Downward Nominal Wage Rigidity, Fixed Exchange Rates, and Unemployment: The Case of Dollarization with a Binding Minimum Wage*

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Abstract

We evaluate the role of exchange rate regimes in external adjustment during the 2014-2016 oil price collapse accompanied by a substantial appreciation of the US dollar. Customs data reveal that Colombian exporters under a floating exchange rate regime could adjust export prices to improve international competitiveness, while Ecuadorian exporters under dollarization could not do so. Ecuadorian administrative payroll dataset provides evidence of DNWR induced by minimum wage regulations, explaining the lack of internal devaluation. We confirm that the resulting loss of international competitiveness led Ecuadorian exporters to reduce employment. The aggregate consequence was a prolonged economic recession with rising unemployment.

Keywords: Downward Nominal Wage Rigidity, Fixed Exchange Rates, Minimum Wage, Dollarization, External Adjustment, Internal Devaluation

JEL Code: E24; F16; F31; F32; F41; F45; J31

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1 Introduction

Does a country's exchange rate regime matter in facilitating external adjustment? It has been one of the most intensely debated topics in the field of open economy macroeconomics over the past decades. A traditional view of exchange rate flexibility as a shock absorber, which goes back at least to Meade (1951), has been frequently challenged by exchange rate pessimism, which varies from elasticity pessimism to the practice of currency invoicing.[1] Given that different assumptions in a model yield different answers, researchers turned to empirical evidence, only to face conflicting findings, not least because of identification challenges prevalent in aggregate-level cross-country studies (Edwards and Yeyati, 2005; Chinn and Wei, 2013; Ghosh et al., 2019 among others).[2]

This paper tackles the question by overcoming typical identification challenges in two important ways. First, we focus on the 2014-16 oil price collapse and the subsequent external adjustment in two neighboring oil exporters with different exchange rate regimes: Ecuador under full dollarization and Colombia under a floating exchange rate system. It thus provides a neat quasi-natural experiment setup for two countries with a similar level of adverse terms of trade shock, as the concurrent rise of the US dollar precipitated a massive depreciation of the Colombian Peso while leading to an effective appreciation in Ecuadorian currency (i.e., US dollar). Second, we make the most of the quasi-natural experiment setting by employing a unique combination of detailed micro-level datasets (i.e., Ecuadorian administrative payroll dataset combined with Ecuadorian and Colombian transaction-level customs datasets) to address any potential endogeneity issues.

Equipped with this novel identification strategy, we investigate the role of exchange rate regimes in external adjustment, finding evidence in favor of the exchange rate as a shock absorber. We further explore the causes and consequences of the absence of the external adjustment channel in Ecuador. Our results reveal that due to downward nominal wage rigidity (DNWR), primarily induced by minimum wages, Ecuadorian firms could not adjust wages, but they had to reduce workforce. As such, this paper contributes to the literature by providing a set of robust micro-level evidence consistent with the theoretical mechanism proposed by Schmitt-Grohé and Uribe (2016) that explains how currency pegs and downward nominal wage rigidities lead to high unemployment during recessions.

More specifically, our main findings are threefold. First, transaction-level customs datasets that cover the universe of Ecuador's and Colombia's exports from 2010 to 2018,

[1]See Obstfeld (2002) for a brief review.

[2]Against this background, Rose (2011) wrote that "*the profession knows surprisingly little about either the causes or consequences of national choices of exchange rate regimes. But since the consequences of these choices are small, understanding their causes is of only academic interest.*"

combined with an event-study analysis, reveal that changes in a firm's export prices denominated in US dollars at the product and destination levels after the shock were weakly positive in Ecuador, which is in stark contrast to the case of Colombia where export prices in US dollars declined significantly after the shock. The absence of export price adjustments by Ecuadorian exporters resulted in the loss of real export sales such that average changes in *real* export values (of products and by destination) in the local currency unit (LCU) declined substantially after the shock in Ecuador while real export values in the LCU rose significantly after the shock in Colombia. The event-study results are corroborated by similar findings under a difference-in-differences estimation strategy after combining the Ecuadorian and Colombian transaction-level customs datasets together, which can alleviate concern about pre-existing differential patterns between Ecuadorian and Colombian firms and can purge unobserved time-varying destination country-product specific characteristics. These findings strongly confirm predictions from the theory of expenditure switching: flexible exchange rate countries like Colombia would be able to lower export prices via domestic currency depreciation in response to adverse external shocks, while dollarized countries like Ecuador would not be able to do so unless internal devaluation was made possible by reducing domestic labor costs.[3]

A question that arises, then, is why internal devaluation did not occur in Ecuador despite the rapid loss of international competitiveness. The monthly Ecuadorian administrative payroll dataset helps uncover the reason behind the failure to reduce labor costs. Using these high-quality microdata, we calculate 12-month nominal wage changes for a sample of workers who remain continuously employed with the same firm. In both the pre- and post-shock periods, there was a significant degree of downward nominal wage rigidity (DNWR) as well as a continuous increase in the average wage. A close match between the average wage growth and the growth rate of the minimum wage suggests that this should be mostly attributed to an increase in the minimum wage.[4] We further restrict our sample to those Ecuadorian exporters (i.e., Ecuadorian firms in the payroll dataset that appeared at least once in the customs dataset) and find that exporters that have a higher share of workers receiving less than next year's minimum wage indeed experienced greater increases in average wages. Moreover, those exporters could not reduce export prices more than the other exporters. Collectively, downward nominal wage rigidity (DNWR) induced by rigid minimum wages acted as a strong force against inter-

[3]Under a fixed exchange rate regime, the exchange rate is not available as an adjustment mechanism. Thus, in the face of an adverse aggregate shock, a wage-based internal devaluation has been considered a shock absorber that can act as a substitute for exchange rate flexibility (Galí and Monacelli, 2016).

[4]Since the minimum wage kept increasing faster than CPI inflation rates even after the shock, the Ecuadorian economy could not avoid ending up with an increase in *real* wages.

nal devaluation by Ecuadorian exporters.

Finally, linking the Ecuadorian administrative payroll dataset to the Ecuadorian transaction-level customs dataset enables us to estimate the real cost of dollarization borne by Ecuadorian exporters in the absence of internal devaluation induced by the minimum wage policy. Specifically, we track the average employment by Ecuadorian exporters throughout the period and document that an increasing trend of employment up until the adverse oil price shock suddenly reversed, plummeting by up to 17 percent over the next three years. Further, we were able to decompose the employment loss into a reduction in new hires and an increase in job separations. Both channels contributed to declining employment at the firm level, but quantitatively, the new hiring channel played a larger role than the job separation channel within Ecuadorian export firms. We also find evidence that the exporters with a higher share of workers receiving less than next year's minimum wage experienced a greater decline in employment. Our findings thus confirm that, with neither internal nor external devaluation, Ecuadorian exporters suffered from the loss of international competitiveness and thus had to reduce workforce, which eventually led to a nationwide increase in involuntary unemployment.[5]

Related Literature This paper contributes to several strands of the literature. A debate on the efficacy of exchange rate flexibility as a shock absorber hinges critically on the practice of currency invoicing in international trade. Strong support for the floating exchange rate regime by the traditional open economy macroeconomics literature stemmed from the assumption of producer currency pricing (PCP), under which a nominal depreciation raises the price of imports relative to exports and thus facilitates external adjustment in response to negative external shocks via the expenditure-switching channel (Obstfeld, 2001; Obstfeld and Rogoff, 1995; Obstfeld and Rogoff, 2000). A group of researchers challenged that view and proposed local currency pricing (LCP) as an alternative mode of invoicing (Engel, 2002; Devereux and Engel, 2007; Betts and Devereux, 2000). To the extent that the price of imported goods is preset and thus rigid in the local currency, a model with LCP implies that the import price would be insensitive to changes in the nominal exchange rate, which helped the case for the fixed exchange rate regime gain ground. Noting that PCP and LCP yield contrasting predictions on the degree of exchange rate pass-through (ERPT) into domestic prices, which is essentially an empirical question, it generated a vast amount of subsequent research on ERPT.[6] Information on the composition of invoic-

[5]We recognize that the informal sector accounts for a large part of Ecuadorian economy. We discuss this issue in Appendix B. Informal Employment in Ecuador.

[6]See Burstein and Gopinath (2014) for a comprehensive review of the ERPT literature. A recent study by Auer et al. (2021) investigated the sources of incomplete exchange rate pass-through and the role of nominal

ing currencies in international transactions has only recently become available. Based on a comprehensive survey of the cross-country invoicing currency information, Gopinath et al. (2020) proposed the dominant currency paradigm (DCP) whereby firms set export prices in a dominant currency (most often the US dollar) and change them infrequently.[7] According to DCP, the weakening of emerging and developing countries' currencies is unlikely to provide a material boost to their economies in the short term, but the traditional exchange rate effects would gradually reemerge over time as prices become more flexible (Adler et al., 2020). Given that 98 percent of Colombian exports are invoiced in US dollars (Casas et al., 2017), our finding that Colombian exporters began adjusting export prices around three to four quarters after the shock supports the prediction from DCP.

A separate literature on trade elasticity, which governs the extent to which relative price changes induced by exchange rate fluctuations affect trade flows, has also been a subject of debate. The earliest statistical studies from the early post-World War II era reported remarkably low levels of elasticity estimates, introducing the phrase "elasticity pessimism" (Metzler, 1948; Machlup, 2013).[8] Since then, subsequent studies have found lower trade elasticity from aggregate-level data and higher elasticity from disaggregate-level data; this discrepancy is known as the international elasticity puzzle *a la* Ruhl (2008).[9] Feenstra et al. (2018) distinguish macro elasticity (i.e., the Armington elasticity between foreign and domestic goods) from micro elasticity (i.e., elasticity of substitution between foreign varieties of similar goods). Imbs and Mejean (2015) proves that the systematic discrepancy between aggregate- and sector-level estimates exists because of a heterogeneity bias. Ruhl (2008) attributes the discrepancy between aggregate- and disaggregate-level estimates of trade elasticity to the fact that the former is identified from high-frequency time series variation mostly capturing intensive margin adjustments, whereas the latter is typically obtained from cross-sectional variation, including both intensive and extensive margin adjustments. Berman et al. (2012) and Fitzgerald and Haller (2018) confirm the importance of distinguishing between intensive and extensive margins using French and Irish micro-level datasets, respectively. Bas et al. (2017) show that firm-level heterogene-

rigidities in price adjustment by exploiting the large and sudden appreciation of the Swiss franc in 2015.

[7] Using a detailed data set for Belgian firms, Amiti et al. (2022) confirmed that a firm's currency choice is a key determinant of the ERPT.

[8] Apart from the traditional price mechanism, Bems and Di Giovanni (2016) uncover the income channel of expenditure switching in imports from a Latvian barcode-level scanner data over the global financial crisis period.

[9] Another puzzling observation that elasticity estimates have been declining over time was partially explained by an increasing share of imported inputs in exports (i.e., the intensification of GVCs), likely due to offsetting ERPTs to imported inputs and exports (Ahmed et al., 2017; Amiti et al., 2014). A separate literature investigates the impoted input compression channel of external adjustment during a crisis associated with a large depreciation (e.g., Gopinath and Neiman, 2014).

ity makes micro-level data necessary for the quantification of aggregate trade elasticity. Instead of estimating the elasticity of trade with respect to exchange rates explicitly, this paper employs Colombian and Ecuadorian transaction-level data and compares average intensive margin adjustments by product and destination for Colombian and Ecuadorian exporters as their exchange rates diverged in response to oil price shocks.

An important role of internal devaluation in external adjustment was brought into the spotlight as the eurozone periphery countries struggled to recover from the 2008-09 global financial crisis (e.g., Decressin et al., 2015). Due to explicit or implicit pegs to the euro, peripheral countries were unable to devalue their currencies. They therefore had to restore their international competitiveness, in principle, solely through internal devaluation. In practice, however, it has been noted that internal devaluation was notoriously difficult owing to downward nominal wage rigidity (Schmitt-Grohé and Uribe, 2013; Schmitt-Grohé and Uribe, 2016).[10] Using a unique combination of detailed micro-level datasets, our empirical findings validate the theoretical mechanism (i.e., high unemployment during contractions arising from the combination of fixed exchange rates, nominal rigidity, and free capital mobility) proposed by Schmitt-Grohé and Uribe (2016).[11]

Our paper contributes to an empirical literature on measuring nominal wage adjustment in microdata.[12] Using administrative datasets that allow for a distinction between the base wage and other forms of compensation such as bonuses and overtime payments, recent studies have found that nominal base wage cuts are exceedingly rare in the U.S. (Grigsby et al., 2021), Iceland (Sigurdsson and Sigurdardottir, 2016), and Portugal (Carneiro et al., 2014). Following this line of research, we employ the Ecuadorian administrative dataset to measure the extent of DNWR in Ecuador and find evidence that nominal base wages were downwardly rigid. Further, linking the Ecuadorian administrative payroll dataset with the Ecuadorian customs dataset, we find that nominal wages for workers employed by Ecuadorian exporters continued to increase within job spells even after the adverse shocks, providing strong empirical evidence that there was no internal

[10] The only successful case was found in Latvia, where internal devaluation was achieved through productivity growth rather than through labor cost reductions (Blanchard et al., 2013).

[11] Galí and Monacelli (2016) also study the relationship between wage rigidity and a fixed exchange rate in the context of a currency union. Drenik (2016) further explores distinct welfare consequences in a model with heterogeneous degrees of nominal wage rigidities and a rich set of heterogeneous agents.

[12] As for the empirical evidence on downward nominal wage rigidity (DNWR), Elsby and Solon (2019) conducted an extensive survey of the current literature. They found that none of the studies denied the existence of some nominal wage stickiness, but they also pointed out that nominal wage cuts are more common than previously thought. Jo (2019) carefully investigated the U.S. Population Survey (1979-2017) and the Survey of Income and Program Participation (1984-2013) and found evidence on wage rigidity in that states with larger employment declines are also the states with greater increases in the share of workers with a zero wage change.

devaluation in Ecuador.[13] Moreover, nominal wage increases were tied to the minimum wage increases both in the pre-shock period and in the post-shock period, thus confirming the contribution of the minimum wage system to DNWR in Ecuador.[14] This finding is in line with the conclusions of Castellanos, García-Verdú and Kaplan (2004) who found evidence of DNWR and wage stickiness introduced by the existence of minimum wages in Mexico. Last but not least, ours relate to more recent studies that incorporate wage rigidities in the trade literature (Rodríguez-Clare et al., 2020; Costinot et al., 2022).

This paper also complements a literature on the impact of exchange rate variations on labor market outcomes such as wages and employment adjustment. Using industry-level US data, Campa and Goldberg (2001) found that exchange rate movements appear to have little effect on jobs and hours worked, but some sizable effects on wages. Using US Current Population Survey data, Goldberg and Tracy (2003) found that the overall elasticity of wages to the exchange rate is small, but exchange rate movements can lead to large wage changes for some workers. More recently, researchers exploited firm-level datasets to examine how exchange rate shocks affect the labor market (e.g., Nucci and Pozzolo, 2010; Dai and Xu, 2017). Our study investigates a similar topic — the relation between exchange rate movements and labor market outcomes. However, we exploit more detailed datasets to establish that, in response to an appreciation of the US dollar, firm-level adjustments occurred mainly through employment, not through wages, mainly because of the presence of minimum wage laws that prevented Ecuadorian exporters from adjusting wages. To our knowledge, there are no other empirical studies that incorporate the role of minimum wages (and DNWR) in this research arena, and that elucidate the mechanism of minimum wages (and DNWR) in transmitting an exchange rate shock into labor market outcomes.

The rest of the paper is organized as follows. Section 2 describes institutional and macroeconomic background. Section 3 describes the data sources. Section 4 measures the extent of nominal wage rigidity in Ecuador. Section 5 takes a comparative approach by contrasting two countries, Ecuador and Colombia, and studies the export price/value adjustment process in response to adverse external shocks. In addition, we confirm the absence of internal devaluation among Ecuadorian exporters. Section 6 documents the real consequences of the lack of external and internal adjustments on employment. Section 7 concludes.

[13] We are not aware of any other empirical studies that test for internal devaluation using micro-level datasets comparable to ours.

[14] The nexus between minimum wages and DNWR was also investigated in the macro literature. Glover (2019) analyzed how DNWR can be created by minimum wages and how that affects inflation and employment in a macro model.

2 Background

2.1 Dollarization in Ecuador

Ecuador, like many other Latin American countries, experienced periods of high inflation in the 1980s and 1990s (see Figure 1). In the late 1990s, Ecuador underwent a triple crisis: a banking crisis, a currency crisis, and a fiscal crisis.[15] The crisis involved 16 of the 40 existing banks in 1997; it entailed a devaluation that reached 250% of the local currency, inflation rates with hyperinflation levels, and a default on the public debt (Jácome, 2004).[16] On the brink of hyperinflation and immersed in a deep macrofinancial crisis, the president of Ecuador, Jamil Mahuad, decided to fully dollarize the economy on January 9, 2000 – the sucre was replaced with the US dollar, and has served as Ecuador's currency since then.[17] Dollarization was a desperate move to restore monetary and price stability in a country that needed an urgent monetary anchor to stabilize expectations, avoid hyperinflation, and stop uncontrolled currency depreciation (Beckerman and Solimano, 2002).

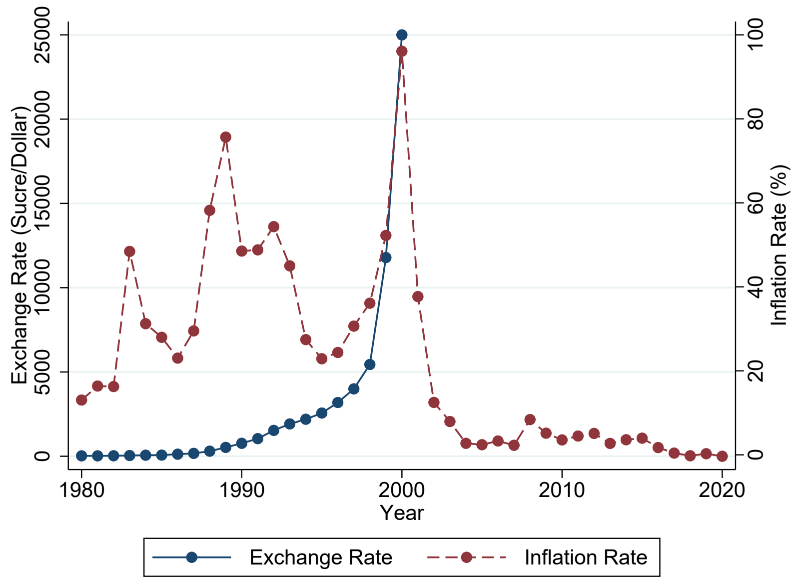
Dollarization brought price stability to Ecuador. Inflation rates dropped from 96.1% in 2000 to 7.9% in 2003 and remained in single digits thereafter (see Figure 1). Another benefit was that it could avoid debt monetization, thereby providing a limit to government overspending. Under dollarization, Ecuadorians do not need to worry about a potential populist leader's exploiting power to finance expenditures with new money (Cachanosky, 2020). However, dollarization also comes at a cost, posing potential challenges to the Ecuadorian economy. Most notably, dollarization means the relinquishing of monetary and exchange rate policies. Large negative shocks often require sizable currency adjustments. Without such exchange rate flexibility, the adjustment to such shocks may require lowering nominal wages and certain prices. Under rigid labor markets, the

[15] Beckerman and Solimano (2002) argue that the crisis was triggered in late 1997 and 1998 by a combination of shocks: plummeting oil prices, heavy damage from El Niño rains, and the Mexican, East Asian, Russian and Brazilian financial crisis. Beckerman and Solimano (2002) further argue that a combination of Ecuador-specific characteristics accounted for severity of the crisis: a) the heavy dependence of public revenue on volatile oil earnings, b) the banking system's exposure to Ecuador's volatile and risky activities, c) inadequate banking supervision, d) political fragmentation, e) week public administration, f) the political system's tendency to maintain energy subsidization, and g) the financial system's partial dollarization. See also Montiel (2013) for more details on Ecuador's 1999 triple crisis.

[16] Given the loss in value of Ecuador's currency (see Figure 1), Ecuadorians used a foreign currency alongside the domestic currency as means of exchange. Before the official dollarization, there was de facto dollarization in the economy.

[17] Before dollarization in late 1992, the exchange regime was initially based on a managed float regime. In 1994, the Central Bank of Ecuador changed it to a pre-announced crawling band. However, several adjustments to the exchange rate band invalidated the initial commitment in most cases (six between 1995 and 1998). The credibility in the exchange regime steadily eroded, leaving the Central Bank of Ecuador without a nominal anchor in its pursuit of price stability (Jácome, 2004).

Figure 1: Exchange Rates and Inflation Rates in Ecuador



Notes: The figure plots exchange rates and inflation rates for the period 1980–2020. The data come from the World Bank.

adjustment could entail a substantial recession.

2.2 Minimum Wage Systems

The minimum wage policy in Ecuador applies to all formal sector workers in the private sector. The minimum wage system in Ecuador has two parts. One is the Unified Minimum Wage (UMW), which is reviewed annually in accordance with the Ecuadorian Labor Code. A key characteristic of the UMW is that the agreement is announced in December prior to the year in which the new UMW is to take effect. It aims to regulate the remuneration that a worker receives in a month (the monthly rate) and is valid for one year. All private firms in Ecuador must pay at least the UMW (wage floor) to both full-time and part-time employees. The second part is the Sectoral Minimum Wage (SMW), which is also reviewed every year and governs all minimum wages for occupations in different sectors of the economy. Since 2011, the SMW has been applied to 21 economic activities, and the agreements have been released together with the UMW at the end of each year.[18]

[18]In essence, focusing on the UMW would be sufficient for our analyses from now on because the UMW acts as the floor for all the SMW and thus the change in SMWs has been broadly indexed to the change in the UMW. See Choi, Rivadeneyra and Ramirez (2021) for more detailed descriptions on the minimum wage

Table 1: Minimum Wage, Inflation, and Real Effective Exchange Rate in Ecuador

Year	Minimum Wage (1)	Nominal Growth Rate (2)	Inflation Rate (3)	Real Growth Rate (4)	REER (5)
2005	$150	10.3%	2.2%	8.1%	105.9
2006	$160	6.7%	3.3%	3.4%	104.1
2007	$170	6.3%	2.3%	4.0%	96.6
2008	$200	17.6%	8.4%	9.3%	95.7
2009	$218	9.0%	5.2%	3.8%	101.1
2010	$240	10.1%	3.6%	6.5%	100.0
2011	$264	10.0%	4.5%	5.5%	97.5
2012	$292	10.6%	5.1%	5.5%	100.4
2013	$318	8.9%	2.7%	6.2%	101.8
2014	$340	6.9%	3.6%	3.3%	105.8
2015	$354	4.1%	4.0%	0.1%	119.5
2016	$366	3.4%	1.7%	1.7%	121.0
2017	$375	2.5%	0.4%	2.0%	116.8
2018	$386	2.9%	-0.2%	3.2%	115.0
2019	$394	2.1%	0.3%	1.8%	116.5

Notes: Unified Minimum Monthly Wage data comes from Subsecretaria de empleo y salarios, Ministerio del Trabajo. Inflation Rate data come from Instituto Nacional de Estadisticas y Censos (INEC). Ecuador is a fully dollarized country. The sucre was replaced with the US dollar in 2000. Since then, the dollar has served as Ecuador's currency. UMW is the national unified minimum monthly wage in US dollars. Nominal Growth Rate is the percentage change in the Unified Minimum Wage. Inflation Rate is based on the consumer price index. Real Growth Rate is calculated as the difference between the nominal growth rate and the (ex-post) inflation rate. REER denotes real effective exchange rate index (2010 = 100), which is drawn from International Financial Statistics (IFS).

Table 1 provides the Unified Minimum Wage levels, inflation rates, and real effective exchange rate indices for the period 2005–2019. The period is characterized by single-digit inflation rates, ranging from -0.2% to 8.4% (see column (3)). The low inflation can mostly be attributed to the dollarization that was implemented in 2000. Column (2) shows that the nominal growth rates of the Unified Minimum Wage were all positive during the period, ranging from 2.1% to 17.6%, far exceeding inflation rates over the same period.[19] In Ecuador, the share of workers who receive the minimum wage is sizable; and the practice of indexing wage changes to the minimum wage increases is widespread. Hence we conjecture that the minimum wage policy may contribute to downward nominal wage rigidities in Ecuador. Column (5) presents Ecuador's real effective exchange rate (REER) indices. In mid-2014, the US dollar started to appreciate against other reserve currencies, which resulted in the appreciation of Ecuador's REER by about 20 percent from 2013 to 2016. Even in this period of exchange rate appreciation, the Unified Minimum Wage

system in Ecuador.

[19] In column (4), even after adjusting for inflation, the real growth rates of the Unified Minimum Wage were also all positive during the period.

continued to rise both in nominal and real terms.

Colombia, Ecuador's neighbor with a flexible exchange rate regime, has similar minimum wage laws that apply to all formal sector workers.[20] Specifically, like Ecuador, the minimum wage in Colombia is a monthly rate; the commission in charge of the minimum wage sets the minimum wage at the end of each year; the government oversees the enforcement of the minimum wage; the share of workers receiving the minimum wage is sizable; and the nominal minimum wage has never decreased in the past two decades or so. Therefore, it suggests that the minimum wage laws in Colombia may have played a similar role in the wage-setting process that leads to downward nominal wage rigidity.[21]

Figure 2 displays the evolution of annual minimum wage growth rate in Colombia and Ecuador. Both countries experienced positive growth in nominal minimum wages throughout the period. More importantly, minimum wage rate grew faster in Colombia than in Ecuador after the shock, suggesting that DNWR, if any, should have been greater in Colombia.

2.3 Macroeconomic Background

The price of oil dropped sharply by almost 60% over a period of about two years between 2014 and 2016 (Figure 3). The sustained decline, which was only surpassed in magnitude by the 67% cumulative decline during the global financial crisis in 2008-09, put severe economic stress on oil exporters around the globe (Baumeister and Kilian, 2016). Those countries that relied heavily on foreign exchange earnings from crude oil exports experienced a deterioration in the fiscal balance while going through domestic demand contraction via negative income effects. With almost half of its total exports covered by crude oil exports (Figure 4-(a)), Ecuador was not an exception.[22]

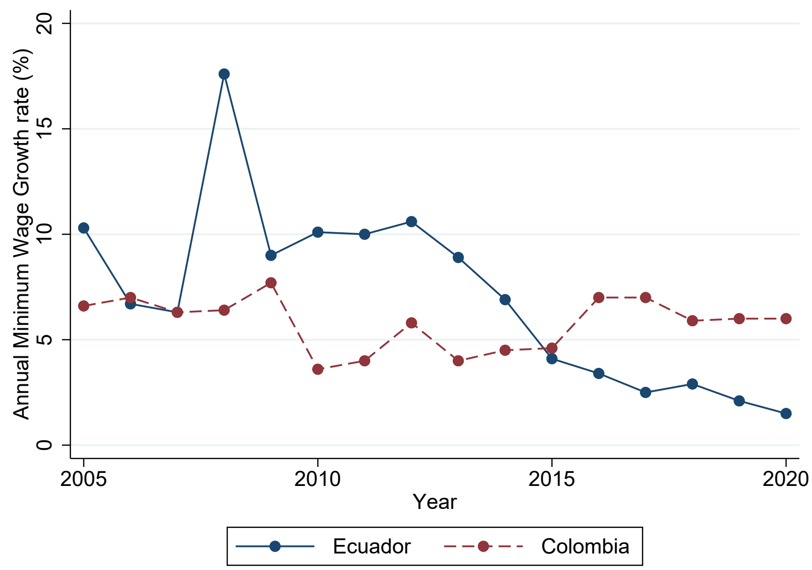
In principle, external adjustment to such adverse shocks can be facilitated by a flexible exchange rate, which allows the domestic currency to depreciate against foreign currencies such that relative price changes result in an expenditure-switching effect, thereby leading to higher exports and a shift in the composition of domestic consumption away from foreign goods toward domestic goods. Unfortunately, however, dollarization in

[20] There are also some minor differences: Colombia's minimum wage is a single-tier system unlike a two-tier system in Ecuador (the UMW and the SMW); On top of the minimum wage system, Colombia provides "transportation assistance" of USD $30 per month to workers who earn up to two times the monthly minimum wage.

[21] Please refer to Section 4 for more details on downward nominal wage rigidity in Ecuador and in Colombia.

[22] According to the IMF's country reports for Ecuador and Colombia, oil-related revenues accounted for 30% and 19% of total fiscal revenues in Ecuador and Colombia as of 2013, respectively.

Figure 2: Minimum Wage Growth Rate: Ecuador and Colombia



Notes: The figure plots the evolution of annual minimum wage growth rate over the period 2005-2020. They are both expressed in nominal wage changes. Ecuadorian minimum wage data comes from Subsecretaria de empleo y salarios, Ministerio del Trabajo; Colombian minimum wage data comes from Ministerio de Trabajo.

Ecuador led to an even more painful adjustment process owing to the lack of exchange rate flexibility as an external shock absorber.[23]

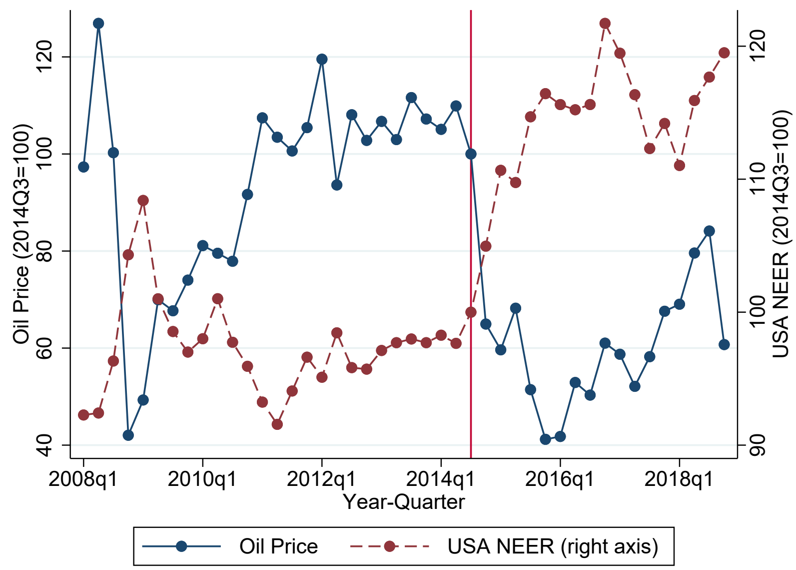
What is worse, the US dollar appreciated substantially against its trading partners' currencies by nearly 20% over the same period (Figure 3), implying an effective appreciation in the nominal exchange rate for a dollarized country like Ecuador. Indeed, Figure 4-(b) displays a notable appreciation in Ecuador's nominal effective exchange rate (NEER) by around 10% over the period, which is in stark contrast to Colombia—a neighboring country with a similar share of oil exports but with the flexible exchange rate regime—whose NEER *depreciated* by 30%.[24]

In theory, even a country with a fixed exchange rate regime can achieve external adjustment via internal devaluation by reducing labor costs (e.g., Decressin et al., 2015; Galí and Monacelli, 2016). In practice, however, internal devaluation rarely occurs, not least

[23]For this reason, about half of the oil exporters with currency pegs adjusted their exchange rate regimes either by switching to a flexible regime or by devaluing the currency, in response to a sustained oil price decline (IMF, 2017b).

[24]IMF (2017b) further documents that most countries with flexible exchange rates had sizable nominal depreciation over the period, while countries that kept their currencies pegged to the US dollar saw sizable appreciation in nominal and real effective terms.

Figure 3: The Evolution of Global Oil Price and U.S. NEER



Notes: The figure plots the evolution of the price of crude oil and U.S. nominal effective exchange rate (NEER) over the period 2008-2018. They are both expressed in index values with 2014 Q3 as a base period. The oil price data corresponds to the simple average of three spot prices – Dated Brent, West Texas Intermediate, and the Dubai Fateh – that is available from the IMF Commodity Price Database. U.S. NEER series is retrieved from the World Bank's Global Economic Monitor (GEM) database.

because of downward nominal wage rigidity (Schmitt-Grohé and Uribe, 2016). In both Ecuador and Colombia, the presence of a binding national minimum wage policy, as discussed above, is expected to have exerted a stronger force against internal devaluation.

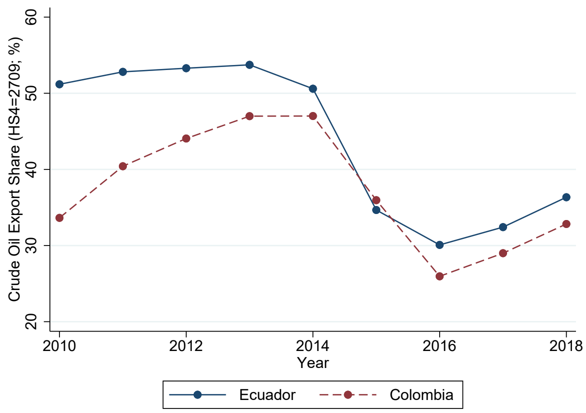
As such, the theory of expenditure switching and exchange rate policy can possibly explain why the adverse effect of the oil price shock was harsher in Ecuador under full dollarization than in Colombia under a floating regime, as suggested by a more rapid increase in unemployment rate (Figure 5-(a)) and a steeper decline in economic growth (Figure 5-(b)) since 2014.[25] This paper aims to verify the hypothesis empirically in a comprehensive framework.

3 Data

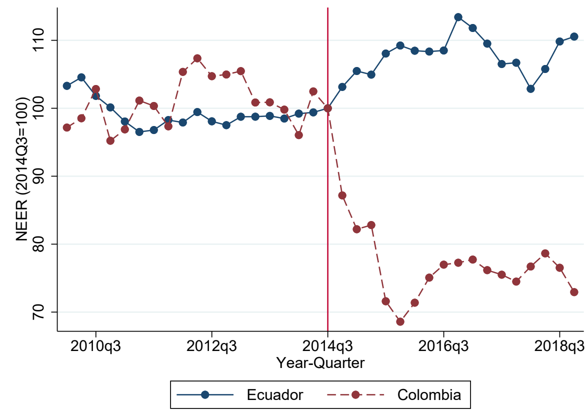
We use worker-level and firm-level data from three sources. First, we use the Ecuadorian administrative payroll dataset for the period 2010–2018, which provides monthly

[25]IMF (2017a) also attributed the contrasting effect of the adverse oil price shocks to different exchange rate regimes in two countries.

Figure 4: Oil Export Share and Nominal Effective Exchange Rate: Ecuador and Colombia



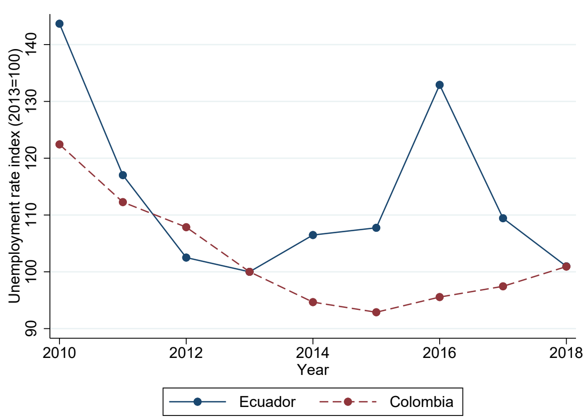
(a) Oil Export Share



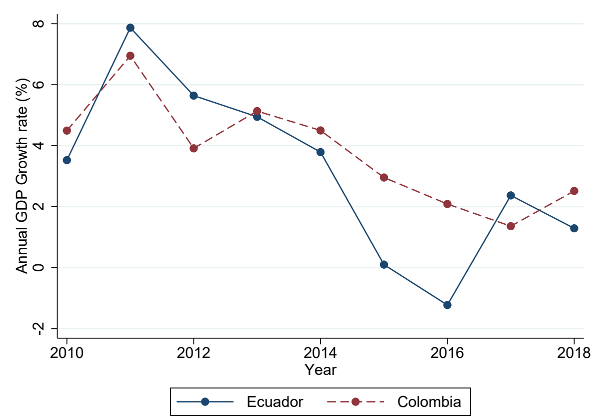
(b) Nominal Effective Exchange Rate

Notes: Figure (a) plots the share of crude oil (HS4=2709) exports in total exports over the period 2010-2018 for Ecuador and Colombia; figure (b) plots the evolution of the nominal effective exchange rate (NEER) over the period 2010-2018 for Ecuador and Colombia, both of which are expressed in index values with 2014 Q3 as a base period. Export data are from the UN Comtrade database downloadable at the World Integrated Trade Solution (WITS). NEER series are retrieved from the World Bank's Global Economic Monitor (GEM) database.

Figure 5: Unemployment Rate and GDP Growth Rate: Ecuador and Colombia



(a) Unemployment Rate



(b) GDP Growth Rate

Notes: Figure (a) plots the evolution of the unemployment rate over the period 2010-2018 for Ecuador and Colombia; figure (b) plots the evolution of annual GDP growth over the period 2010-2018 for Ecuador and Colombia. Annual frequency unemployment data and real GDP data are available at the World Bank's Global Economic Monitor (GEM) database.

remuneration and days worked in a month at the worker-firm-year-month level for the universe of formal sector workers in Ecuador. Second, we use the Ecuadorian customs dataset for the period 2010–2018, which provides export values and quantities at the transaction level (i.e., firm-product-country-year-month-day level) for all international transactions in Ecuador. We merge those two datasets based on the firm identifiers. Third, we use the Colombian transaction-level customs dataset for the same period, which contains similar information as the Ecuadorian customs dataset.

3.1 Ecuadorian Administrative Payroll Dataset

The Ecuadorian administrative payroll dataset covers the universe of formal sector workers who make social security contributions in Ecuador from January 2010 through December 2018. The dataset comes from Instituto Ecuatoriano de Seguridad Social (Social Security Administration in Ecuador). The variables in the dataset include a person identifier, age, gender, occupation description, individual classification, monthly remuneration, days worked in a month, a firm identifier, and an industry code for the firm.[26] The monthly remuneration is the base pay, not including benefits, bonuses, or raises.[27] The payroll dataset is used to measure the extent of downward nominal wage rigidity in Ecuador (in Section 4) and to analyze the impacts of the adverse shocks during 2014-16 on wage and employment adjustments (in Sections 5 and 6).[28]

First, in order to construct our primary sample in Section 4, we use the dataset for the period January 2012–December 2013 and set the year 2013 as the base year—i.e., one year before the global oil price collapse and the US dollar appreciation. We exclude voluntary and independent contributors, "Voluntario / Independiente"[29]; we drop negative

[26]Individuals in the dataset are classified as follows: "Privada", "Publica", and "Voluntario / Independiente". "Privada" refers to private sector; individuals who work for private firms are classified in this category. "Publica" means public sector; individuals who work in the public sector are classified in this category. "Voluntario" refers to voluntary contributors such as non-working individuals. "Independiente" means independent contributors who work for themselves as freelancers or business owners rather than for an employer.

[27]The base pay must be the largest component of total labor income. Although we do not have information on other types of payment in total labor income in Ecuador, Mexican National Household Income and Expenditure Survey (ENIGH) indicated that the share of the base pay in the total labor income is about 87 percent in Mexico (see Castellanos, García-Verdú and Kaplan (2004)). Relatedly, using Ecuador's National Employment, Unemployment and Underemployment Survey (ENEMDU), we find that more than 90% of individual total income is labor income. In sum, total income comes mainly from labor income especially through the base wage in Ecuador.

[28]Note that we use a more comprehensive sample, covering entire private and public sector firms, in Section 4 where we analyze the extent of downward nominal wage rigidity in Ecuador. Thereafter, the sample is restricted to firms that also appeared in the customs dataset (i.e., the sample is limited to exporters only).

[29]Note that only 1.7 percent of total observations is dropped.

observations of monthly remuneration and exclude observations if days worked is fewer than 0 and more than 30[30]; we then convert monthly remuneration into monthly wages using the information on days worked for each individual[31]; finally we calculate the 12-month nominal wage growth rate between 2012 and 2013 for each individual who remain employed over the 12-month period in the same job.

Table 2 summarizes descriptive statistics of the 12-month period nominal wage changes between 2012 and 2013. The sample contains a total of 22,888,141 observations. The average nominal wage growth rate is 12.3 percent, which is slightly higher than the minimum wage growth rate of 8.9 percent (see Table 1). The standard deviation of wage growth rate is relatively large, 67.4 percent. The median wage growth rate is 8.9 percent, which is the same as the minimum wage growth rate.

Table 2: Summary Statistics: Nominal Wage Changes in Ecuador

Variable	# of Obs (1)	Mean (2)	SD (3)	10th (4)	25th (5)	50th (6)	75th (7)	90th (8)
Wage Growth Rate	22,888,141	12.3%	67.4%	-0.03%	0%	8.9%	11.8%	30.8%

Notes: The table provides descriptive statistics on the annual change in nominal wages for all workers in our employer-employee matched sample who remain employed over the 12-month period in the same job between 2012 and 2013.

Next, in order to construct our primary sample in Sections 5 and 6, we link the firm identifiers in the Ecuadorian customs data (2010–2018) to the Ecuadorian payroll data (2010–2018). Then we keep observations in the payroll dataset that have the matched firm IDs. This means that the sample is restricted to workers in the firms that appeared at least once (i.e., conducted at least one export transaction in the period) in the customs dataset (2010–2018). We exclude public sector workers (and firms), "Publica"[32]; we further exclude firms with a missing industry code and outsourcing firms; we drop negative observations of monthly remuneration and exclude observations if days worked is fewer than 0 and more than 30[33]; we convert the data frequency from monthly to quarterly; we then calculate a full-time-equivalent monthly wage rate for each job spell.

Table 3 presents summary statistics of the Ecuadorian payroll dataset that is restricted to firms that conduct at least one exporting transaction in the customs dataset (2010-2018).

[30] Days worked in full-time jobs is recorded as 30 in the dataset. The number of dropped observations is almost negligible.

[31] In Ecuador, since 2008, the constitution prohibits hourly labor hiring (article 327 on the 2008 constitution). As a result, employers were forced to pay the Unified Minimum Wage (UMW) using yearly contracts that specify monthly wages, not hourly wages. Hence the monthly wage is the reference measure for gauging a worker's wage in Ecuador.

[32] Note that only 6.0 percent of total observations is dropped.

[33] The number of dropped observations is almost negligible.

Table 3: Summary Statistics: Ecuadorian Payroll Dataset

				Monthly Wage			Firm Size		
Year	# of Job Spells	# of Workers	# of Firms	Mean	Median	S.D.	Mean	Median	S.D.
2010	353,431	333,125	1,556	541	349	935	173	44	478
2011	384,726	358,632	1,740	589	386	1,043	167	40	464
2012	410,021	382,092	1,891	657	421	1,411	165	39	457
2013	427,041	398,101	2,026	726	456	1,318	162	36	440
2014	446,028	414,962	2,116	764	488	1,366	161	36	442
2015	435,560	406,785	2,123	801	506	1,471	160	36	444
2016	402,697	382,477	2,067	834	516	3,832	155	34	442
2017	402,917	382,407	1,990	837	530	2,119	161	35	459
2018	411,845	389,498	1,930	858	546	2,406	169	35	478

Notes: This table provides summary statistics from an Ecuadorian payroll dataset that is linked to the Ecuadorian customs dataset through firm IDs. The monthly raw datasets are aggregated up to worker-exporter(firm)-quarter level. "# of Job Spells" denotes the number of unique job spells; "# of Workers" indicates the number of unique workers; "# of Firms" indicates the number of unique firms. "Monthly Wage" means a full-time-equivalent monthly wage rate; "Firm Size" denotes the number of workers employed by a firm.

The sample contains a total of 353,431 observations (i.e., job spells) in 2010 and ends with a total of 411,845 observations in 2018. The total number of workers ranges from 333,125 to 414,962; and the total number of firms ranges from 1,556 to 2,123. Notably, the number of job spells (and workers) reached a peak in 2014, the first year of the global oil price collapse and the US dollar appreciation, and then trended downward until 2017; the number of exporters matched to the payroll dataset reached a peak in 2015, the year following the adverse shock, and trended downward thereafter. Regardless of the adverse shock in 2014, the mean and median nominal wages continued to rise every year, possibly driven by the Universal Minimum Wage that continued to rise over the same period. (see Table 1). The average (and median) number of workers per firm (i.e., firm size) showed a downward trend until 2016 and increased thereafter.

3.2 Ecuadorian and Colombian Customs Datasets

To explore the pattern of export price adjustments, we employ the Ecuadorian transaction-level customs dataset that covers the universe of Ecuador's exports from 2010 through 2018 – four years before and after the initial global oil price drop. The dataset provides detailed information, including an exporter identifier number, FOB value, quantity (net weight), 10-digit HS product code, country of destination, dates, etc.[34] Given the FOB value and quantity information provided, unit prices can be derived as the value-to-weight ratio. Excluding outlier transactions, the value of export transactions in the dataset

[34] This dataset is also used in Adão, Carrillo, Costinot, Donaldson and Pomeranz (2022).

adds up to 98 percent of the official export value compiled by the UN Comtrade database over the period 2010-2018.[35] We construct the baseline sample data by aggregating the transaction-level raw data to exporter(firm)-6 digit HS product code-destination country-quarter level.

To conduct a comparative analysis, we also use the Colombian transaction-level customs dataset from the export transaction database of the Colombian National Customs and Taxes Authority (DIAN). It covers the universe of Colombian exports for the same period and contains the same types of detailed information as the Ecuadorian dataset. To make it comparable to the Ecuadorian dataset, we also exclude flower exports (HS4 code=0603) and aggregate the raw dataset to exporter(firm)-6 digit HS product code-destination country-quarter level. The value of export transactions in the baseline dataset adds up to nearly 100 percent of the official export value from UN Comtrade for the period 2010-2018.[36]

Table 4 provides key summary statistics of the baseline customs data from Ecuador and Colombia, whereby the unit of observation is defined at the exporter(firm)-6 digit HS product code-destination country-quarter level. It reveals several interesting facts. First, we note that the number of observations increases in both countries, from 20,088 in 2010 to 46,035 in 2018 for Ecuador, and from 109,003 in 2010 to 171,392 in 2018 for Colombia. Second, the total value of Colombia's exports is about twice that of Ecuador, and the median unit price of exported goods from Colombia is two to three times higher than that from Ecuador. Third, although the overall quality of the Colombian dataset is somewhat better than that of the Ecuadorian dataset in that the former matches close to 100 percent of total official export values compiled by the UN Comtrade database in almost all years over the period, we are assured that, once summed over the entire sample period, the total export value from the Ecuadorian dataset accounts for 98 percent of the total official export value for Ecuador in the UN Comtrade database. Lastly, it shows a clear pattern of unit price changes that is consistent with the role of exchange rate regimes in riding out the storm: the average (or median) unit price in Ecuador trended downward until 2013, after which it reversed course. Exactly the opposite pattern is observed in Colombia, where the average (or median) unit price initially increased until 2013 but began declining in 2014, possibly reflecting the extent to which domestic currency depreciation lowered

[35]We exclude (i) transactions with unreasonably extreme values (top 0.008%) and (ii) flowers exports (HS4 code=0603) that far exceed export values recorded in the UN Comtrade database. Accordingly, we compared the total value of exports in the cleansed dataset with that from the UN Comtrade database excluding flower exports (HS4 code=0603).

[36]This dataset is also used in Bernard, Bøler and Dhingra (2018), Ahn and Sarmiento (2019), Gopinath, Boz, Casas, Díez, Gourinchas and Plagborg-Møller (2020).

Table 4: Summary Statistics: Customs Datasets from Ecuador and Colombia

	Ecuador							Colombia						
		Export Price (Value/Weight, $)			Export Value (FOB, million $)				Export Price (Value/Weight, $)			Export Value (FOB, million $)		
Year	Obs.	Mean	Median	S.D.	Total	UN Comtrade	Coverage(%)	Obs.	Mean	Median	S.D.	Total	UN Comtrade	Coverage(%)
2010	20,088	42.3	5.3	161.5	13,621.5	16,882.2	80.7	109,003	41.7	11.9	96.3	37,186.4	38,579.0	96.4
2011	24,742	36.6	4.9	149.1	19,930.1	21,662.6	92.0	116,836	44.1	13.9	94.4	53,404.7	55,702.2	95.9
2012	18,134	27.5	4.4	117.0	22,896.7	23,080.7	99.2	121,420	46.6	15.2	97.9	57,716.1	59,003.6	97.8
2013	31,064	32.4	3.6	146.9	22,103.5	24,120.4	91.6	157,906	52.0	14.7	113.6	56,422.7	57,487.3	98.1
2014	40,819	39.5	5.0	156.2	24,997.3	24,806.2	100.8	158,079	52.3	14.6	112.7	51,362.1	53,420.6	96.1
2015	38,790	48.7	5.0	180.4	16,094.7	17,510.7	91.9	160,031	51.4	13.8	120.0	36,916.2	34,395.4	107.3
2016	42,313	51.5	5.1	190.2	17,087.3	15,995.2	106.8	164,741	48.6	12.6	120.6	29,386.3	29,732.7	98.8
2017	43,647	45.9	4.7	179.0	19,774.3	18,271.9	108.2	168,259	45.2	11.9	111.4	36,343.3	36,366.7	99.9
2018	46,035	43.3	4.5	178.5	23,552.0	20,754.2	113.5	171,392	46.0	11.8	113.2	40,311.8	40,373.4	99.8

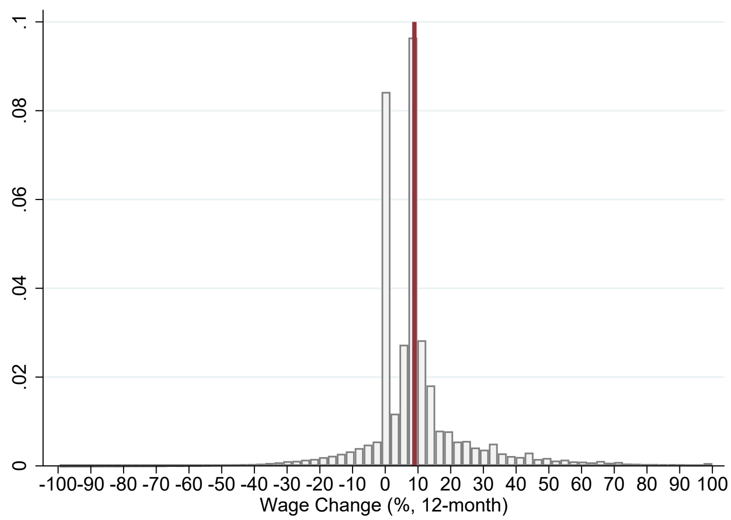
Notes: This table provides summary statistics from the customs datasets from Ecuador and Colombia. For both countries, the transaction-level raw datasets are aggregated up to exporter(firm)-6digit HS product code-destination country-quarter level. For Ecuador, the baseline dataset excludes outlier transactions with unreasonably extreme values (top 0.008%) as well as flowers exports that correspond to "0603" in HS4 code. To be comparable, the baseline dataset for Colombia also excludes flowers exports ("0603" in HS4 code). Accordingly, flowers exports ("0603" in HS4 code) are excluded in the total export value from the UN Comtrade database for both countries.

its export prices in US dollar terms.

4 Downward Nominal Wage Rigidity

This section explores nominal wage adjustments for workers who remained employed over the 12-month period in the same job, using a methodology similar to that used by Grigsby, Hurst and Yildirmaz (2021). Specifically, we use monthly frequency data and set the year 2013 as the base year—i.e., one year before the global oil price collapse and the US dollar appreciation.[37] For all job-stayers in the payroll dataset in 2013, we calculate 12-month nominal wage growth rates between 2012 and 2013.[38]

Figure 6: 12-Month Nominal Wage Change Distribution, 2013



Notes: The figure plots the annual change in nominal wages for all workers in our sample who remained employed over the 12-month period in the same job from 2012 to 2013. The red vertical line indicates the growth rate of the Unified Minimum Wage from $292 in 2012 to $318 in 2013 (i.e., 8.9%).

Figure 6 plots the distribution of 12-month nominal wage changes for all workers in the sample in 2013. There are several notable patterns from the nominal wage change distribution in Figure 6 (see also corresponding row ”All” in Table 5). First, there is a clear asymmetry in the nominal wage changes such that only 10.1 percent of workers who remained employed over the 12-month period in the same job received a nominal

[37]In 2013, the nominal minimum wage growth rate was 8.9%; the inflation rate was 2.7%.

[38]As noted, in Ecuador, the constitution prohibits hourly labor hiring (article 327 in the 2008 constitution). Therefore monthly wage, not hourly wage, is the reference measure for gauging workers’ wages in Ecuador.

Table 5: Percentage of Employees Receiving Nominal Wage Cuts, Freezes, and Increases, 2013

Sample	Wage Cuts (1)	Wage Freezes (2)	Wage Increases (3)	Wage Increases (=MW Growth) (4)
All	10.1%	20.1%	69.8%	15.5%
Public	5.0%	57.9%	37.0%	1.1%
Private	11.6%	9.0%	79.4%	19.7%
Less than MW	0.01%	0.01%	99.98%	42.7%
Equal to or More than MW	15.8%	31.5%	52.7%	0.01%

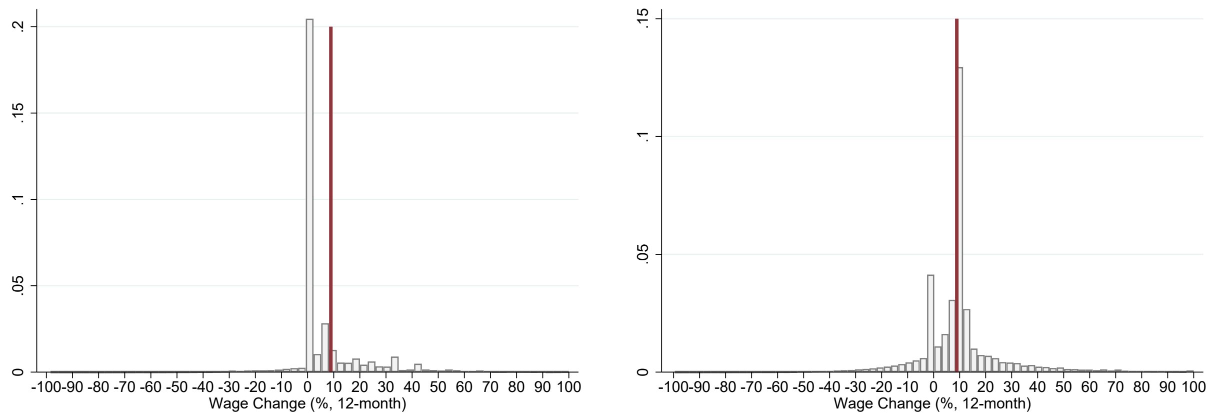
Notes: Columns (1), (2), and (3) show the percentage of employees receiving nominal wage cuts, freezes, and increases in the year 2013. In column (4), we present the percentage of the nominal wage increase that is equal to the growth rate of the minimum wage in the year 2013. Different samples are presented across rows. "All" indicates that the sample consists of all workers. "Public" (resp. "Private") means that the sample is restricted to public (resp. private) sector workers; "Less than MW" (resp. "Equal to or More than MW") means that the sample is restricted to workers receiving less than (resp. equal to or more than) the 2013 Unified Minimum Wage level—i.e. $318 in the year 2012.

wage decline and 69.8 percent of those received a nominal wage increase. The percentage receiving wage cuts in Ecuador is comparable to that in Mexico, where Castellanos, García-Verdú and Kaplan (2004) found some evidence of downward nominal wage rigidity such that the percentage receiving wage cuts was about 11 percent in periods of low inflation and much lower in periods of high inflation.[39] Second, the wages for 20.1 percent of workers who remained employed over the 12-month period in the same job did not change. The large spike at zero is also widely observed in the empirical studies of downward nominal rigidity (see Kahn, 1997; Castellanos et al., 2004; Jo, 2019; Grigsby et al., 2021). Those two points support the existence of downward nominal wage rigidity in Ecuadorian labor markets. Third, 15.5 percent of workers who remained employed over the 12-month period in the same job received a wage change that is exactly equal to the minimum wage growth rate, showing another spike at the minimum wage growth rate. This implies that nominal wage changes are, to some extent, indexed to increases in the minimum wage, and that there are two spikes in the nominal wage change distribution. The bimodal distribution resembles the kernel density estimates of Castellanos, García-Verdú and Kaplan (2004) using administrative records of the Mexican Social Secu-

[39]Elsby and Solon (2019) gathered previous empirical studies and found that nominal wage cuts from one year to the next appear quite common, typically affecting 15 to 25 percent of job-stayers in periods of low inflation. On the contrary, a more recent study by Grigsby, Hurst and Yildirmaz (2021), found that nominal base wage declines are much rarer than previously thought, with only 2% of job-stayers receiving a nominal base wage cut during a given year. While those two studies give us some criteria to evaluate the extent of downward nominal wage rigidity in Ecuador, their results are based mostly on developed countries and hence are not directly comparable to ours.

rity Institute (IMSS).

Figure 7: 12-Month Nominal Wage Change Distribution by Sector, 2013



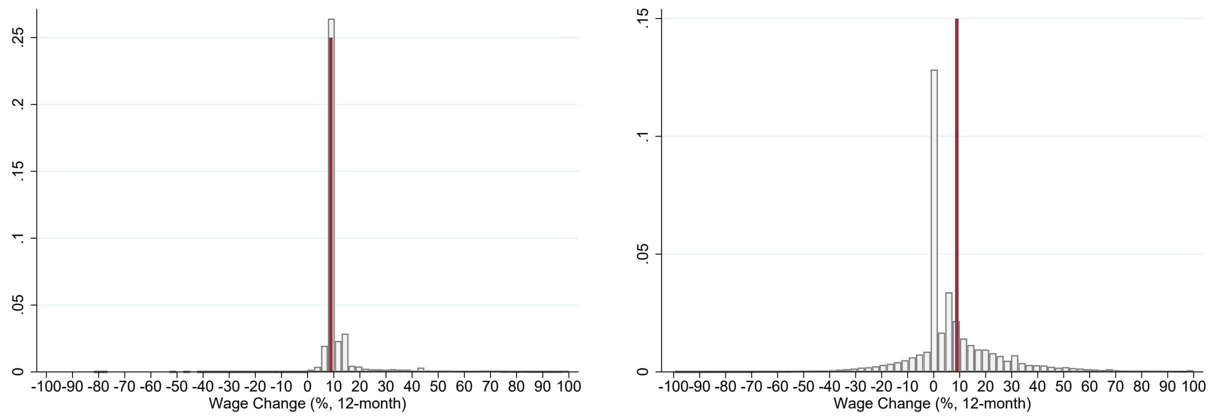
(a) Public Sector

(b) Private Sector

Notes: Figures (a) and (b) plot the annual change in nominal wages for public and private sector workers, respectively, in our employer-employee matched sample who remained employed over the 12-month period in the same job from 2012 to 2013. The red vertical line indicates the growth rate of the Unified Minimum Wage from \$292 in 2012 to \$318 in 2013 (i.e., 8.9%).

In Ecuador, the public sector and the private sector have different wage-setting systems. For instance, the minimum wage law applies to workers in the private sector only. The public sector workers are subject to different government legislation. Hence, the degree of nominal wage rigidity in the public and private sectors may differ. Figure 7 plots the distribution of 12-month nominal wage changes by sector—i.e., public and private—in the sample in 2013. In Table 5, percentages of receiving nominal wage changes for public and private sector workers are presented (see corresponding rows "Public" and "Private"). There are several different patterns between the two sectors. First, nominal wage cuts are rarer in the public sector than in the private sector such that only 5 percent of workers who remained employed over the 12-month period in the same job received a nominal wage cut in the public sector while 11.6 percent received a nominal wage cut in the private sector. Second, nominal wage freezes are more frequent in the public sector than in the private sector. The percentage of employees whose wages were frozen is 57.9 percent in the public sector and 9.0 percent in the private sector. Third, 37.0 percent of workers in the public sector and 79.4 percent of workers in the private sector received a nominal wage increase, meaning that wage increases are more prevalent in private sector than in public sector. Fourth, private sector wages are more closely aligned with the increase in the minimum wage. The percentage of workers who received wage increases equal to the minimum wage growth rate is 19.7 percent; while only 1.1 percent of public sector workers received wage increases that are equal to the minimum wage growth rate.

Figure 8: 12-Month Nominal Wage Change Distribution for Workers by Wage Level, 2013



(a) Less Than MW

(b) Equal To or More Than MW

Notes: Figures (a) and (b) plot the annual change in nominal wages for workers whose wages are less than, and equal to or more than the 2013 Unified Minimum Wage (i.e. $318, in the year 2012), respectively, in our employer-employee matched sample who remained employed in the same job over the 12-month period from 2012 to 2013. The red vertical line indicates the growth rate of Unified Minimum Wage from $292 in 2012 to $318 in 2013 (i.e., 8.9%).

The fact that about 20 percent of private sector workers received wage increases equal to the minimum wage growth rate confirms that the minimum wage law played an important role in the wage-setting system in Ecuador. We delve further into the extent to which the minimum wage law contributed to downward nominal wage rigidity in Ecuador. Figure 8 plots the distribution of 12-month nominal wage changes by wage level in the sample in 2013: Figure (a) is to restricted workers who received less than the 2013 Unified Minimum Wage level, i.e. $318, in the year 2012 and Figure (b) is restricted to workers who received equal to or more than the 2013 Unified Minimum Wage. Table 5 presents the percentages of workers who received nominal wage changes of "less than" (and "equal to or more than") the 2013 Unified Minimum Wage level in the year. Almost all workers (i.e., 99.98 percent) who earned less than the 2013 Unified Minimum Wage in 2012 received wage increases; 42.7 percent of of those received a wage increase equal to the minimum wage increase. The downward nominal wage stickiness was most pronounced for workers receiving less than next year's minimum wage. Hence, the minimum wage law contributed to downward nominal wage rigidity to a great extent. For workers who received equal to or more than the 2013 Unified Minimum Wage in 2012, the percentage whose nominal wages were cut, frozen, or increased was 15.8%, 31.5%, and 52.7%, respectively. It is worth mentioning that only a small portion of workers received wage reductions (i.e., downward nominal wage rigidity can also be identified) in this group, possibly owing to the wage spillover effects from the minimum wage increase (Choi, Rivadeneyra and Ramirez, 2021).

Table 6: Percentage of Workers Whose Nominal Wages Were Cut, Frozen, or Increased, 2011-2018

Year	Wage Cuts (1)	Wage Freezes (2)	Wage Increases (3)	Wage Increases (=MW Growth) (4)
2011	9.0%	17.6%	73.5%	14.5%
2012	10.5%	13.4%	76.2%	12.1%
2013	10.1%	20.1%	69.8%	15.5%
2014	11.3%	18.7%	70.0%	15.8%
2015	13.6%	20.6%	65.8%	15.4%
2016	15.5%	24.6%	60.0%	17.0%
2017	12.1%	25.7%	62.2%	22.4%
2018	11.9%	26.6%	61.5%	21.7%

Notes: Columns (1), (2), and (3) show the percentage of nominal wage cuts, freezes, and increases. Column (4) shows the percentage of nominal wage increases that are equal to the growth rate of the minimum wage. The sample consists of all workers.

We next ask whether the nominal wages were downwardly rigid during the recession (i.e., after 2014Q3). We repeat the above analysis for the full sample, by year, and summarize the results in Table 6. The percentage of workers receiving nominal wage cuts increased slightly after 2014, but a strong pattern of DNWR continued.[40] During the recession, the percentage of workers whose wages were frozen increased relatively more than the percentage whose wages were cut,[41] meaning that wage freezes were more frequent than wage cuts. Finally, the indexation of wage changes to the minimum wage increases was even more frequent after the shock,[42] suggesting that minimum wage laws played a role in preventing nominal wages from falling. Taken together, in both pre- and post-shock periods, there was a significant level of downward nominal wage rigidity (DNWR), induced by stringent minimum wage regulations, in Ecuador. Moreover, we note that a similar pattern must have held in Colombia due to the structure of the minimum wage

[40] The percentage of workers receiving a nominal wage cut ranged from 9.0% to 10.5% before the shock; the percentage receiving a nominal wage cut ranged from 11.3% to 15.5% after the shock.

[41] The percentage of workers receiving a nominal wage freeze ranged from 13.4% to 20.1% before the shock; the percentage receiving a nominal wage freeze ranged from 18.7% to 26.6% after the shock.

[42] The percentage of workers receiving a nominal wage increase equal to the minimum wage growth rate ranged from 12.1% to 15.5% before the shock; the percentage receiving a nominal wage increase equal to the minimum wage growth rate ranged from 15.4% to 22.4% after the shock.

regulation that is akin to that in Ecuador as discussed in Section 2.2.[43]

5 External Adjustment

This section aims to identify the role of exchange rate regimes in facilitating adjustments to adverse external shocks. Our strategy is twofold. First, we consider two neighboring heavy oil exporters with different exchange regimes, Ecuador and Colombia, and investigate each country's export price and value adjustment dynamics around the oil price plunge of 2014-16 by employing each country's transaction-level customs data. Next, we assess the extent to which internal devaluation process was missing by matching the Ecuadorian administrative payroll data to the Ecuadorian customs data.

5.1 A Tale of Two Countries

We use an event-study approach to investigate how Ecuadorian exporters adjusted their export prices in response to the adverse oil price shock and what roles dollarization played in the process.[44] Considering the timing of the sudden drop in the price of oil accompanied by US dollar appreciation, we are interested in tracking export price movements before and after around the third quarter of 2014. One key strength of our empirical strategy is our use of a detailed transaction-level customs dataset. This allows us to trace variations in export prices for each exporter-HS6 product-destination country triplet, and thus to effectively control for any supply-side specific effects at the exporter-HS6 product level or demand-side specific effects at the destination-HS6 product level.

Specifically, we compare the estimated coefficients across time dummies with a regression of export unit prices in log with exporter-HS6 product-destination country triplet fixed effects:

$$\ln \mathrm{Y}_{ijkt} = \sum_{s \neq 2014Q3} \beta_s \times \mathbb{1}\{s = t\} + \psi_{ijk} + \varepsilon_{ijkt} \tag{1}$$

where the dependent variable, $\ln \mathrm{Y}_{ijkt}$, is the log of export unit price (in USD) of firm i's export product (HS6 code) j to importing country k in time t. Export unit price is

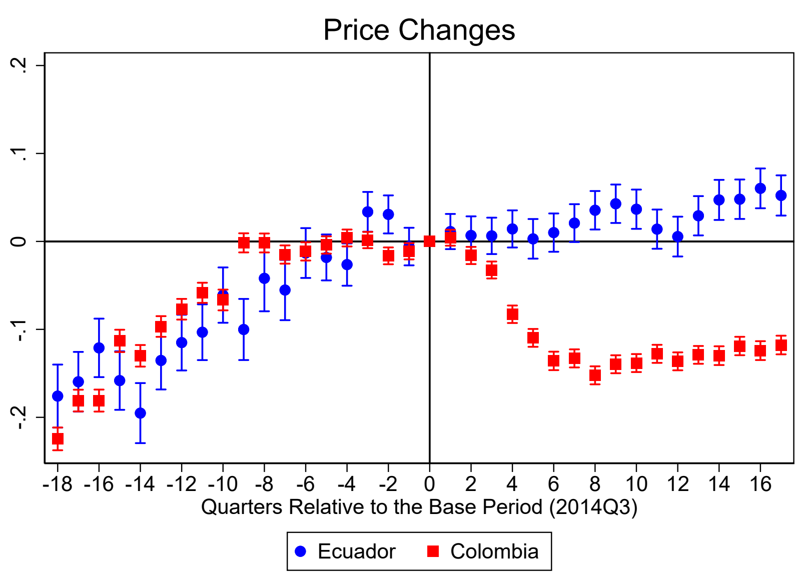
[43] According to Iregui, Melo and Ramírez (2012), who studied firms' wage adjustment practices in the Colombian formal labor market using a survey of 1,305 firms, the extent of DNWR in Colombia is quite similar to that in Ecuador such that (1) most firms adjust base wages annually; (2) wage increases were concentrated around the inflation rate, which is typically anchored to the minimum wage change; and (3) none of those firms cut wages.

[44] Appendix A provides robustness checks from alternative estimation models such as difference-in-differences and dynamic treatment effect models.

calculated as the FOB value divided by net weight (i.e., value-to-weight ratio). Exporter-HS6 product-destination country triplet fixed effects are captured by ψ_{ijk}, and $\mathbb{1}\{s = t\}$ is an indicator variable corresponding to a time dummy that equals 1 if the time (year-quarter) is t and 0 otherwise. The sample period begins in 2010Q1 and ends in 2018Q4; a reference point is set at 2014Q3. Standard errors are clustered at the exporter-product-country level.

Albeit informative, one downside of this approach is that it cannot fully separate out the US dollar appreciation shock from the oil price shock, and hence we are unable to exactly identify the extent to which dollarization prevented external adjustment. To overcome this identification challenge, we run additional regression of equation (1) separately for Colombia, a neighboring country with a similar share of oil exports but with a flexible exchange rate regime. The two countries could be expected to have experienced a similar level of adverse terms of trade shock, so any observed difference in export price adjustment dynamics can be attributed to their exchange rate divergence.

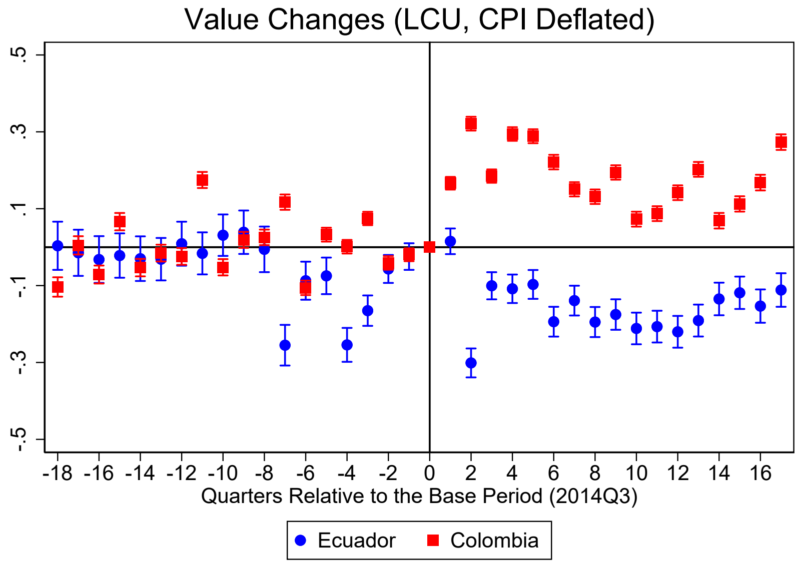
Figure 9: Event Study Analysis: Export Price Dynamics in Ecuador and Colombia



Notes: The figure plots event-study analysis results from equation (1) where the dependent variable is the log of export price (in USD). 95% confidence intervals are represented by bars. The results are illustrated separately for Ecuador (blue circles) and Colombia (red squares).

The event-study analysis results for Ecuador and Colombia are described separately in Figure 9. Coefficient estimates on time dummy variables for Ecuador are shown in blue circles; 95 percent confidence intervals are represented by the blue bars. We note that average export prices in Ecuador had been on an increasing trend until around 2014Q3,

Figure 10: Event Study Analysis: Export Value Dynamics in Ecuador and Colombia



Notes: The figure plots event-study analysis results from equation (1) where the dependent variable is the log export value in the local currency unit (LCU) deflated by domestic CPI. 95% confidence intervals are represented by bars. The results are illustrated separately for Ecuador (blue circles) and Colombia (red squares).

and then stabilized over the next four years with a few upticks. This is in stark contrast to the case of Colombia, illustrated with red squares. Although the pre-trend average export price in Colombia before the adverse oil price shock appears very close to that in Ecuador, it declined significantly after the shock.[45] This is precisely what the theory of expenditure switching would predict for two countries with different exchange rate regimes: exporters in flexible exchange rate countries like Colombia are able to lower export prices thanks to domestic currency depreciation, while those in dollarized countries cannot do so.

As a result, elastic export demand would imply that external competitiveness improved and thus export volume increased in Colombia, whereas Ecuador lost external competitiveness and ended up with a relative decline in export volume. Valuation effects from the sharp depreciation of the Colombian peso further suggest that overall export value in each country's domestic currency increased in Colombia relative to that in

[45]It is worth noting that the decline in Colombian export price is particularly pronounced beginning three to four quarters after the shock. Considering that 98 percent of Colombian exports are invoiced in US dollars (Casas et al., 2017), this is consistent with the prediction from a model of DCP whereby the traditional exchange rate effects would gradually reemerge over time as prices become more flexible (Adler et al., 2020).

Ecuador. To verify the consequences of differential patterns of export price adjustments in the two countries, we repeat the event-study analysis in equation (1) by replacing the dependent variable with the log of export value, whereby export value is converted into the local currency unit (LCU) and then deflated by the domestic consumer price index (CPI).[46] Figure 10 illustrates the event-study analysis results for real export value regressions. As earlier, coefficient estimates on time dummy variables for Ecuador are represented by blue circles, those for Colombia by red squares. The trends in average export value before the adverse oil price shock were not very different in the two countries, but they began to diverge immediately after the shock, which is consistent with what the theory of expenditure switching would suggest.

5.2 The Missing Role of Internal Devaluation

In principle, even under a fixed exchange rate system, exporters should be able to adjust their export prices by reducing labor costs (e.g., Decressin et al., 2015; Galí and Monacelli, 2016). However, this channel of internal devaluation was not available in Ecuador owing to the downward nominal wage rigidity that stemmed from the binding minimum wage, as discussed in Section 4.[47] To verify the extent to which the absence of internal valuation prevented external adjustment in Ecuador, we further investigate whether Ecuadorian exporters, who were more likely to be pressured to raise wages in accordance with the minimum wage increases, indeed found it harder to adjust their export prices.

To operationalize this idea, we zoom in on the sample that is restricted to Ecuadorian firms in the payroll dataset that appeared at least once in the customs dataset (2013-2018) – i.e., firms that had at least one export transaction over the period. We define those firms as "Ecuadorian exporters" henceforth, which are then further categorized into two groups: exporters that were more likely to be pressured to raise wages and other exporters. That is, we define exporters with a workforce consisting of 50 percent or more minimum wage workers as "exporters with a high share of MW workers"; those with a workforce of less than 50 percent minimum wage workers are defined as "exporters with a low share of MW workers."[48] This categorization is based on our discussion in Section 4:

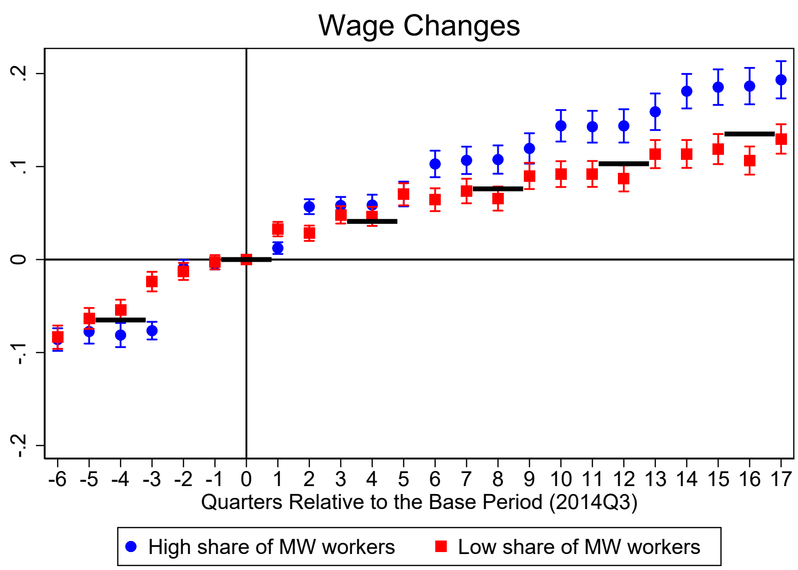
[46]The conversion into LCU applies to Colombia only because a full dollarization means that Ecuador's domestic currency is US dollar.

[47]Note also that the inflation rate ranges from -0.2% to 5.1% between 2010 and 2018 (i.e., the period of low inflation); hence downward sticky nominal wages in Ecuador cannot be simply attributed to high inflation rates as in other developing countries where double-digit inflation rates are prevalent.

[48]More precisely, by minimum wage workers we mean those workers whose wage levels in 2013 were lower than the 2014 Unified Minimum Wage. We categorize firms into two groups based on their share of minimum wage workers in total workers as of 2013.

wage growth induced by an increase in the minimum wage must have been most binding for minimum wage workers such that firms with a higher share of minimum wage workers were more likely to have suffered from downward nominal wage rigidity.

Figure 11: Wage Changes within Firms and Minimum Wages in Ecuador



Notes: The figure displays the log of firms' average wage changes relative to the quarter of the exchange rate shock based on the estimates of equation (2). 95% confidence intervals are displayed in bars. The black thick horizontal lines denote the normalized Unified Minimum Wage. The level at 2014Q3 (i.e., the Unified Minimum Wage in 2014) is normalized as 0. The results are illustrated separately for Ecuadorian exporters with a high share of minimum wage workers (blue circles) and those with a low share of minimum wage workers (red squares).

To examine the validity of the idea, we first estimate the following event study regression model separately for the two groups of Ecuadorian exporters:

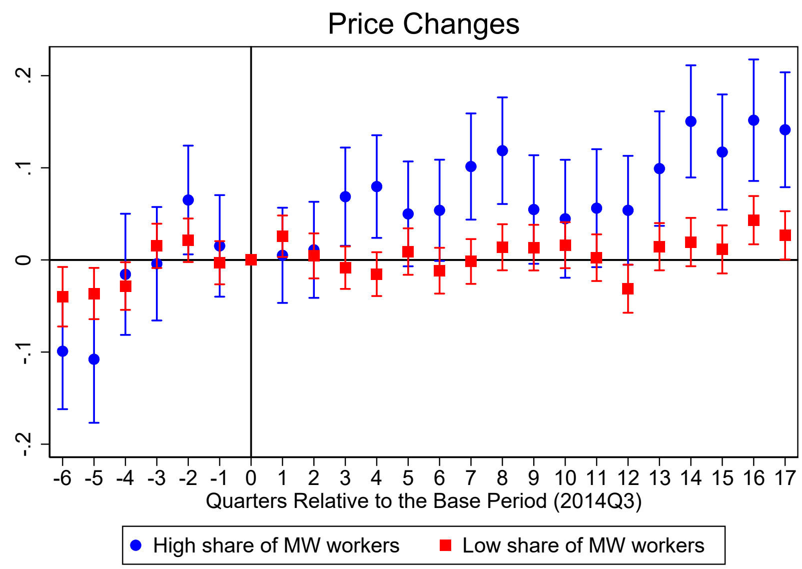
$$\ln \mathrm{w}_{jt} = \sum_{s \neq 2014Q3} \beta_s \times \mathbb{1}\{s = t\} + \psi_j + \varepsilon_{jt}. \tag{2}$$

where the dependent variable is the log of the average wage for firm j in time t. ψ_j denotes firm fixed effects, while $\mathbb{1}\{s = t\}$ is an indicator variable corresponding to a time dummy that equals 1 if the time (year-quarter) is t and 0 otherwise. The sample period begins in 2013Q1 and ends in 2018Q4; a reference point is set at 2014Q3.[49] Standard errors are clustered at the firm level.

[49]Since our categorization for separating firms into two groups is based upon the year 2013, we set the starting period as 2013Q1.

Figure 11 displays the estimation result. Overall, the average wage paid by Ecuadorian exporters shows a growth pattern similar to that of the Unified Minimum Wage (illustrated with red horizontal lines). More interestingly, exporters with a higher share of minimum wage workers (blue squares) tend to have raised average wages significantly more than the increase in minimum wage in the post-shock periods, whereas exporters with a lower share of minimum wage workers (red squares) raised average wages just as much as (or slightly less than) the increase in the minimum wage in the same period. This confirms our conjecture that exporters with a higher share of minimum wage workers were more likely to be pressured to raise wages.

Figure 12: Event Study Analysis: Export Price Dynamics in Ecuador



Notes: The figure plots event-study analysis results from equation (1) where the dependent variable is the log of export price (in USD). 95% confidence intervals are represented by bars. The results are illustrated separately for Ecuadorian exporters with a high share of minimum wage workers (blue circles) and those with a low share of minimum wage workers (red squares).

Finally, we check whether the two different groups of exporters showed any differential patterns of export price adjustment over the period by running a regression of equation (1) separately for two groups of Ecuadorian exporters. The estimation results are summarized in Figure 12, where exporters with a higher share of minimum wage workers are represented by blue circles and those with a lower share of minimum wage workers are represented by red squares. Unlike in the pre-shock period, during which their export price movements were not statistically different from each other, the pattern of export price movements diverged in the post-shock period. In particular, exporters with a higher share of minimum wage workers raised export prices after the shock. In contrast, exporters with a lower share of minimum wage workers kept their export prices at the pre-shock level.[50] Overall, the evidence suggests that internal devaluation was not a viable option for Ecuadorian exporters because of downward nominal wage rigidity induced by a continued increase in the minimum wage.

6 Employment Adjustment

We have established that the combination of a rigid minimum wage system and full dollarization prevented Ecuadorian exporters from adjusting nominal wages (i.e., internal devaluation), and thus from adjusting export prices (i.e., external devaluation) in the period of the negative external shocks. In addition, the monetary authority of Ecuador was unable to reduce real wages through a devaluation, since its hands were tied by the currency peg. Schmitt-Grohé and Uribe (2016) show theoretically that the combination of fixed exchange rates, nominal rigidity, and free capital mobility will give rise to high unemployment during contractions. Exploiting the detailed micro datasets in Ecuador, we now assess such real consequences empirically for Ecuadorian exporters by estimating the following event-study regression equation:

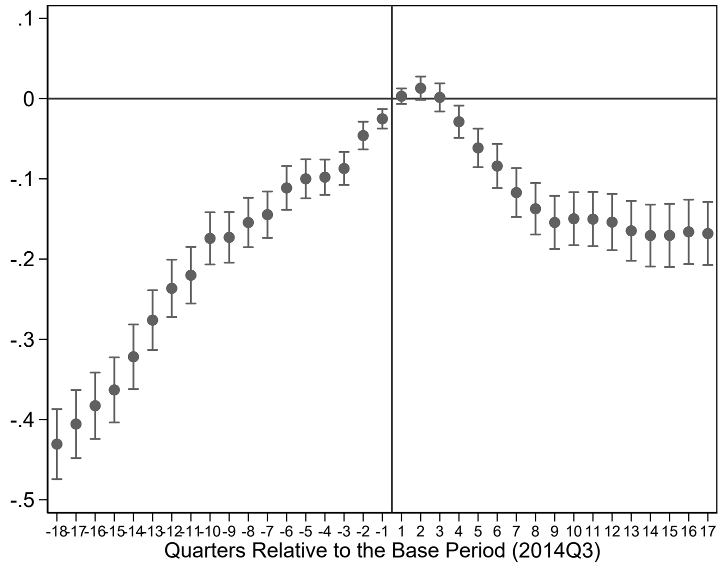
$$\ln \mathrm{E}_{jt} = \sum_{s \neq 2014Q3} \beta_s \times \mathbb{1}\{s = t\} + \psi_j + \varepsilon_{jt} \tag{3}$$

where the dependent variable is the log of employment for firm j in time t. ψ_j denotes firm fixed effects, while $\mathbb{1}\{s = t\}$ is an indicator variable corresponding to a time dummy that equals 1 if the time (year-quarter) is t and 0 otherwise. The sample period begins in 2010Q1 and ends in 2018Q4; a reference point is set at 2014Q3. Standard errors are clustered at the firm level.

Figure 13 shows estimates of β_s between 2010Q1 and 2018Q4, representing average log employment changes, relative to 2014Q3, within firms. The trend of employment changes is starkly different from that of wage changes for Ecuadorian exporters (see Figure 11). Up until 2014Q3, just like wages, employment for Ecuadorian exporters was rising, with average growth rate of 38.3% for 16 quarters before the shock. However, after two quarters (2014Q4 and 2015Q1) of modest employment increase, the average employment level began to plummeting continuously until around 2018Q3 (16 quarters after the shock) by which the employment level was 17 percent lower than that in 2014Q3. It thus

[50] As we raise the threshold value for the share of minimum wage workers from 50 percent to a higher level such as 75 or 90 percent, the contrast between two groups becomes even stronger.

Figure 13: Employment Changes within Firms in Ecuador



Notes: The figure displays the log employment changes relative to the quarter of the exchange rate shock based on estimates of equation (3). 95% confidence intervals are displayed in bars.

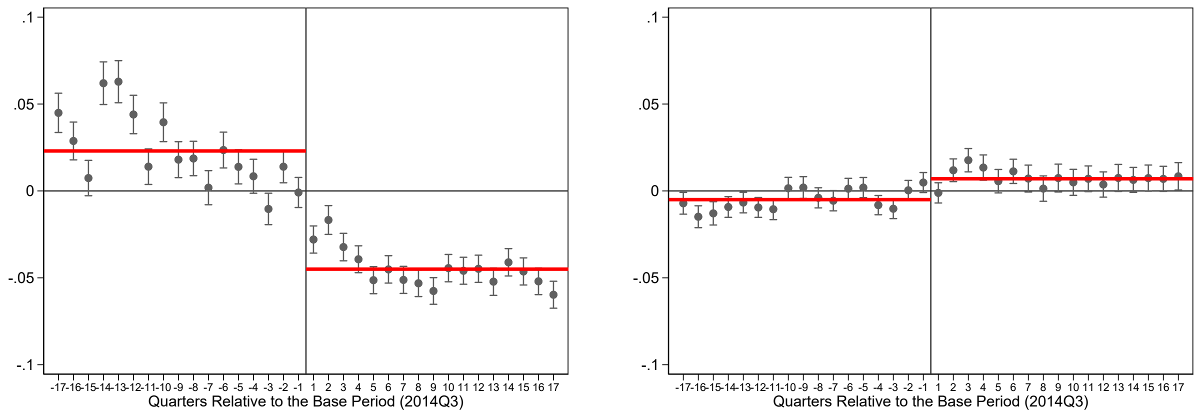
confirms that Ecuadorian exporters that were unable to adjust export prices had to end up dismissing a large number of workers, which validates the conjecture that involuntary unemployment ensues from the absence of both external and internal devaluation (Schmitt-Grohé and Uribe, 2016).

So far, we have identified the negative employment impacts of the shock.[51] We further investigate the margins of adjustment by Ecuadorian exporters to the shock in more detail; those Ecuadorian firms may have reduced new hires or may have dismissed existing workers. Our matched employer-employee payroll dataset enables us to unravel respective contribution to the employment reductions. To do so, we define NH_{jt} as the fraction of employed workers in time t that are newly hired relative to time $t-1$ at firm j. Likewise, we define JS_{jt} as the fraction of employed workers at time t that are separated from firm j in time $t+1$. We estimate the following event-study regression equation:

$$\ln \text{Y}_{jt} = \sum_{s \neq 2014Q3} \beta_s \times \mathbb{1}\{s = t\} + \psi_j + \varepsilon_{jt} \tag{4}$$

[51]More precisely, the negative employment effects refer to detachments from Ecuadorian formal sector exporters. We acknowledge those separated workers may have been either unemployed or employed in informal sector. Due to the data limitation, we cannot distinguish these two cases precisely, but both outcomes are clearly worse consequences than the status of formal employment from a worker's perspective. Please refer to Appendix B for more discussion on informal employment in Ecuador.

Figure 14: New Hires and Job Separations within Firms in Ecuador



(a) New Hire Rates

(b) Job Separation Rates

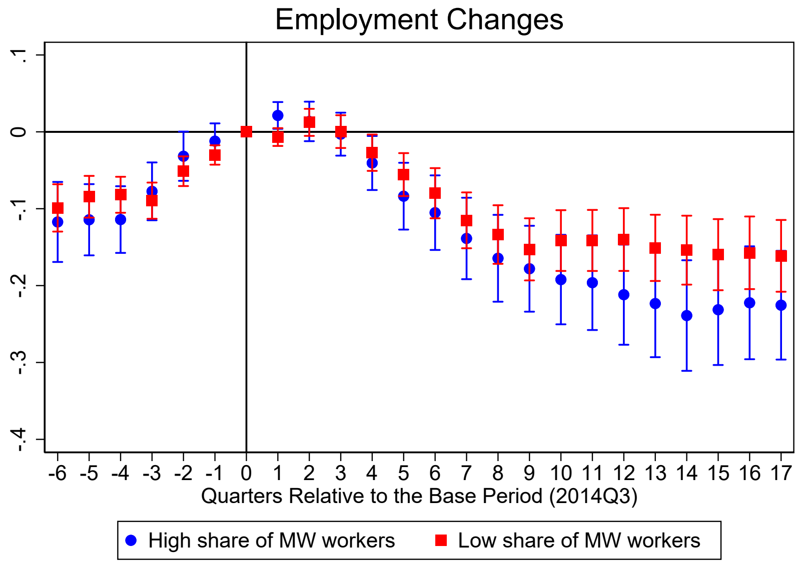
Notes: Figure (a) displays the changes of the new hire rate relative to the quarter of the exchange rate shock based on estimates of equation (4); figure (b) displays the changes of the job separation rate relative to the quarter of the exchange rate shock based on estimates of equation (4). 95% confidence intervals are displayed in bars. The red horizontal lines denote the averages before and after the shock (i.e., 2014Q3), respectively.

where $Y_{jt} \in \{NH_{jt}, JS_{jt}\}$.

Figure 14 shows estimates of β_s between 2010Q2 and 2018Q4, representing average new hire rates in (a) and average job separation rates in (b), relative to 2014Q3, within firms. Notably, Ecuadorian firms slowed down new hiring and dismissed more existing workers in response to the shock.As for new hiring, the average rate before the shock was 2.3 percentage points higher relative to 2014Q3, whereas it was 4.5 percentage points lower after the shock .Similarly, the average rate of job separation before the shock was 0.5 percentage points lower relative to 2014Q3, while it was 0.7 percentage points higher after the shock. Quantitatively, the new hiring channel played a larger role than the job separation channel in reducing total employment within Ecuadorian firms.

In Section 5.2, we reported that exporters with a high share of MW workers, relative to those with a low share of MW workers, were pressured to raise wages more and thus found it harder to lower export prices to remain international competitiveness. If that is true, we would expect that exporters with a high share of MW workers would have reduced employment more than exporters with a low share of MW workers. To test this hypothesis, we run regression of equation (3) separately for two groups. Figure 15 shows the estimation results. Employment by exporters with a high share of MW workers (blue circles) declined by 4.1% (4 quarters after the shock), 16.4% (after 8 quarters), 21.2% (after

Figure 15: Employment Changes within Firms and Minimum Wages in Ecuador



Notes: The figure displays the log employment changes relative to the quarter of the exchange rate shock based on estimates of equation (2). 95% confidence intervals are displayed in bars. The level of the 2014Q3 (i.e., the Unified Minimum Wage in 2014) is normalized as 0. The results are illustrated separately for Ecuadorian exporters with a high share of minimum wage workers (blue circles) and those with a low share of minimum wage workers (red squares).

12 quarters), and 22.2% (after 16 quarters), whereas employment by exporters with a low share of MW workers (red squares) declined by 2.7% (4 quarters after the shock), 13.4% (after 8 quarters), 14.0% (after 12 quarters), and 15.7% (after 16 quarters). The result suggests that because there was no internal devaluation, Ecuadorian exporters, especially those with a high share of MW workers, were hit hard by the negative external shocks.

7 Conclusion

This paper explores the episode of the 2014-16 oil price collapse and accompanying substantial dollar appreciation to provide new evidence on the role of exchange rate regimes in external adjustment. During the process, the minimum wage laws act as sources of downward nominal wage rigidity that also prevent an internal devaluation. The Ecuadorian administrative payroll dataset and the Ecuadorian transaction-level customs dataset, supplemented by the Colombian transaction-level customs dataset, offer a unique perspective on how Ecuadorian firms responded to the adverse shock over the period from 2010 to 2018 — four years before and after the initial global oil price drop — in a fully dollarized economy.

Our main findings can be summarized as follows. First, by combining the Ecuadorian and Colombian customs datasets, we document that Ecuadorian exporters under full dollarization could not adjust export prices, while Colombian exporters under a floating exchange rate regime could adjust export prices to strengthen international competitiveness. Second, using the Ecuadorian administrative payroll dataset, we document the presence of downward nominal wage rigidity in both the pre- and post-shock periods, mostly driven by the rigid minimum wage laws, which prevented Ecuadorian firms from adjusting wages flexibly. Third, combining Ecuadorian customs and payrolls datasets, we show empirically that the combination of downward nominal wage rigidity and a fixed exchange rate gives rise to massive involuntary unemployment, as suggested by theoretical models (Schmitt-Grohé and Uribe, 2013; Schmitt-Grohé and Uribe, 2016). Collectively, our results paint a comprehensive picture of the extent to which a country with a fixed exchange rate regime responds to an adverse external shock in the presence of downward nominal wage rigidity.

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Appendix

Appendix A: Robustness

This section provides additional empirical results for the robustness checks. Since we presented our findings in the main text mostly using an event-study approach for illustrative purposes, we report the baseline findings using alternative methodologies such as difference-in-differences and dynamic treatment effect analyses. In addition, we confirm the robustness of our baseline findings for the sample restricted to manufacturing exports.

A.1 Difference-in-Differences

One disadvantage of the event-study approach is that all the time-varying shocks in a separate regression of equation (1) are fully absorbed by time dummy variables. To the extent that there were substantial levels of *time-varying* destination-specific or product-specific shocks, the composition difference in the export structure across destination countries or products could have contributed to the differential pattern of export price adjustment dynamics in the two countries. We address this concern by pooling the two countries' datasets in the following difference-in-differences specification:

$$\ln \mathrm{Y}_{ijkt} = \beta \mathrm{ECU}_i \times \mathrm{Post}_t + \gamma_{jkt} + \psi_{ijk} + \varepsilon_{ijkt} \tag{5}$$

where i indicates a firm, j means a product (HS-6-digit level), k represents the destination country, and t is time (i.e., year-quarter). The dependent variable can be either the log of export price or the log of export value. ECU_i is an indicator variable that equals 1 if a firm i is Ecuadorian and 0 Colombian. Post_t is an indicator variable that equals 1 if the time t is after 2014Q4 and 0 otherwise. γ_{jkt} and ψ_{ijk} capture product-country-time fixed effects and exporter-product-country fixed effects, respectively. Standard errors are clustered at the exporter-product-country level, allowing them to be correlated within exporter-product-country cells.

The coefficient β identifies the role of exchange rate regimes in driving the external adjustment in response to adverse oil price shocks for two heavy oil exporters: a fully dollarized country (Ecuador) and a flexible exchange rate country (Colombia).

Table A.1 summarizes the estimation results on β from different sets of fixed effects with a log of export price as the dependent variable. Column (1) includes only exporter-product-country fixed effects, similar to the event-study approach in equation (1). Col-

Table A.1: Export Price Changes across Exchange Rate Regimes, 2010Q1 - 2018Q4

	Dependent Variable: Log of Export Price				
	(1)	(2)	(3)	(4)	(5)
$\text{ECU}_i \times \text{Post}_t$	0.056***	0.123***	0.108***	0.124***	0.131***
	(0.006)	(0.006)	(0.009)	(0.007)	(0.014)
Fixed Effects:					
Firm-HS6-Imp	Yes	Yes	Yes	Yes	Yes
Time	No	Yes	No	No	No
HS6-Time	No	No	Yes	No	No
Imp-Time	No	No	No	Yes	No
HS6-Imp-Time	No	No	No	No	Yes
Observations	1,367,652	1,367,652	1,340,569	1,367,113	996,023
R-squared	0.881	0.882	0.894	0.883	0.916

Notes: The dependent variable is the log of export price. ECU_i is an indicator variable that equals 1 if a firm i is Ecuadorian and 0 Colombian. Post_t is an indicator variable that equals 1 if the time t is after 2014Q4 and 0 otherwise. Standard errors are clustered at the firm-product-country level. *** p<0.01, ** p<0.05, * p<0.1.

umn (2) adds time fixed effects to exporter-product-country fixed effects, while columns (3) and (4) instead add product-time and country-time fixed effects, respectively. Column (5) corresponds exactly to our benchmark equation (5) as both exporter-product-country fixed effects and product-country-time fixed effects are included. Overall, positive and statistically significant estimation results across columns (1) through (5) confirm that Ecuador's export price increased relative to Colombia's export price after the adverse oil price shock accompanied by US dollar appreciation.

Next, we repeat running the regression of equation (5) by replacing the dependent variable with the log export value in LCU deflated by domestic CPI. Table A.2 summarizes estimation results on β, yielding negative and statistically significant coefficient estimate across columns (2) through (5). This suggests that exporters in Colombia were able to benefit from domestic currency depreciation in the form of an increase in real export revenues in domestic currency, up to nearly 40 percent more than what exporters in Ecuador experienced in the absence of exchange rate flexibility.

A.2 Dynamic Treatment Effects

Although time-varying product or country shocks were effectively taken care of in the previous difference-in-differences estimation strategy, there remains a concern that Ecuadorian exporters' pricing behavior could have been different from Colombian exporters' pricing behavior even before the adverse oil price shock, thereby violating the parallel

Table A.2: Export Value Changes across Exchange Rate Regimes, 2010Q1 - 2018Q4

	Dependent Variable: Log of Export Value (LCU, CPI deflated)				
	(1)	(2)	(3)	(4)	(5)
$\text{ECU}_i \times \text{Post}_t$	-0.087***	-0.276***	-0.356***	-0.293***	-0.366***
	(0.011)	(0.013)	(0.018)	(0.014)	(0.026)
Fixed Effects:					
Firm-HS6-Imp	Yes	Yes	Yes	Yes	Yes
Time	No	Yes	No	No	No
HS6-Time	No	No	Yes	No	No
Imp-Time	No	No	No	Yes	No
HS6-Imp-Time	No	No	No	No	Yes
Observations	1,367,652	1,367,652	1,340,569	1,367,113	996,023
R-squared	0.917	0.918	0.924	0.919	0.938

Notes: The dependent variable is the log of export value in local currency unit (LCU) deflated by domestic CPI. ECU_i is an indicator variable that equals 1 if a firm i is Ecuadorian and 0 Colombian. Post_t is an indicator variable that equals 1 if the time t is after 2014Q4 and 0 otherwise. Standard errors are clustered at the firm-product-country level. *** p<0.01, ** p<0.05, * p<0.1.

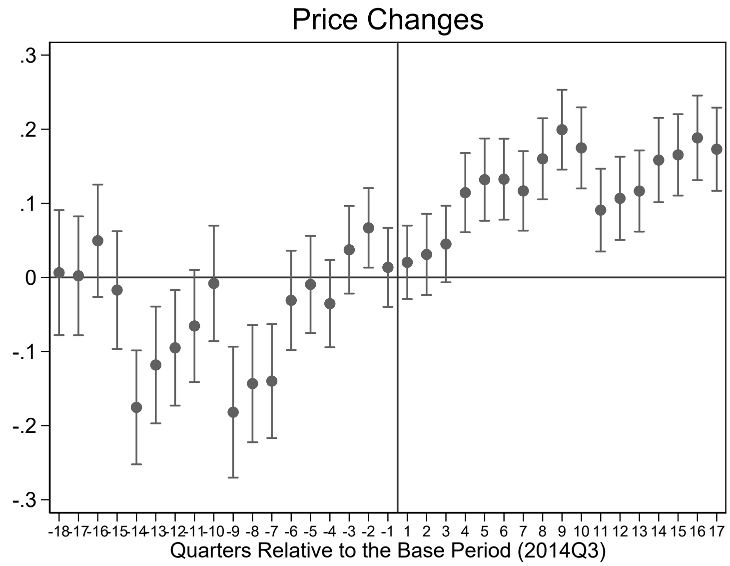
pre-trend assumption. To alleviate the concern for the parallel-trend assumption, we specify the following regression to capture the dynamics of treatment effects:

$$\ln \text{Y}_{ijkt} = \sum_{s \neq 2014Q3} \beta_s \mathbb{1}\{s = t\} \times \text{ECU}_i + \gamma_{jkt} + \psi_{ijk} + \varepsilon_{ijkt} \quad (6)$$

where $\mathbb{1}\{s = t\}$ is an indicator variable that equals 1 if the time is t and 0 otherwise. All the rest are the same as before: The dependent variable can be either the log of export price or the log of export value; ECU_i is an indicator variable that equals 1 if a firm i is Ecuadorian and 0 Colombian; γ_{jkt} and ψ_{ijk} capture product-country-time fixed effects and exporter-product-country fixed effects, respectively. Standard errors are clustered at the exporter-product-country level, allowing them to be correlated within exporter-product-country cells.

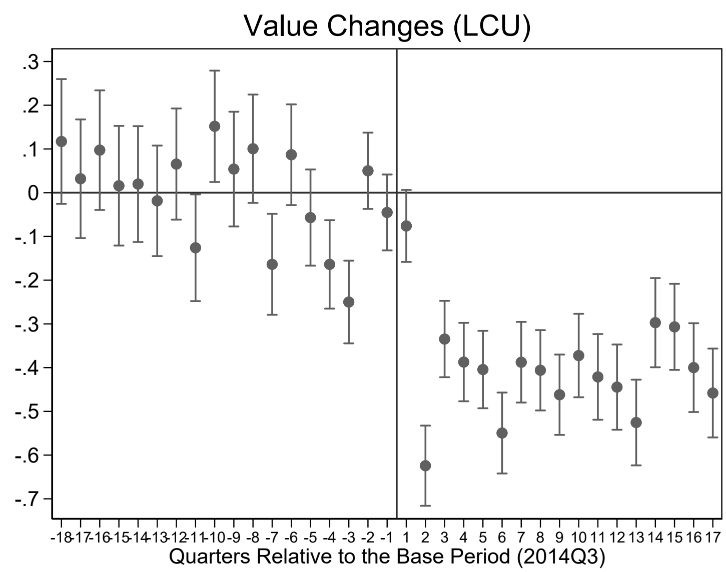
The coefficient estimates on β_s from equation (6) are described in Figure A.1. In the pre-shock period from 2010 until 2014, confidence intervals of the estimated coefficients mostly lie around 0, implying that Ecuador's average export price movements were not statistically different from Colombia's average export price movements. Some exceptions are found in 2011 and 2012 when Ecuador's average export price declined relative to Colombia's average export price. In fact, this coincides with the appreciation of Colombia's peso, as seen in Figure 4-(b), which is consistent with the theory of expenditure-switching at the time of domestic currency appreciation. Most interestingly, the sustained

Figure A.1: Dynamic Treatment Effects: Export Price Dynamics in Ecuador vs. Colombia



Notes: The figure plots coefficients estimate on β_s's from the dynamic treatment effects analysis as specified in equation (6) where the dependent variable is the log export price (in USD).

Figure A.2: Dynamic Treatment Effects: Export Value Dynamics in Ecuador vs. Colombia



Notes: The figure plots coefficients estimate on β_s's from the dynamic treatment effects analysis as specified in equation (6) where the dependent variable is the log export value in the local currency unit (LCU) deflated by domestic CPI.

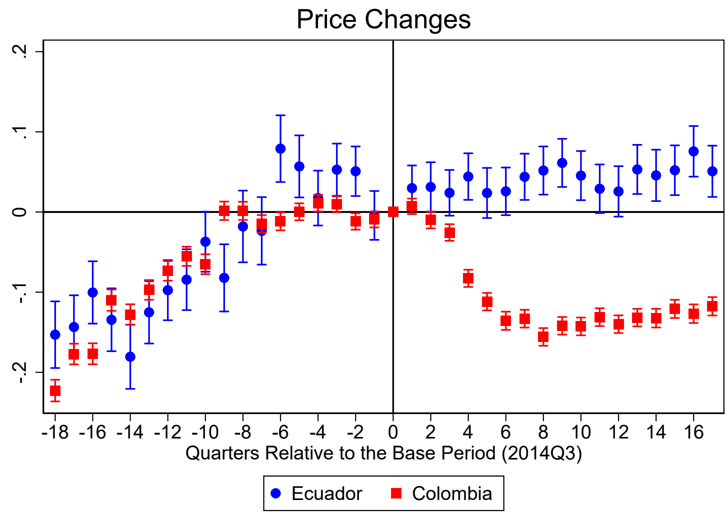
increase in average export price in Ecuador relative to that in Colombia after the shock period highlights the role of exchange rate regimes in external adjustment, which underlies the theory of expenditure switching. The fact that an increase in export prices relative to Colombian exports became statistically significant particularly four quarters after the shock likely reflects the price stickiness in dollar-invoiced exports.

We repeat the specification in equation (6) by replacing the dependent variable with the log export value in the LCU deflated by domestic CPI. Figure A.2 summarizes the estimation results, confirming that average export value movements in the two countries were not statistically different until 2014, after which Colombia's export value increased substantially relative to Ecuador's export value driven by the valuation effects associated with the depreciation of the Colombian peso.

A.3 Manufacturing

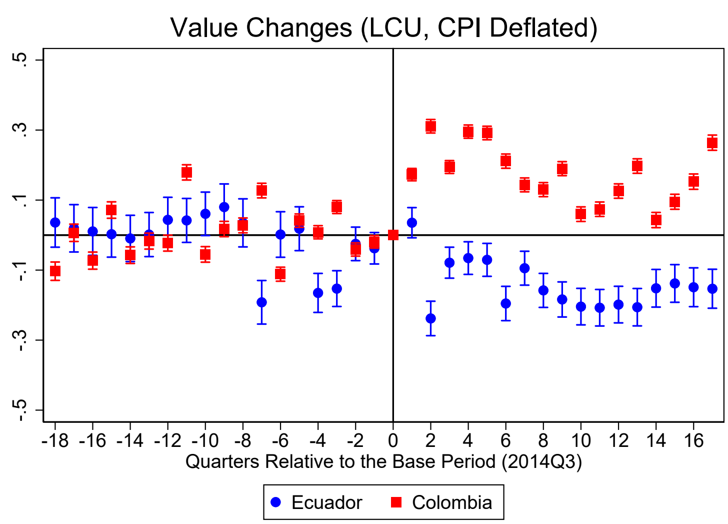
To alleviate potential concern that our baseline sample covers all types of export transactions, including agricultural products as well as oil products, we restrict the sample to manufacturing exports only. Figure A.3 is a manufacturing export version of Figure 9, and Figure A.4 is a manufacturing export version of Figure 10. Turning to the difference-in-difference analysis, Tables A.3 and A.4 correspond to Tables A.1 and A.2. The dynamic treatment effect analysis results in Figures A.5 and A.6 are manufacturing export versions of Figures A.1 and A.2. We conclude that all the results are almost identical to the baseline results both qualitatively and quantitatively.

Figure A.3: Event-Study Analysis: Export Price Dynamics in Ecuador and Colombia: MFG only



Notes: The figure plots event-study analysis results from equation (1) where the dependent variable is the log of export price (in USD). The results are illustrated separately for Ecuador (blue circles) and Colombia (red squares). The sample is restricted to manufacturing export transactions.

Figure A.4: Event-Study Analysis: Export Value Dynamics in Ecuador and Colombia: MFG only



Notes: The figure plots event-study analysis results from equation (1) where the dependent variable is the log export value in local currency unit (LCU) deflated by domestic CPI. The results are illustrated separately for Ecuador (blue circles) and Colombia (red squares). The sample is restricted to manufacturing export transactions.

Table A.3: Export Price Changes across Exchange Rate Regimes, 2010Q1 - 2018Q4: MFG Only

	Dependent Variable: Log of Export Price				
	(1)	(2)	(3)	(4)	(5)
ECUXpost	0.061***	0.124***	0.114***	0.129***	0.141***
	(0.007)	(0.008)	(0.011)	(0.009)	(0.016)
Fixed Effects:					
Firm-HS6-Imp	Yes	Yes	Yes	Yes	Yes
Time	No	Yes	No	No	No
HS6-Time	No	No	Yes	No	No
Imp-Time	No	No	No	Yes	No
HS6-Imp-Time	No	No	No	No	Yes
Observations	1,169,025	1,169,025	1,146,131	1,168,470	841,453
R-squared	0.864	0.865	0.878	0.866	0.900

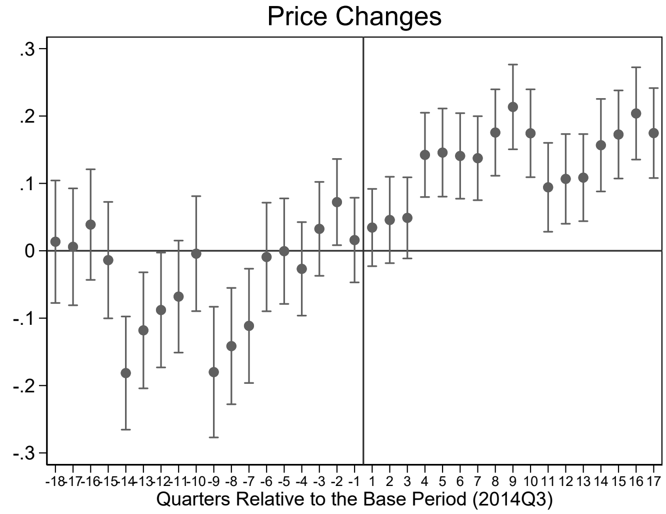
Notes: The dependent variable is the log of export price. ECU_i is an indicator variable that equals 1 if a firm i is Ecuadorian and 0 Colombian. Post_t is an indicator variable that equals 1 if the time t is after 2014Q4 and 0 otherwise. The sample is restricted to manufacturing export transactions. Standard errors are clustered at the firm-product-country level. *** p<0.01, ** p<0.05, * p<0.1.

Table A.4: Export Value Changes across Exchange Rate Regimes, 2010Q1 - 2018Q4: MFG Only

	Dependent Variable: Log of Export Value (LCU, CPI deflated)				
	(1)	(2)	(3)	(4)	(5)
ECUXpost	-0.108***	-0.290***	-0.361***	-0.296***	-0.364***
	(0.014)	(0.015)	(0.020)	(0.017)	(0.029)
Fixed Effects:					
Firm-HS6-Imp	Yes	Yes	Yes	Yes	Yes
Time	No	Yes	No	No	No
HS6-Time	No	No	Yes	No	No
Imp-Time	No	No	No	Yes	No
HS6-Imp-Time	No	No	No	No	Yes
Observations	1,169,025	1,169,025	1,146,131	1,168,470	841,453
R-squared	0.912	0.912	0.919	0.913	0.933

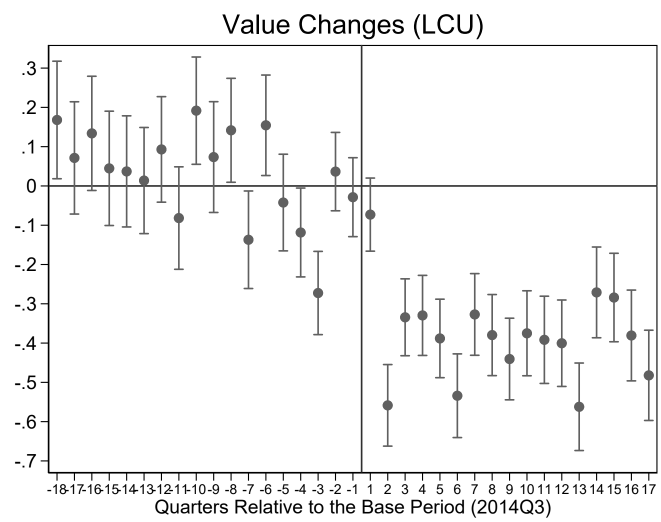
Notes: The dependent variable is the log of export value in the local currency unit (LCU) deflated by domestic CPI. ECU_i is an indicator variable that equals 1 if a firm i is Ecuadorian and 0 Colombian. Post_t is an indicator variable that equals 1 if the time t is after 2014Q4 and 0 otherwise. The sample is restricted to manufacturing export transactions. Standard errors are clustered at the firm-product-country level. *** p<0.01, ** p<0.05, * p<0.1.

Figure A.5: Dynamic Treatment Effects: Export Price Dynamics in Ecuador vs. Colombia: MFG only



Notes: The figure plots the coefficients estimate on β_s from the dynamic treatment effects analysis as specified in equation (6) where the dependent variable is the log export price (in USD). The sample is restricted to manufacturing export transactions.

Figure A.6: Dynamic Treatment Effects: Export Value Dynamics in Ecuador vs. Colombia: MFG only

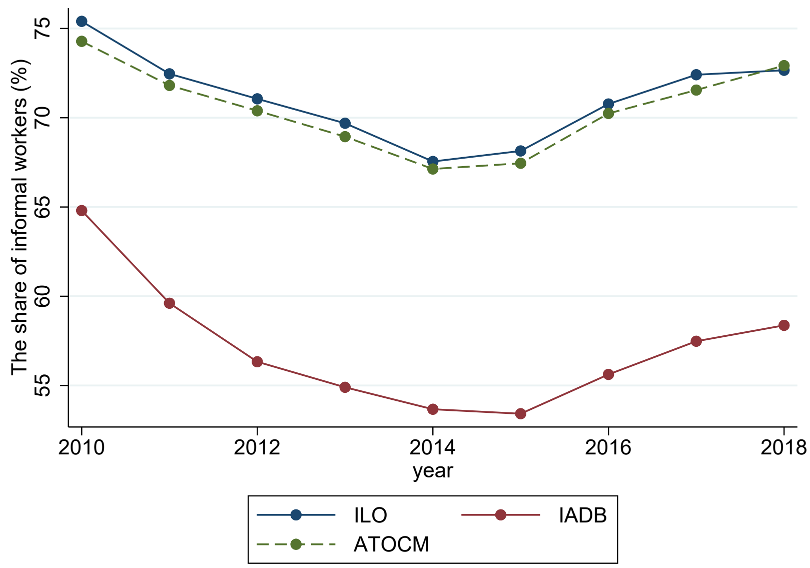


Notes: The figure plots the coefficients estimate on β_s from the dynamic treatment effects analysis as specified in equation (6) where the dependent variable is the log export value in the local currency unit (LCU) deflated by domestic CPI. The sample is restricted to manufacturing export transactions.

Appendix B: Informal Employment in Ecuador

Informal employment in Ecuador is quite prevalent, and the share of informal employment in Ecuador is estimated to be as high as 70%. Here, an informal employee refers to the following: (1) any worker who is hired by a company that does not have RUC (the Taxpayer Unique Registry in Ecuador), such as household-owned, unincorporated businesses operating on a small scale; (2) any worker who does not have an employment contract and is not enrolled in social security.

Figure B.1: Informal Employment in Ecuador, 2010-2018



Notes: The data come from the International Labour Organization (ILO), Inter-American Development Bank (IADB), and Arias et al. (2020). ATOCM refers to the estimates in Arias et al. (2020).

Figure B.1 shows the trend of informal employment in Ecuador in the period 2010–2018. Arias et al. (2020) used employment contracts and social security data to determine if an employee is formal or informal. The green dotted line (the estimates of Arias et al. (2020)) shows that the share of informal employment was 74% in 2010, declined to 67% until 2014, and then rebounded to 73% in 2018. The proposed calculation by Arias et al. (2020) appears to be quite similar to the estimates of the International Labour Organization (ILO) in blue. The estimates of the Inter-American Development Bank (IADB), in red, consider only social security status to determine informality. Informality is therefore estimated to be 9 to 15 percentage points lower than the two estimates above, but the trend of the three estimates during 2010-2018 is quite similar. The increasing share of informality after 2014/2015 seems consistent with our earlier finding that the 2014-16 oil price collapse combined with US dollar appreciation resulted in a reduction in formal employment in Ecuadorian firms. Although we cannot pinpoint whether the reduction in formal employment led to unemployment or informality, both outcomes are clearly worse outcomes than formal employment.

Another potential question regarding our finding in Section 6 is whether firms still hire workers informally. If they do so, the employment levels within firms may be the same and the observed decline in employment just captures the shift in workforce composition from formal to informal. Although we cannot rule out this possibility completely because there are no datasets available for testing the hypothesis, we think that this scenario is less likely to have happened for the following reasons.[52]

Once a company lays off a worker, the company must report the event to the Ministry of Labor and the Social Security Administration. In addition, according to the labor laws in Ecuador, every worker who works for a company or a person must be immediately added to the social security system and earn at least the minimum wage (Unified Minimum Wage). If the company hires a worker informally, it violates the labor laws of Ecuador, and regulatory agencies may impose severe sanctions on the company. In our core sample exporters in Ecuador are generally bigger firms. Relatively large firms, which contribute the most to the social security and tax bases in Ecuador, have always been subject to the government's employment rules and regulations. Therefore the risk of a firm being sanctioned for hiring workers informally is far greater than the benefits to those firms from hiring workers informally. For Ecuadorian exporters in our sample, therefore, we would not expect to observe hidden (or informal) hiring, especially any switching from formal to informal hiring.

[52] Our argument here is based on interviews with several experts on informal employment in Ecuador. We are grateful to Andrea Molina (at Facultad de Ciencias Sociales y Humanísticas, ESPOL) and Paul Carrillo-Maldonado (at Universidad de Las Américas, UDLA) for their helpful feedback.