that the relevant null hypothesis implies a specific sign for the difference. The null hypothesis of the upward adjustment being slower than the downward adjustment cannot be rejected (p-value is 0.953). A more agnostic approach assuming no priors on

the direction of the difference in the speed of adjustment entails using a two-tailed test. In that case, the null of equal responses of exports to upward or downward changes in the RER is rejected with 90 percent confidence.

If expectations of reversals or supply constraints prevent export responses moving upwards after real exchange depreciations, it is possible that with large enough depreciations, the asymmetric export response unveiled above vanishes. We check that by interacting the error correction term with a dummy that signals large prior exchange rate movements. We focus on the exchange rate changes rather than on world income changes since the latter variable is more stable, and less subject to large changes. Results, reported in the Appendix (Table A.6), show that it takes large depreciations of the exchange rate for the asymmetry to disappear (those in the top 5 percent of exchange rate depreciations in the sample, for appreciations, the negative export response is not sensitive to the size of the appreciation).²² Yet, we should be cautious to interpret these results given the small sample size.

Taken altogether, these findings confirm that in Pakistan, exports increase like slow rockets but fall like fast feathers depending on whether RER appreciates or depreciates unless the size of the depreciation is very large. These results are in line with those unveiled by Demian & di Mauro (2018) for a set of European countries, and those unveiled by Cheung & Sengputa (2013), at the firm-level, for India.

The follow-up question is why. The remainder of the paper uses a more detailed data set to test a number of hypotheses.

²² We also test whether increased exchange rate volatility, a proxy for uncertainty, affects the asymmetric response identified in this paper. If exporters face uncertainty about the exchange rate, they will be more cautious to carry out necessary, and to some extent irreversible, investments to increase export capacity. We find no effects of exchange rate volatility in determining the asymmetric export response to changes in the RER (Table A.5).

Product-Level Baseline

To test for robustness of the asymmetric-adjustment result, we turn to an alternative more detailed data set. We explore whether the same pattern arises when exports are disaggregated by product-destination. In this case, we test responses to BRER movements, conditional on the relevant partner's income (GDP) within a fixed-effects model framework.²³ With Pakistan being a small economy, its nominal exchange rate being managed during the period, and its exporters - at the product level - being small and therefore price takers, the partner's income and the BRER can be considered exogenous. Table 4 reports results of estimating equation (3). Column 1 reports the model estimates when ϕ_3 is restricted to zero (i.e. no asymmetric response of export quantities to appreciations and depreciations allowed). Our estimates reveal that exports are price inelastic. A 10 percent bilateral depreciation leads to a 0.61 percent increase in export quantities to that destination, *ceteris paribus* and on average. Moreover, the elasticity of exports with respect to the trading partner's income is still below one, but substantially higher than that of the BRER – a 10 percent increase in Y_{it}^* is associated with an increase in export quantities to that trading partner by 3.4 percent. Column 2 reports estimates of equation (3) without restricting ϕ_3 to zero, revealing a differential impact of export quantities to appreciations or depreciations of the BRER. Export quantities fall by more when the BRER appreciates than they increase when the BRER depreciates. The elasticity of export quantities with respect to depreciations of the BRER is 25 percent lower than the elasticity with respect to appreciations ($-0.051/-0.068=0.75$).

These findings confirm the asymmetric response of exports to changes in their determinants that was found when looking at macro data. Exports fall fast (like fast feathers) when the BRER

²³ A longer time dimension of the data relative to the cross-sectional dimension would have allowed testing the hypotheses of this section within a panel cointegration framework.

appreciates, but struggle to rise (like slow rockets) when it depreciates. In particular, the increases in exports experienced following BRER depreciations have been milder than the drops after appreciations.

Table 3: Regression on Pakistani exports quantities. 2003-2017

VARIABLES	Total Exports	
	(1)	(2)
$\ln BRER_{it}$	-0.061*** (0.001)	-0.068*** (0.002)
$\ln BRER_{it} \times d_{it}$		0.017*** (0.003)
$\ln Y_{it}^*$	0.340*** (0.004)	0.340*** (0.004)
Time FE	Yes	Yes
Product FE	Yes	Yes
Observations	1,527,012	1,527,012
R ²	0.286	0.286

***, **, * imply significance at the 1%, 5% and 10% respectively.
SE, adjusted for clustering at the HS6-year level, are reported in brackets.

Deciphering the Channels

Having established that exports in Pakistan respond asymmetrically to the improvement and worsening of conditions, we delve into the underlying drivers of the weak export response to RER depreciations. We focus on three channels: information frictions, supply constraints (proxied by access to and dependence on finance, and factor intensity), and PTM behavior of global buyers. Results are discussed in turn.

Information Frictions

Table 5 shows results of estimating equation (3). Columns 1 and 2 report the model estimates for total exports, as in Table 4. Columns 3 and 4 report the same results when focusing on the intensive margin only, while columns 5 and 6 are the same for the extensive margin (using a linear probability model). These results are in line with those already discussed. Both for the intensive

and the extensive margin, exports are more reactive to appreciations than to depreciations. Proportionately, the difference in the reaction is similar for the intensive margin and the extensive margin of exports.

Table 4: Asymmetric export responses to BRER appreciations and depreciations - 2003-2017

VARIABLES	Total Exports		Intensive Margin		Extensive Margin	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln BRER_{it}$	-0.061*** (0.001)	-0.068*** (0.002)	-0.088*** (0.004)	-0.095*** (0.004)	-0.009*** (0.000)	-0.009*** (0.000)
$\ln BRER_{it} \times d_{it}$		0.017*** (0.003)		0.017*** (0.005)		0.002*** (0.000)
$\ln Y_{it}^*$	0.340*** (0.004)	0.340*** (0.004)	0.507*** (0.006)	0.506*** (0.006)	0.036*** (0.000)	0.036*** (0.000)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,527,012	1,527,012	367,229	367,229	1,527,012	1,527,012
R ²	0.286	0.286	0.441	0.441	0.253	0.253

***, **, * imply significance at the 1%, 5% and 10% respectively.
SE, adjusted for clustering at the HS6-year level, are reported in brackets.

We then estimate equation (3) for two sub-samples: differentiated products and homogenous products. If part of the reason why exports react less to depreciations than to appreciations of the RER is because increasing shipments or finding new clients takes more time than shrinking or losing clients, since information needs to be gathered in terms of finding clients, building relationships, identifying pricing strategies, and tailoring the product to the needs of the foreign buyer, then it is likely that this asymmetric effect is more marked for differentiated products than homogenous, since these types of information frictions are more binding for them. Results are reported in Table 6.

Table 5: Information costs and asymmetric export responses to BRER – by type of product-
2003-2017

VARIABLES	Differentiated products			Homogenous products		
	Total (1)	Intensive (2)	Extensive (3)	Total (4)	Intensive (5)	Extensive (6)
$\ln BRER_{it}$	-0.079*** (0.002)	-0.118*** (0.005)	-0.011*** (0.000)	-0.036*** (0.004)	-0.021** (0.010)	-0.006*** (0.000)
$\ln BRER_{it} \times d_{it}$	0.021*** (0.003)	0.026*** (0.006)	0.002*** (0.000)	-0.005 (0.005)	-0.020 (0.013)	0.000 (0.000)
$\ln Y_{it}^*$	0.369*** (0.004)	0.553*** (0.007)	0.040*** (0.000)	0.257*** (0.007)	0.361*** (0.014)	0.023*** (0.001)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,101,181	271,121	1,101,181	394,905	88,768	394,905
R ²	0.297	0.445	0.262	0.268	0.411	0.237

***, **, * imply significance at the 1%, 5% and 10% respectively.
SE, adjusted for clustering at the HS6-year level, are reported in brackets.

Results are in line with that hypothesis. Column 1 reports the unrestricted model estimates for total exports of differentiated products. Changes in export quantities are associated with changes in BRER, but the association is lower for depreciations than for appreciations. When BRER appreciates by 10 percent, exports of differentiated products fall on average by 0.79 percent. When BRER depreciates by 10 percent, exports increase by 0.58 percent on average, making the elasticity of export quantities with respect to the BRER 27 percent lower for depreciations than for appreciations. Columns 2 and 3 focus on the intensive and extensive margin of exports. Both results show asymmetry in line with total export quantities. Exports of products actively sold to a trading partner are more elastic to BRER changes than overall exports (it is easier to increase or decrease existing shipments after conditions change than to establish new ones (or break them altogether)). They fall by 1.18 percent when BRER appreciates 10 percent, and increase by 0.90 percent when it depreciates by 10 percent. The probability of opening a new product-destination export line drops by 0.11 percent after a bilateral real appreciation of 10 percent, and increases by

0.09 percent after a depreciation of 10 percent. Column 4 reports the unrestricted model estimates for homogenous products. In contrast with previous results, the coefficient associated with the interaction term between BRER level and real depreciations is not significantly different from zero, revealing no difference in the impact of export quantities between depreciations and appreciations for homogenous products such as rice or wheat. When BRER depreciates 10 percent, exports of homogenous products rise on average by 0.36 percent. Columns 5 and 6 confirm this pattern for homogenous products both in the intensive and extensive margin.

We highlight two main results. First, overall patterns reveal the baseline specifications above – at the product-destination level these appear to be driven by the reaction of exports of differentiated products to BRER changes. These products respond differently to appreciations and depreciations, while homogenous products show no evidence of an asymmetric reaction to BRER depreciations. To give a sense of the economic significance of this result, if differentiated products had responded to depreciations as they do to appreciations, and using the estimates from the sample, Pakistani exports of differentiated products would have increased by an additional 60 million dollars per year due to the 21 percent real depreciation from end-2017 to June 2019 – which adds about half a percentage point to growth. Second, exports of differentiated products are more sensitive to BRER variations. On average and *ceteris paribus*, a 10 percent depreciation is associated with a 0.58 percent increase for differentiated products and a 0.36 percent raise for homogenous products.

Supply Constraints

The usual culprit for slow export responses to RER depreciations is the lack of an ‘exportable surplus’ – in other words, because firms struggle to ramp up production when the RER depreciates. This is not only the untested hypothesis in Abbas and Waheed (2015), but also well-established

conventional wisdom among a portion of policy makers and public opinion.²⁴ The often-repeated notion that exports in Pakistan do not pick up because there is no ‘exportable surplus’ suggests firms struggle to increase production when conditions improve, either because of challenges to build capacity or to secure more workers.

If supply constraints explain the relatively weaker export response to depreciations in RER and appreciations, then sectors that can easily procure additional capital and hire additional labor to ramp up production – either because they have disproportionately more access to finance than other sectors, or because they rely mainly on the abundant factor in the economy, labor – are likely to be better positioned to equally respond to depreciations and appreciations, while those sectors that struggle to access finance, or that rely mainly on the scarce factor in the economy – capital – are likely to show more asymmetric responses to changes in the RER.²⁵ We test this proposition by looking at it from three different angles: sectoral access to finance; sectoral financial dependence; and factor intensities.

We first explore the correlation between our indicators of access to finance (loan intensity by sector), structural financial dependence, and labor intensity. If these characteristics are systematically correlated (i.e. if higher labor intensiveness struggles to access finance), then our estimates will fail to adequately isolate the explanatory effects over exports. We find that the three variables are not statistically correlated at HS2 sectors, as can be seen in Table 7.

²⁴ For example, <https://www.dawn.com/news/1367119>.

²⁵ In the context of uncertainty, bankruptcy costs can also explain that firms (or, in an aggregated manner, sectors) react more cautiously to improvements in conditions, if some of the investments they need to make to ramp up production are to some extent irreversible (see Dixit and Pindyck 1994; Greenwald and Stiglitz 1993; Varela 2011).

Table 6: Correlation between analyzed supply constraints, by HS2 sector

VARIABLES	Access to finance (1)	Finance dependence (2)
Finance dependence	-0.009 [0.961] n=34	
Labor intensity	-0.285 [0.114] n=32	-0.050 [0.789] n=31

***, **, * imply significance at the 1%, 5% and 10% respectively.
p-values (in brackets) and number of observations are reported for each correlation coefficient.

Table 8 presents the results of the estimating of equation (4). Equation (4) is an expanded version of equation (3) where we interact the BRER with an indicator of access to finance,, a structural finance dependence indicator from Rajan and Zingales (1998), and a measure of labor intensity. We include these three variables separately (a model in which all variables are included as regressors is presented in Table A.13 in the Appendix).²⁶

Table 7: Supply constraints and export responses to BRER depreciations - 2003-2017

VARIABLES	Total Exports (1)	Total Exports (2)	Total Exports (3)
$\ln BRER_{it}$	-0.073*** (0.003)	-0.136*** (0.003)	-0.010 (0.007)
$\ln BRER_{it} \times Finance_Access_j$	-0.032*** (0.008)		
$\ln BRER_{it} \times Finance_Dependence_j$		0.194*** (0.006)	
$\ln BRER_{it} \times Labor_Intensity_j$			-0.296*** (0.024)
$\ln BRER_{it} \times d_{it}$	0.018*** (0.004)	0.037*** (0.004)	0.001 (0.009)
$\ln BRER_{it} \times d_{it} \times Finance_Access_j$	0.002 (0.010)		
$\ln BRER_{it} \times d_{it} \times Finance_Dependence_j$		-0.057*** (0.008)	
			0.083***

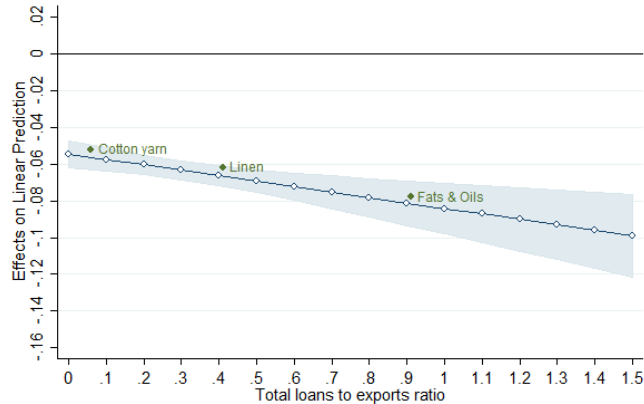
²⁶ Sample sizes in Table 8 differ between each column and from Table 4 and 5 because of coverage in the explanatory variables. The main sectors affected by the exclusion are Fish (Sector 03 in HS2 classification), Edible fruits and nuts (Sector 08), Pearls and precious stones and metals (Sector 71), Optical instruments (Sector 90), and Toys (Sector 95).

$\ln BRER_{it} \times d_{it} \times Labor_Intensity_j$			(0.030)
$\ln Y_t^*$	0.404***	0.426***	0.441***
	(0.005)	(0.005)	(0.005)
Observations	1,093,779	967,268	842,560
R ²	0.310	0.320	0.313

***, **, * imply significance at the 1%, 5% and 10% respectively.
SE, adjusted for clustering at the HS6-year level, are reported in brackets.

Column 1 presents the results regarding access to finance. The coefficients on the interaction of the BRER with the access to finance ratio are negative, which means that the elasticity of export with respect to the BRER rises as the ratio of outstanding loans to exports of the sector increases. The triple interaction, also including the depreciation dummy, is not statistically different from zero, revealing no specific impact of access to finance on the responsiveness of exports to depreciations of the BRER. Jointly, the coefficients imply that sectors with higher persistent access to finance are more responsive to BRER depreciations, as shown in Figure 2. At the mean, an additional 10 percent in the ratio of loans over exports is related to a 4.7 percent larger BRER elasticity. That is, for the sector exporting linen, with a ratio of outstanding loans to exports of 0.41, the export elasticity with respect to bilateral exchange rates is at 0.06 percent, while for fats and oils, with a ratio of loans to exports of 0.91, the elasticity is almost a third larger, at 0.08 percent. It is possible, however, that sectors with larger export responses to RER depreciations secure more financing in Pakistan, introducing endogeneity. Hence, we use two largely exogenous indicators of supply constraints, to check for robustness – a structural indicator on financial dependence (due to Rajan and Zingales (1998)), and labor intensities.

Figure 2: BRER elasticity in depreciations, by loan ratio



Column 2 shows the results for the structural indicator on sectoral finance dependence from Rajan and Zingales (1998). Jointly, the coefficients reveal that the elasticity of exports with respect to the BRER decreases as sectoral finance dependence increases, and so does the elasticity with respect to BRER depreciations in particular.

Figure 3: BRER elasticity in depreciations, by finance dependence

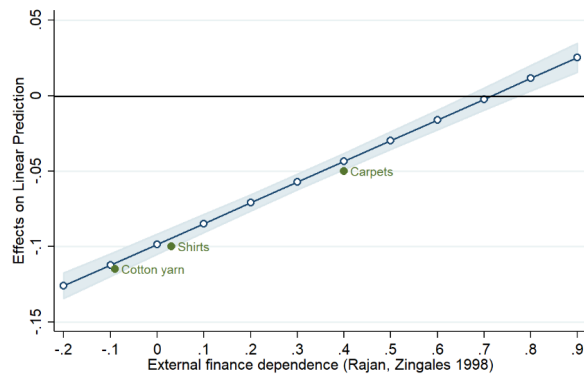
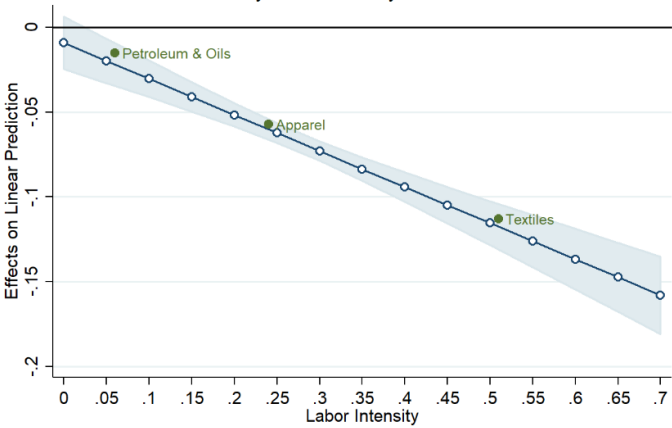


Figure 3 illustrates this pattern for different levels of financial dependence. Exports from sectors more dependent on external finance are less sensitive to BRER depreciations. At the mean, an additional 10 percent finance dependence is related to a 21.6 percent lower BRER elasticity. A sector with low finance dependence, similar to that of Shirts (0.03 in the Rajan and Zingales indicator) expands exports, on average, 1 percent for a 10 percent BRER depreciation. In contrast,

a more dependent sector, with levels as of Carpets (0.40), increases exports 0.5 percent when BRER depreciates 10 percent.

Column 3 in Table 8 presents estimates for the link between sectoral labor intensity, BRER depreciations, and exports. The coefficient on the interaction of the BRER and labor intensiveness of the sector is negative, and the triple interaction also includes the depreciation dummy in positive. As in the previous case, the effect is dominated by the first coefficient, but the triple interaction implies a reduction of the elasticity to BRER as labor intensiveness increases. Adding up the effects, the estimates show that exports from sectors more intensive in labor are more sensitive to BRER depreciations, as shown in Figure 4. At means, an additional 10 percent labor intensity in production is related to a 29.8 percent larger BRER elasticity. This implies that a labor-intensive sector, with levels such as textiles (51 percent of labor in value added), increases exports 1.1 percent when BRER depreciates by 10 percent, while a sector with labor intensity similar to apparel (24 percent) rises 0.6 percent.

Figure 4: BRER elasticity in depreciations, by labor intensity



Taken altogether, these results point to the importance of supply constraints in ensuring an export response to RER depreciations. Sectors with lower structural dependence on finance, and those

with relatively higher intensity of labor, show higher export responsiveness to BRER depreciations than those that are more dependent on finance, or whose production process is more intensive in the scarce factor – capital.

To give a sense of economic significance, we use our results to compute a back-of-the envelope simulation in which all sectors have as much access to finance as electrical machinery has. Our results show, after the real depreciation of December 2017 to June 2019, 21 percent of exports would have expanded an additional US\$234 million, on average and *ceteris paribus*, adding one percentage point to growth.

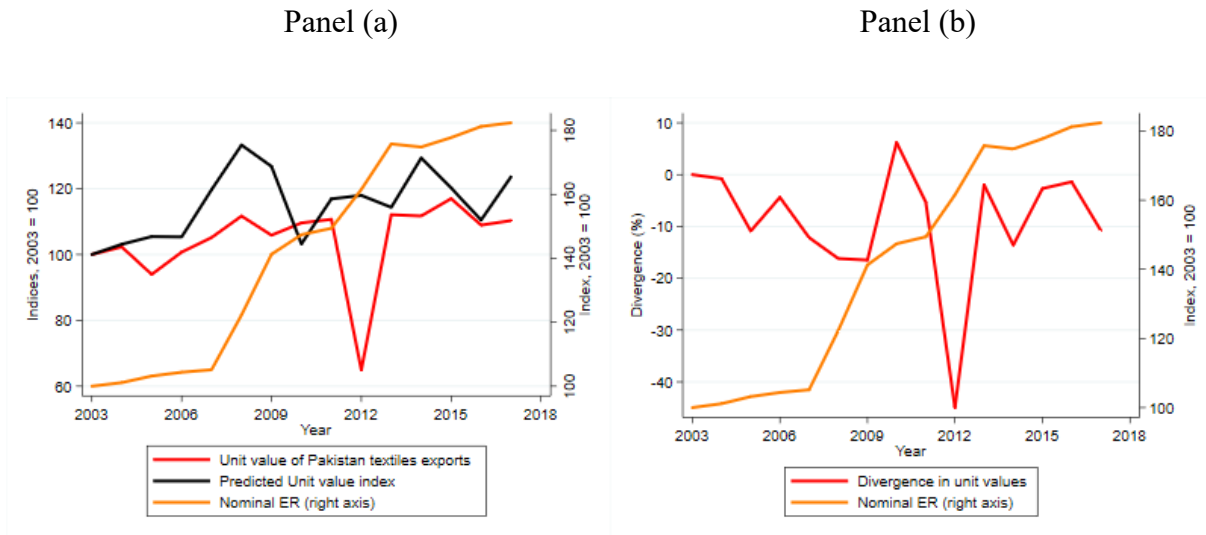
Pricing to Market

The third plausible channel through which depreciations can exert a lower reaction in exports than appreciations is that of pricing to (sourcing) market. One form of it implies that global buyers appropriate some of the profits following a rupee depreciation, decreasing dollar-prices. This is akin to the PTM behavior as described in the seminal work of Krugman (1987) and requires some degree of market power of global buyers. Essentially, if there are costs of searching new global buyers – as the results presented above on information costs seem to suggest – Pakistani exporters may be willing to accept a lower dollar price for their exportable goods after rupee depreciations. In that case, even if export quantities increase following depreciations of the rupee, as dollar-prices fall, the increase in export values is dampened to an extent.

We first plot the evolution of the actual unit values of Pakistani textiles exports (which comprise close to 60 percent of total exports) and the predicted ones (measured as the unit values received by Pakistan's competitors for the same products) since 2003. If the dollar-prices that Pakistani producers secure in export markets follow the same trends as those secured by the average Pakistani competitors for the same export basket ('predicted'), then one would expect that the unit

values of Pakistani exports and the predicted line would follow the same trends (even if levels were different, due to, for example, different quality). Figure 5(a) plots these trends along with the evolution of the nominal exchange rate (PKR relative to the dollar). In a context of rupee depreciation, actual and predicted unit values diverge. As observed in Figure 5(b), the divergence implies a reduction in Pakistani relative unit values throughout the years.

Figure 5: Actual and predicted Pakistani unit values for textiles and apparel, and nominal exchange rates (PKR against USD)



The trends presented hint to global buyers smoothening prices in rupee terms, somehow in line with PTM behavior, and in violation of one of the implications of the dominant currency paradigm. Terms of trade do not seem to be independent of nominal exchange rates. To formally test PTM behavior, we examine whether there is a systematic association between dollar-prices received by Pakistani exporters and the Pakistani rupee/dollar exchange rate, as described in equation (5).

Table 9 presents results for Pakistani export prices. Results show that on average, aggregate dollar-prices are adjusted downwards when the Pakistani rupee depreciates. Column 1 report results of estimating equation (5) when ϕ_6 is set to zero. This restriction imposes the same unit values

response to appreciations or depreciations of the exchange rate. As shown in column 1, a 10 percent increase in the nominal exchange rate is associated with a 0.38 percent decrease of export prices in dollars. In column 2 we allow for differential impacts for depreciations and appreciations (by not restricting $\phi_6 = 0$). Results show that the overall impact on export prices is indeed different depending on whether there is a depreciation or appreciation taking place. Export prices react almost 15 percent more when the rupee depreciates than when it appreciates (the 15 percent is the additional 0.005 impact for depreciations divided by the baseline impact for appreciations, 0.034).

Table 8: Pricing to market in Pakistan
(2003-2017)

VARIABLES	(1)	(2)
$\ln NER_{it}$	-0.038*** (0.017)	-0.034* (0.018)
$\ln NER_{it} \times d_{it}$		-0.005** (0.002)
$\ln Y_{it}$	0.033*** (0.018)	0.037** (0.018)
Time FE	Yes	Yes
Trading-partner FE	Yes	Yes
Product FE	Yes	Yes
Observations	369,916	369,916
R ²	0.982	0.982

***, **, * imply significance at the 1%, 5% and 10% respectively.
SE, adjusted for clustering at the HS6-year level, are reported in brackets.

We further check whether this unveiled asymmetric pattern changes the size of NER changes. Table 10 presents results of estimating equation (6) interacting a set of dummies that identify large changes in bilateral nominal exchange rate (those in the top quartile of the distribution (column 2), those in the top decile (column 3), and those in the percentile 95 (column 4)). Estimates show a differential effect for the top 10 percent and top 5 percent NER changes that accentuates the asymmetric reaction of export prices. Asymmetry in PTM appears to be bigger when NER change

is larger. A 10 percent nominal exchange rate appreciation among the top 10 percent is associated with a 0.19 percent decrease in export prices in dollars. A similar depreciation in the top 10 percent is associated with a 0.43 percent increase in export prices, more than doubling the reaction. Among the top 5 percent NER changes the asymmetry further increases. The reaction of export prices is almost four times larger for depreciation than for appreciations.

Table 9: Pricing to market in Pakistan, by NER change percentiles

(2003-2017)

VARIABLES	Total (1)	p75 (2)	p90 (3)	p95 (4)
$\ln\text{NER}_{it}$	-0.034* (0.018)	-0.033* (0.017)	-0.034* (0.017)	-0.034* (0.018)
$\ln\text{NER}_{it} \times \text{Percentile dummy}$		0.004 (0.003)	0.015* (0.008)	0.023** (0.010)
$\ln\text{NER}_{it} \times d_{it}$	-0.005** (0.002)	-0.004* (0.002)	-0.004** (0.002)	-0.004* (0.002)
$\ln\text{NER}_{it} \times d_{it} \times \text{Percentile dummy}$		-0.008 (0.005)	-0.020* (0.011)	-0.028** (0.012)
$\ln Y_{it}$	0.037** (0.018)	0.041** (0.018)	0.041** (0.019)	0.040** (0.019)
Time FE	Yes	Yes	Yes	Yes
Trading-partner FE	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes
Observations	369,916	369,916	369,916	369,916
R-squared	0.982	0.982	0.982	0.982

***, **, * imply significance at the 1%, 5% and 10% respectively.

SE, adjusted for clustering at the HS6-year level, are reported in brackets.

(1) NER change percentiles considers absolute yearly variation in bilateral NER between Pakistan and trading partners.

Finally, we examine sectoral patterns in this PTM behavior. The dollar-price adjustment following changes in nominal exchange rates is not necessarily homogenous across sectors. To test the heterogeneity in the response, we estimated equation (6) for the 25 most relevant Pakistani export products, which represented half of total exports in the analyzed period (see Appendix Table A.14).

Table 11 shows that currency depreciations yield different impacts on export dollar-prices. The prices of 14 of the most relevant export products are affected by currency changes. All show statistically and economically significant dollar-price reductions after rupee depreciations, except for ‘bed linen of cotton’ and for ‘cement’, suggesting that part of the gain in the markup of Pakistani exporters due to a depreciation is appropriated by global buyers. The effect is also economically significant for one of the largest export sectors in Pakistan - Apparel and Clothing (HS chapters 61-62). When we do not allow for differential impact in appreciations and depreciations (restricting ϕ_6 to zero), a 10 percent change in bilateral nominal exchange rate implies prices adjustments from 0.4 percent to 1.4 percent for those type of products. When we allow for depreciations to have a different effect than appreciations on unit values (without restricting $\phi_6 = 0$), seven products yield significantly higher adjustment in prices when there is a depreciation. Among these, rice and cotton yarn stand out as they are among the top Pakistani export products in terms of export shares (see Table 11).

Table 10: Bilateral nominal exchange rate elasticity on prices in current US dollars of Pakistani exports.

2003-2017, by HS6 code

HS6 CODE	Description	Share ⁽¹⁾	N	$\phi_6 = 0$	ϕ_6 non-restricted	
				$\ln NER_{it}$	$\ln NER_{it}$	$\ln NER_{it} \times d_{it}$
				(1)	(2)	(3)

100630	Rice	7.5%	1,681	-0.034	-0.019	-0.016**
630231	Bed linen of cotton	4.2%	1,477	0.145***	0.033	0.000
520512	Cotton yarn	3.8%	948	0.008	0.011	-0.009**
630260	Kitchen linen	3.4%	1688	-0.032	-0.062*	-0.001
271019	Petroleum oils	2.9%	190	0.313	0.225	-0.012
620342	Trousers	2.9%	1119	-0.063**	-0.062**	0.000
630210	Bed linen knitted	2.4%	1331	0.105	0.079	0.003
630239	Bed linen not of cotton	2.2%	1304	-0.029	-0.031	0.001
610510	Shirts of cotton	1.8%	1179	-0.127***	-0.130***	0.000
420310	Leather apparel	1.8%	1260	-0.060***	-0.065***	-0.002**
630710	Cloths	1.6%	1122	-0.072***	-0.048***	0.000
620462	Trousers	1.5%	817	-0.041*	-0.044*	0.000
252329	Cement	1.5%	310	0.293**	0.409***	-0.003
520942	Fabrics	1.4%	795	-0.026***	-0.027***	-0.001
711319	Jewelry	1.4%	65	0.599	0.978	-0.024
901890	Medical instruments	1.3%	1080	-0.064**	-0.058**	-0.004***
610910	T-shirts	1.1%	1236	-0.072***	-0.071***	-0.002***
520532	Cotton yarn	1.1%	725	-0.034	-0.039	0.004
520819	Fabrics	1.0%	843	-0.004	-0.005	-0.001
620322	Ensembles of cotton	1.0%	617	-0.125***	-0.116***	0.000
610590	Shirts	0.9%	202	-0.142***	-0.138***	0.004
950662	Balls	0.8%	1592	0.004	0.003	-0.002***
570110	Carpets	0.8%	1094	-0.055***	-0.051***	-0.003*
100640	Rice, broken	0.8%	788	0.055	0.058	0.001
520522	Cotton yarn	0.8%	771	-0.093**	-0.086**	-0.003

***, **, * imply significance at the 1%, 5% and 10% respectively.

(1) Export Share refers to product share in total Pakistani exports in 2003-2017. See Table A.14 in the Appendix for more information.

5. Conclusion

In this paper we show that exports do not respond symmetrically to appreciations and depreciations of the RER in Pakistan, and that the extent of the asymmetry is substantial, limiting the role that competitive RERs have had in boosting export growth elsewhere. We find this asymmetric pattern to be robust to the periodicity of the data, as well as to the level of disaggregation – asymmetric export responses are also found when using product-destination-level data for exports, and BRERs. The asymmetric export response to appreciations and depreciations only vanishes when exchange rate changes are very large – in the top 5 percent of the exchange rate change distribution, suggesting that it is very large depreciations that allow exporters to overcome information costs, supply constraints, or PTM behavior from global buyers.

We exploit sectoral variation in the extent of product differentiation – proxying the variation in costs associated with gathering information on the buyers when ramping up exports; and variation in access to finance, financial dependence, and factor intensity – proxying variation in supply constraints.

We find, first, that differentiated products – more intensive in information at the time of increasing shipments or building new export relationships than homogeneous products – show a distinct export response to appreciations and depreciations, being more responsive to the former than to the latter, while exports of homogenous products react symmetrically to upward and downward changes in the RER. Second, we confirm well-established conventional wisdom – a part of the failure of exports to grow after RER depreciations lies in the inability of sectors to create ‘exportable surplus’ – or, in other words, to increase supply when conditions improve. Exports from sectors with higher access to finance schemes, lower finance dependence, and higher labor intensity react more to depreciations as they face lower supply constraints. They can obtain

financing to incorporate additional equipment or to get the needed workers that are abundant in the market. Back-of-the-envelope calculations based on our results suggest that if exports of differentiated products responded to depreciations as they do to appreciations, and if all sectors had a similar access to finance as electrical machinery does, after the real depreciation experienced between December 2017 and June 2019, exports would have grown by an additional 1.5 percentage points.

Finally, we test another conventional wisdom assertion – that dollar-prices systematically fall for Pakistani exporters relative to others, when the rupee depreciates, which could be consistent with global buyers with market power stabilizing purchase prices in rupees rather than in dollars, akin to pricing to (source) market. Markup adjustments tend to stabilize Pakistani export prices in rupees, to a larger extent during depreciations. This is further accentuated for larger NER changes. Back-of-the-envelope calculations suggest that in the absence of pricing to sourcing market in Pakistan, Pakistani exports would have grown by an additional US\$150 million, which accounts for an additional 0.6 percentage points.

The results provide disaggregated underpinnings for the weaker export response to RER depreciations relative to that to appreciations, and help quantify the importance of each of the three channels – information, supply constraints, and pricing to market. The sluggish reaction to depreciations stems from these three different channels. Public policy should consider how sector, firms, and products' characteristics determine differential responses to improvements in price competitiveness. Complementary policies addressing those particularities, active export promotion to reduce information costs for differentiated goods, and support to export finance could help achieve more sustained increases in exports.

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Appendix

1 Additional Procedures for the Macro-Level Baseline

We use annual data to verify the robustness of our results to the periodicity of the data. Table A.1 shows the long-run relationship for Pakistani exports using annual data from 1996 to 2018. Table A.2 presents the estimates for the error correction model, allowing for asymmetric correction in column 2.

Table A.1: Long-run relationships exports

VARIABLES	Annual (1)
$\ln REER_t$	-0.352 (0.214)
$\ln Y_t^*$	0.955*** (0.099)
Observations	23
R ²	0.911

***, **, * imply significance at the 1%, 5% and 10% respectively.
Newey-West SE are reported in parenthesis.

Table A.2: Error correction model for exports

VARIABLES	Annual (1)	Annual (2)
Speed of Adjustment	-0.735** (0.284)	
Speed of Adjustment (downward)		-1.078*** (0.329)
Speed of Adjustment (upward)		-0.342 (0.533)
$\Delta \ln X_{t-1}$	0.183 (0.293)	0.239 (0.299)
$\Delta \ln REER_t$	0.412 (0.237)	0.327 (0.269)
$\Delta \ln REER_{t-1}$	0.332 (0.385)	0.338 (0.433)
$\Delta \ln Y_t^*$	1.252*** (0.390)	1.015** (0.412)
$\Delta \ln Y_{t-1}^*$	-0.084 (0.319)	-0.180 (0.368)

Observations	21	21
R ²	0.568	0.586

***, **, * imply significance at the 1%, 5% and 10% respectively.
Newey-West SE are reported in parenthesis.

As an additional robustness check, we test whether our main results change with the magnitude of deviations from the long-run equilibrium and with the expectations of stability of the RER depreciations.²⁷

First, we run a set of error correction models modifying the absolute value of the threshold level. We define these thresholds by considering the actual distribution of residuals observed. Results in Table A.3 show that exports seem more responsive to large changes in the RER (large error terms, those in the top 25 percent of top 10 percent of the distribution) than to small ones. Yet, we cannot reject the null hypothesis of the speed of adjustment being the same for small and large deviations.

Table A.3: Error correction model for exports, by size of deviation

VARIABLES	p75 (1)	p90 (2)
Speed of Adjustment (small deviations)	-0.235*** (0.061)	-0.227** (0.087)
Speed of Adjustment (large deviations)	-0.390*** (0.099)	-0.316*** (0.077)
$\Delta \ln X_{t-1}$	-0.310*** (0.104)	-0.324*** (0.104)
	0.063 (0.354)	0.099 (0.366)
$\Delta \ln REER_t$		
$\Delta \ln REER_{t-1}$	1.169*** (0.330)	1.160*** (0.337)
	0.768* (0.393)	0.853** (0.417)
$\Delta \ln Y_t^*$		

²⁷ In line with the results in Das et al (2007).

$\Delta \ln Y_{t-1}^*$	1.293** (0.589)	1.282** (0.581)
Observations	93	93

***, **, * imply significance at the 1%, 5% and 10% respectively.
Newey-West SE are reported in parenthesis.

Second, we control our main results by lagged nominal exchange rate volatility, measured through standard deviation (SD) and coefficient of variation (CV) of the daily NER in the past 1-3 months. The indicators are proxies of exchange rate uncertainty, if agents are backward looking. Results in Table A.4 and Table A.5 suggest that export responses are not affected by past volatility.

Table A.4: Error correction model for exports with symmetric adjustment

Heterogeneity by lagged NER volatility

VARIABLES	SD			CV		
	3 months (1)	2 months (2)	1 month (3)	3 months (4)	2 months (5)	1 month (6)
Speed of Adjustment (total)	-0.303*** (0.077)	-0.306*** (0.072)	-0.314*** (0.070)	-0.308*** (0.084)	-0.309*** (0.076)	-0.323*** (0.073)
Speed of Adjustment (total) x Lagged NER volatility	0.020 (0.026)	0.028 (0.026)	0.067* (0.037)	2.399 (3.752)	3.187 (3.895)	9.331 (5.973)
$\Delta \ln X_{t-1}$	-0.321*** (0.102)	-0.321*** (0.102)	-0.321*** (0.102)	-0.321*** (0.102)	-0.320*** (0.102)	-0.319*** (0.102)
$\Delta \ln REER_t$	0.072 (0.363)	0.075 (0.361)	0.056 (0.362)	0.078 (0.361)	0.089 (0.360)	0.072 (0.361)
$\Delta \ln REER_{t-1}$	1.146*** (0.351)	1.134*** (0.354)	1.134*** (0.343)	1.156*** (0.349)	1.131*** (0.366)	1.124*** (0.352)
$\Delta \ln Y_t^*$	0.876** (0.421)	0.871** (0.418)	0.841** (0.409)	0.905** (0.441)	0.900** (0.435)	0.873** (0.414)
$\Delta \ln Y_{t-1}^*$	1.250** (0.590)	1.247** (0.587)	1.264** (0.572)	1.237** (0.606)	1.222* (0.615)	1.229** (0.581)
Quarterly dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	93	93	93	93	93	93
R ²	0.489	0.491	0.495	0.489	0.490	0.495

***, **, * imply significance at the 1%, 5% and 10% respectively.
Newey-West SE are reported in parenthesis.

Note: Daily NER used for SD and CV taken from Bank for International Settlements (BIS).

Table A.5: Error correction model for exports with asymmetric adjustment

Heterogeneity by lagged NER volatility

VARIABLES	SD			CV		
	3 months (1)	2 months (2)	1 month (3)	3 months (4)	2 months (5)	1 month (6)
Speed of Adjustment (downward)	-0.393** (0.165)	-0.391** (0.160)	-0.391*** (0.147)	-0.410*** (0.155)	-0.372** (0.155)	-0.365** (0.147)
Speed of Adjustment (downward) x Lagged NER volatility	-0.170 (0.166)	-0.207 (0.229)	-0.457 (0.350)	-9.495 (10.201)	-21.872 (16.395)	-53.865* (32.103)
Speed of Adjustment (upward)	-0.112 (0.126)	-0.140 (0.115)	-0.155 (0.110)	-0.121 (0.139)	-0.142 (0.121)	-0.155 (0.114)
Speed of Adjustment (upward) x Lagged NER volatility	0.008 (0.029)	0.016 (0.028)	0.048 (0.041)	1.520 (4.500)	2.604 (4.183)	8.067 (6.439)
$\Delta \ln X_{t-1}$	-0.293*** (0.102)	-0.299*** (0.101)	-0.308*** (0.102)	-0.288*** (0.101)	-0.301*** (0.103)	-0.315*** (0.104)
$\Delta \ln REER_t$	0.083 (0.392)	0.060 (0.382)	0.051 (0.375)	0.091 (0.388)	0.035 (0.384)	-0.006 (0.375)
$\Delta \ln REER_{t-1}$	0.945*** (0.350)	1.021*** (0.340)	1.002*** (0.336)	0.919** (0.383)	1.004*** (0.342)	0.980*** (0.332)
$\Delta \ln Y_t^*$	0.694 (0.440)	0.732* (0.427)	0.738* (0.427)	0.734* (0.440)	0.690 (0.440)	0.665 (0.447)
$\Delta \ln Y_{t-1}^*$	1.094* (0.590)	1.134* (0.576)	1.154** (0.578)	1.065* (0.632)	1.107* (0.597)	1.137* (0.585)
Quarterly dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	93	93	93	93	93	93
R ²	0.503	0.503	0.506	0.502	0.506	0.510

***, **, * imply significance at the 1%, 5% and 10% respectively.

Newey-West SE are reported in parenthesis.

Note: Daily NER used for SD and CV taken from Bank for International Settlements (BIS).

Third, we check whether the asymmetric export response to upward and downward changes in the RER depends on the size of the exchange rate change. We find that the asymmetric export response disappears when exchange rate changes are relatively large (top 5 percent).

Table A.6: Error correction model for exports with asymmetric adjustment

Heterogeneity by lagged NER volatility

VARIABLES	Baseline (1)	p50 (2)	p75 (3)	p90 (4)	p95 (5)
Speed of Adjustment (downward)	-0.459*** (0.137)	-0.432*** (0.156)	-0.453*** (0.138)	-0.454*** (0.140)	-0.455*** (0.136)
Speed of Adjustment (downward) x Lagged NER change dummy		-0.067 (0.263)	-0.088 (0.310)	-0.024 (0.277)	-0.368 (0.394)
Speed of Adjustment (upward)	-0.127 (0.095)	-0.296* (0.175)	-0.171 (0.155)	-0.141 (0.135)	-0.080 (0.104)
Speed of Adjustment (upward) x Lagged NER change dummy		0.306 (0.214)	0.108 (0.207)	0.051 (0.191)	-0.294** (0.123)
$\Delta \ln X_{t-1}$	-0.287*** (0.098)	-0.286*** (0.101)	-0.286*** (0.099)	-0.289*** (0.101)	-0.286*** (0.101)
$\Delta \ln REER_t$	0.103 (0.370)	0.014 (0.374)	0.068 (0.387)	0.099 (0.376)	0.162 (0.367)
$\Delta \ln REER_{t-1}$	1.030*** (0.355)	0.815* (0.443)	0.961** (0.435)	1.014** (0.403)	0.934** (0.381)
$\Delta \ln Y_t^*$	0.871** (0.412)	0.894* (0.475)	0.821* (0.426)	0.863* (0.442)	0.783* (0.429)
$\Delta \ln Y_{t-1}^*$	1.147* (0.580)	0.848 (0.703)	1.064 (0.678)	1.123* (0.632)	1.099* (0.584)
Observations	93	93	93	93	93

***, **, * imply significance at the 1%, 5% and 10% respectively.
Newey-West SE are reported in parenthesis.

We use both the Akaike Information Criteria (AIC) and the Bayesian Information Criteria (BIC) to select the best lags for the model. We test several variations and select the structure that minimizes both criteria: including only the first difference.

Table A.7: Model selection

MODEL FORMULATION	AIC (1)	BIC (2)
Only first difference	-215.84*	-187.99*
First and second differences	-210.15	-172.32
Up to third difference	-205.39	-157.68
Up to fourth difference	-196.68	-139.18
Up to fifth difference	-194.76	-132.54

Only second difference	-180.09	-152.35
Only third difference	-181.43	-153.81
Only fourth difference	-181.30	-153.80
Only fifth difference	-174.74	-147.36
First and third difference	-207.05	-166.88
First and fourth difference	-201.87	-161.88

* indicates value where the criterion is minimized

In addition, we test the stationarity of the series by running both Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. The ADF test is specified with a trend term in the regression, and the null hypothesis for the KPSS is that of trend stationarity. It is worth noting that null hypothesis in ADF is that the variable contains a unit root, and the alternative is that the variable was generated by a stationary process. For KPSS, the null is that the series is trend stationary, whereas the alternative is the opposite. Due to the low power of the tests, and the low number of observations, we include a column with the most data we could find on an annual basis.

Table A.8: Unit-root tests

(a) Augmented Dickey-Fuller

VARIABLES	Test statistic (quarterly) (1)	Test statistic (annual) (2)	Test statistic (annual, extended sample) (3)
Log of exports	-2.656	-1.214	-2.973
Log of REER	-1.96	-1.631	-1.320
Log of World GDP	-3.479**	-1.584	-0.107
Δ Log of exports	-15.043***	-3.753**	-8.878***
Δ Log of REER	-8.036***	-3.549**	-6.496***
Δ Log of World GDP	-15.485***	-3.253*	-4.969***

Note: All regressions include a trend term.

Column 2 refers to annual data restricted to the same period of quarterly data.

Column 3 is annual data since 1960 for REER and World GDP, and since 1967 for exports.

*, **, and *** implies significance at 10, 5, and 1% level, respectively.

(b) Kwiatkowski-Phillips-Schmidt-Shin test

VARIABLES	Test statistic (quarterly) (1)	Test statistic (annual) (2)	Test statistic (annual, extended sample) (3)
Log of exports	0.431***	0.136*	0.113
Log of REER	0.364***	0.144*	0.157**
Log of World GDP	0.351***	0.128*	0.175**
Δ Log of exports	0.109	0.159**	0.116
Δ Log of REER	0.106	0.161**	0.117
Δ Log of World GDP	0.0963	0.140*	0.088

Note: Test statistics for the 3rd lag for quarterly data, 8th lag for annual data, and 10th lag for annual (extended sample). These are maximum lags according to Schwert criterion in each case. The null hypothesis is trend stationarity in all cases

We run cointegration tests. The Engle-Granger tests whether the first difference of the residuals is non-stationary. We reject the null hypothesis (of stationarity) for our main specification, suggesting the series are cointegrated (see Table A.9).

Table A.9: Engle-Granger cointegration tests

	Test statistic (1)	p-value (2)
Quarterly data	-3.557	0.0066

Note: p-value is MacKinnon's approximate p-value.

We also run a Vector Error Correction Model and find evidence of at least one cointegrating vector between exports, real exchange rate, and world income (see Table A.11). Results for the VECM model show long-run causal relationship (a la Granger, see Table A.13) and short-run causal relationship from real exchange rate and world income over Pakistani exports (see Table A.14). As both relationships stand, we can state that there is Granger causality from RER and world income on exports.

Table A.10: VECM lag selection

LAGS	LL (1)	AIC (2)	BIC (3)
0	137.922	-2.965	-2.883
1	449.998	-9.626	-9.295
2	475.860	-9.997	-9.417
3	496.012	-10.242	-9.414
4	524.655	-10.674*	-9.598*

* indicates value where the criterion is minimized.

Table A.11: VECM Johansen cointegration test

RANK	LL (1)	eigenvalue (2)	Trace statistic (3)
0	509.299	.	30.712
1*	521.839	0.241	5.632
2	524.645	0.060	0.020
3	524.655	0.0002	

Note: VECM with 4 lags and constant trend.

* signals the selected number of cointegrating equations.

Table A.12: VECM

VARIABLES	$\Delta \ln X$ (1)	$\Delta \ln RER$ (2)	$\Delta \ln Y^*$ (3)
u_{t-1}	-0.373*** (0.086)	-0.009 (0.033)	0.032 (0.039)
$\Delta \ln X_{t-1}$	-0.272** (0.106)	-0.019 (0.041)	0.086* (0.048)
$\Delta \ln X_{t-2}$	-0.103 (0.098)	-0.028 (0.038)	0.180*** (0.045)
$\Delta \ln X_{t-3}$	-0.199** (0.096)	0.042 (0.037)	0.027 (0.043)
$\Delta \ln RER_{t-1}$	0.888*** (0.318)	0.255** (0.122)	-0.166 (0.145)
$\Delta \ln RER_{t-2}$	0.977*** (0.336)	-0.093 (0.129)	0.245 (0.153)
$\Delta \ln RER_{t-3}$	0.748** (0.342)	0.196 (0.131)	-0.284* (0.156)
$\Delta \ln Y^*_{t-1}$	0.054 (0.238)	0.022 (0.091)	-0.413*** (0.108)
$\Delta \ln Y^*_{t-2}$	0.859*** (0.225)	0.201** (0.086)	-0.209** (0.103)

$\Delta \ln Y^*_{t-3}$	0.477** (0.223)	0.102 (0.086)	-0.578*** (0.101)
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Observations	91	91	91
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***, **, * imply significance at the 1%, 5% and 10% respectively.

Table A.13: Long-run Granger causality tests

VARIABLES	chi2 (1)	p-value (2)
$\ln X$	19.05	0.000
$\ln RER$	0.07	0.786
$\ln Y^*$	0.66	0.418

Table A.14: Short-run Granger causality tests

VARIABLES		chi2	p-value
DEPENDENT	INDEPENDENT	(1)	(2)
$\Delta \ln X$	$\Delta \ln RER$	20.43	0.000
	$\Delta \ln Y^*$	17.02	0.001
$\Delta \ln RER$	$\Delta \ln X$	3.22	0.359
	$\Delta \ln Y^*$	6.11	0.107
$\Delta \ln Y^*$	$\Delta \ln X$	17.60	0.001
	$\Delta \ln RER$	6.87	0.076

Note: All lags are jointly tested for each variable.

TAR and M-TAR Models

We test for asymmetry in the ECM by adopting a TAR model, in which we split between positive and negative residuals. We first test for asymmetric-adjustment hypothesis following Enders and Granger (1998):

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \varepsilon_t \quad (6)$$

$$\text{with } I_t = \begin{cases} 1 & \text{if } \mu_{t-1} \geq 0 \\ 0 & \text{if } \mu_{t-1} < 0 \end{cases}$$

Column 1 in Table A.15 shows the resulting estimates, which confirm cointegration between exports, real exchange rate, and world income with TAR adjustment. Results justify the estimation of an asymmetric error correction model, as depicted in the main results and column 2 in Table A.15.

As a robustness check, we follow the same procedure but using a Momentum-Threshold Autoregressive Model (M-TAR) in which the threshold, instead of referring to the level of the residuals, refers to the sign of the change in the residuals:

$$I_t = \begin{cases} 1 & \text{if } \Delta\mu_{t-1} \geq 0 \\ 0 & \text{if } \Delta\mu_{t-1} < 0 \end{cases}$$

Column 3 in Table A.15 also confirms cointegration with a M-TAR adjustment. Column 4 presents the result for an asymmetric error correction model. We find that speed of downward correction is higher than upward correction, but fail to reject the null hypothesis at a 10 percent confidence.

The models and interpretations differ qualitatively. The TAR model captures 'deep' movements, which makes it better suited for series where persistence of troughs and peaks differ. Concerning exports, we can expect that TAR models fit situations in which the adjustment process differs

depending whether actual exports are above or below the long-term equilibrium. The M-TAR model is focused in sharp movements, adapting better for series with steep movements. We can expect a good fit when exports react to the recent tendency regarding long-term equilibrium, with a distinct pattern when exports close the gap with equilibrium than when they widen the gap.

Our estimates confirm that the main determinant of the asymmetric response of exports is the level of the difference with long-term equilibrium, as tested by the TAR adjustment in the ECM. In turn, the estimates for the M-TAR adjustment in the ECM cannot confirm differences for exports when the difference with long-term equilibrium closed or widened in the previous period. The results allow us to reject the possible concern that the differential response we find in our main specification responds to past changes in the gap with the long-term equilibrium, rather than in the level of the gap, as we state.

Table A.15: Error correction model with asymmetric adjustment for Pakistani exports.

Quarterly data

VARIABLES	TAR Residuals		M-TAR Exports	
	(1)	(2)	(3)	(4)
Speed of Adjustment (downward)	-0.342*** (0.110)	-0.459*** (0.137)		
Speed of Adjustment (upward)	-0.056 (0.101)	-0.127 (0.095)		
Speed of Adjustment (positive shocks)			-0.336*** (0.105)	-0.363*** (0.090)
Speed of Adjustment (negative shocks)			-0.035 (0.106)	-0.191** (0.077)
Δu_{t-1}	-0.266** (0.102)		-0.255** (0.102)	
$\Delta \ln X_{t-1}$		-0.287*** (0.098)		-0.301*** (0.099)
$\Delta \ln REER_t$		0.103 (0.370)		0.099 (0.367)
$\Delta \ln REER_{t-1}$		1.030*** (0.355)		1.075*** (0.346)
$\Delta \ln Y_t^*$		0.871** (0.412)		0.901** (0.404)
$\Delta \ln Y_{t-1}^*$		1.147* (0.580)		1.194** (0.561)
Quarterly dummies	Yes	Yes	Yes	Yes
Observations	93	93	93	93
R ²	0.234	0.499	0.237	0.495
<i>F</i> -statistic	4.08	2.80	4.48	2.11
<i>p</i> -value				
Ho: upward=downward	0.046	0.098	0.037	0.1498
Ho: upward≤downward		0.953		0.927
Ho: upward≥downward		0.047		0.073

***, **, * imply significance at the 1%, 5% and 10% respectively.

Newey-West SE are reported in parenthesis.

Figure A.2: Recursive CUSUM plot for asymmetric ECM
confidence interval at 95% around the null



* Corresponding to quarterly estimates in Table 3.

Table A.16: Regression on Pakistani exports quantities. 2003-2017

VARIABLES	Total (1)	Total (2)	Total (3)	Total (4)	Total (5)	Total (6)
$\ln BRER_{it}$	-0.083*** (0.002)	-0.027*** (0.005)	-0.035*** (0.005)	0.089*** (0.011)	-0.047*** (0.010)	0.089*** (0.013)
$\ln BRER_{it} \times Differentiated_Prod_j$		-0.070*** (0.006)	-0.144*** (0.006)	-0.106*** (0.007)		-0.170*** (0.008)
$\ln BRER_{it} \times Finance_Access_j$		-0.011 (0.008)			-0.050*** (0.011)	-0.010 (0.011)
$\ln BRER_{it} \times Finance_Dependence_j$			0.242*** (0.006)		0.201*** (0.008)	0.261*** (0.009)
$\ln BRER_{it} \times Labor_Intensity_j$				-0.359*** (0.025)	-0.244*** (0.027)	-0.330*** (0.028)
$\ln BRER_{it} \times d_{it}$	0.019*** (0.003)	0.006 (0.007)	0.015** (0.007)	-0.024* (0.014)	0.022* (0.012)	-0.010 (0.015)
$\ln BRER_{it} \times d_{it} \times Differentiated_Prod_j$		0.019** (0.007)	0.031*** (0.008)	0.027*** (0.009)		0.041*** (0.011)
$\ln BRER_{it} \times d_{it} \times Finance_Access_j$		-0.004 (0.011)			0.004 (0.014)	-0.009 (0.014)
$\ln BRER_{it} \times d_{it} \times Finance_Dependence_j$			-0.066*** (0.008)		-0.065*** (0.011)	-0.078*** (0.011)
$\ln BRER_{it} \times d_{it} \times Labor_Intensity_j$				0.097*** (0.032)	0.054* (0.032)	0.072** (0.033)
$\ln Y_{it}^*$	0.404*** (0.005)	0.404*** (0.005)	0.426*** (0.005)	0.440*** (0.005)	0.455*** (0.005)	0.456*** (0.005)
Observations	1,093,779	1,073,340	949,141	827,868	806,589	792,420
R-squared	0.310	0.312	0.324	0.316	0.321	0.326

Note: We trim outliers, considering HS2 sectors that add up to 95% of total exports.

***, **, * imply significance at the 1%, 5% and 10% respectively.

SE, adjusted for clustering at the HS6-year level, are reported in brackets.

Table A.17: Total exports in current US dollars. 2003-2017, by HS6 code

HS6 CODE	Description	Total Exports (1)	Share (2)	Cumulative (3)
100630	Rice	21,800	7.5%	7.5%
630231	Bed linen of cotton	12,300	4.2%	11.7%
520512	Cotton yarn	11,100	3.8%	15.5%
630260	Kitchen linen	9,980	3.4%	18.9%
271019	Petroleum oils	8,420	2.9%	21.8%
620342	Trousers	8,370	2.9%	24.6%
630210	Bed linen knitted	7,010	2.4%	27.0%
630239	Bed linen not of cotton	6,430	2.2%	29.2%
610510	Shirts of cotton	5,410	1.8%	31.1%
420310	Apparel	5,380	1.8%	32.9%
630710	Cloths	4,580	1.6%	34.5%
620462	Trousers	4,470	1.5%	36.0%
252329	Cement	4,450	1.5%	37.5%
520942	Fabrics	4,060	1.4%	38.9%
711319	Jewelry	3,950	1.4%	40.3%
901890	Medical instruments	3,680	1.3%	41.5%
610910	T-shirts	3,300	1.1%	42.6%
520532	Cotton yarn	3,160	1.1%	43.7%
520819	Fabrics	2,970	1.0%	44.7%
620322	Ensembles of cotton	2,790	1.0%	45.7%
610590	Shirts	2,720	0.9%	46.6%
950662	Balls	2,410	0.8%	47.5%
570110	Carpets	2,340	0.8%	48.3%
100640	Rice, broken	2,340	0.8%	49.1%
520522	Cotton yarn	2,340	0.8%	49.9%

Table A.18: Bilateral nominal exchange rate elasticity on prices in current US dollars of
Pakistani exports.
2003-2017, by section

SECTION	N	$\ln NER_{it}$ (1)	$\ln NER_{it} \times d_{it}$ (2)
Animal	8,643	0.317***	-0.06
Chemicals	20,475	-0.001	-0.066
Food products	16,551	0.087	-0.666***
Footwear	8,499	-0.308***	0.033
Fuels	458	0.150	0.286***
Hides and skins	15,137	0.245***	-0.036
Mach and elec	23,837	0.266	0.241
Metals	24,403	-0.302	0.223
Minerals	5507	-0.423**	-0.248
Miscellaneous	19,768	-0.244	0.072
Plastics or rubber	15,076	-0.249**	0.090
Stone and glass	10,070	1.905*	-1.352**
Textiles and clothing	157,780	0.083	0.009
Transportation	4,735	-0.126*	0.909**
Vegetable	25,866	0.016	-0.286**
Wood	13,465	0.051	-0.128

***, **, * imply significance at the 1%, 5% and 10% respectively.

Table A.19: PTM, by NER change percentile

VARIABLES	(1) Total	(2) p25	(3) p50	(4) p75	(5) p90	(6) p95
ln_NER	-0.034* (0.018)	-0.033* (0.017)	-0.034** (0.017)	-0.033* (0.017)	-0.034* (0.017)	-0.034* (0.018)
ln_NER x Percentile Dummy		0.002 (0.004)	-0.001 (0.003)	0.004 (0.003)	0.015* (0.008)	0.023** (0.010)
ln_NER x Depreciation	-0.005** (0.002)	-0.005 (0.003)	-0.005** (0.003)	-0.004* (0.002)	-0.004** (0.002)	-0.004* (0.002)
ln_NER x Depreciation x Percentile Dummy		-0.001 (0.005)	0.001 (0.004)	-0.008 (0.005)	-0.020* (0.011)	-0.028** (0.012)
ln_GDP	0.037** (0.018)	0.037** (0.018)	0.037** (0.018)	0.041** (0.018)	0.041** (0.019)	0.040** (0.019)
Observations	369,916	369,916	369,916	369,916	369,916	369,916
R-squared	0.982	0.982	0.982	0.982	0.982	0.982

Heteroskedasticity robust standard errors adjusted for clustering at the HS6-year level are reported in brackets, where ***, **, * imply significance at the 1%, 5% and 10% respectively. NER change percentile considers absolute yearly variation in bilateral NER between Pakistan and trading partners