Downard Nominal Wage Rigidity, Fixed Exchange Rates, and Unemployment: Evidence from a Quasi Natural Experiment*

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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 Downward Nominal Wage Rigidity (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 Nominar Wage Rigidity (DNWR), 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 the strict minimum wage regulation, Ecuadorian firms could not adjust wages, and thus 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.

Our main findings can be summarized in more detail as follows. First, transaction-

[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.*"

level customs datasets, covering the universe of Ecuador's and Colombia's exports from 2010 to 2018, reveal that Ecuadorian firms' export prices denominated in US dollars at the product and destination levels slightly increased after the shock, which is in stark contrast to the case of Colombia where export prices in US dollars declined—particularly pronounced beginning in three to four quarters after the shock. Considering that 98 percent of Colombian exports are invoiced in US dollars (Casas et al., 2017), we note that this is consistent with the prediction from a model of Dominant Currency Paradigm (DCP) whereby the traditional exchange rate effects would gradually reemerge over time as prices become more flexible (Adler et al., 2020). Moreover, 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, whereas real export values in the LCU rose significantly after the shock in Colombia. 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 show that minimum wages played an important role in the wage-setting system in Ecuador, contributing to DNWR to a great extent. We further find that exporters that have a higher share of workers receiving less than the next year's minimum wage are more likely to face severe downard nominal wage rigidity and, as a result, that they could not reduce export prices relative to exporters with a lower share of workers receiving less than the next year's minimum wage. In sum, these finding suggest that DNWR induced by stringent minimum wage regulations acted as a strong force against internal 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. Specifically, we track the average employment by Ecuadorian exporters throughout the period and document that an in-

[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).

creasing trend of employment up until the adverse oil price shock suddenly reversed, plummeting by up to 17 percent over the next three years. We also find evidence that the exporters with a higher share of workers receiving less than the next year's minimum wage experienced a greater decline in employment, which is further shown to be not simply driven by compositional bias. Our findings thus confirm that, with neither internal nor external devaluation available as a viable option, 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.[4]

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) (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). Noting that PCP and LCP yield contrasting predictions on the degree of exchange rate pass-through (ERPT) into domestic prices, and hence those on the extent of expenditure switching, it generated a vast amount of subsequent research on ERPT.[5] Based on a comprehensive survey of the cross-country invoicing currency information, Gopinath et al. (2020) proposed DCP whereby firms set export prices in a dominant currency (most often the US dollar) and change them infrequently.[6] 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 due to price rigidities.

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

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

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

[6]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.

owing to DNWR (Schmitt-Grohé and Uribe, 2013; Schmitt-Grohé and Uribe, 2016).[7,8]

At the same time, our paper contributes to an empirical literature on measuring nominal wage adjustment in microdata.[9] Using administrative datasets, 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. Moreover, nominal wage increases were tied to the minimum wage increases, thus confirming the contribution of the minimum wage system to DNWR in Ecuador.[10] This finding is in line with Castellanos, García-Verdú and Kaplan (2004) who found evidence of DNWR and wage stickiness introduced by minimum wages in Mexico.

This paper also complements a literature on the impact of exchange rate variations on labor market outcomes (e.g., Campa and Goldberg, 2001; Goldberg and Tracy, 2003). 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 mostly through employment due to 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) explicitly in this research arena.

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 DNWR and its association with minimum wages in Ecuador. Section 5 takes a comparative approach by contrasting two countries, Ecuador and Colombia, and studies the export adjustment process in response to adverse external shocks. In addition,

[7] 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).

[8] 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.

[9] As for the empirical evidence on DNWR, Elsby and Solon (2019) conducted an extensive survey of the 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) found evidence on wage rigidity in that US states with larger employment declines are also the states with greater increases in the share of workers with a zero wage change.

[10] The nexus between minimum wages and DNWR was also investigated in the macro literature (e.g., Glover, 2019). Ours also relate to more recent studies that incorporate wage rigidities in the trade literature (Rodríguez-Clare et al., 2020; Costinot et al., 2022).

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.

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.[11] 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).[12] 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.[13] 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).

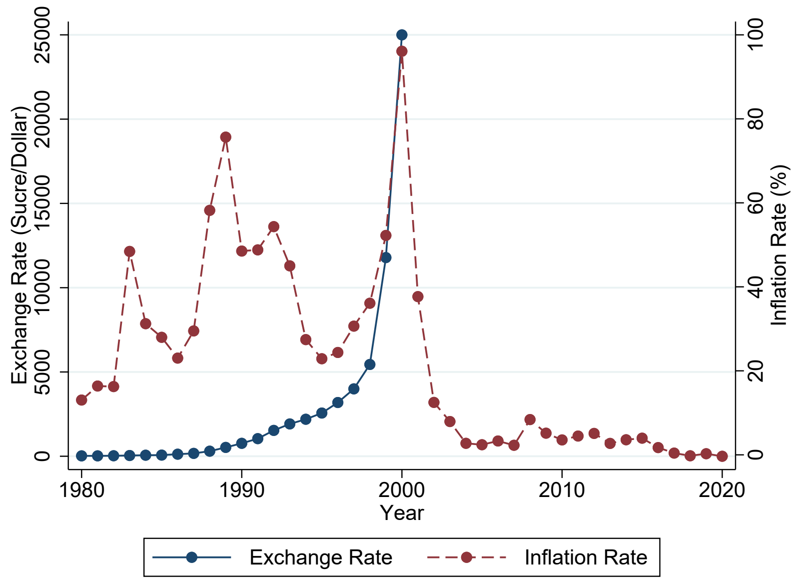
Dollarization brought price stability to Ecuador. Inflation rates dropped from 96.1% in 2000 to 7.9% in 2003 and remained in single digits thereafter (see Figure 1). Another benefit was that it could avoid debt monetization, thereby providing a limit to government overspending. Under dollarization, Ecuadorians 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 chal-

[11] 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.

[12] 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.

[13] Prior to the introduction of dollarization, the exchange rate 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 rate 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.

lenges 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 adjustment could entail a substantial recession.

2.2 Minimum Wage Systems

The strict implementation of minimum wage increases in Ecuador throughout the period provides an ideal setting for our empirical analysis. This can be attributed to the political regime of the former president Rafael Correa (2007-2017), a left-wing economist, who introduced significant institutional changes, including increased spending on planning and public administration as well as the increase in the minimum wage. Prior to his regime, the minimum wage in Ecuador has been adjusted mainly to compensate the increase in inflation. However, in 2008, the minimum wage had an unprecedented jump from $170 to $200, a 17.6% nominal growth rate (9.3% real ex-post growth rate). Since then, the increase in the minimum wage continued throughout his regime even during the recession period after the oil price shock.

In a nutshell, 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.[14]

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

Year	Minimum Wage	Nominal Growth Rate	Inflation Rate	Real Growth Rate	REER
	(1)	(2)	(3)	(4)	(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 mini- mum monthly wage in US dollars. Nominal Growth Rate is the percentage change in the UMW. 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 UMW levels, inflation rates, and real effective exchange rate indices for the period 2005–2019. The period is characterized by single-digit inflation rates,

[14]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 system in Ecuador.

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 UMW were all positive during the period, ranging from 2.1% to 17.6%, far exceeding inflation rates over the same period.[15] 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 UMW 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.[16] 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 DNWR.[17]

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

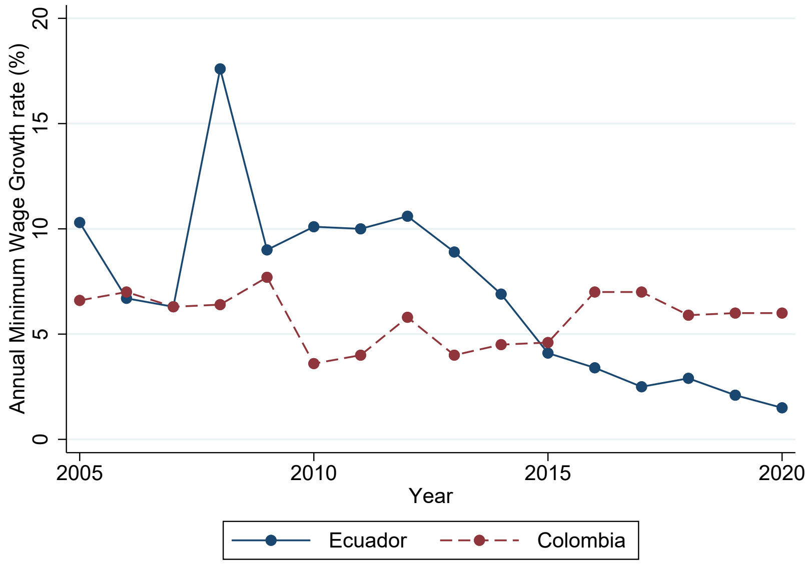
The price of oil dropped sharply by almost 60% over a period of about two years between 2014 and 2016 (Figure 3). The sustained decline, which was only surpassed in magnitude by the 67% cumulative decline during the global financial crisis in 2008-09, put severe economic stress on oil exporters around the globe (Baumeister and Kilian, 2016). Those

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

[16]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.

[17]Please refer to Section 4 for more details on DNWR in Ecuador.

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.

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.[18]

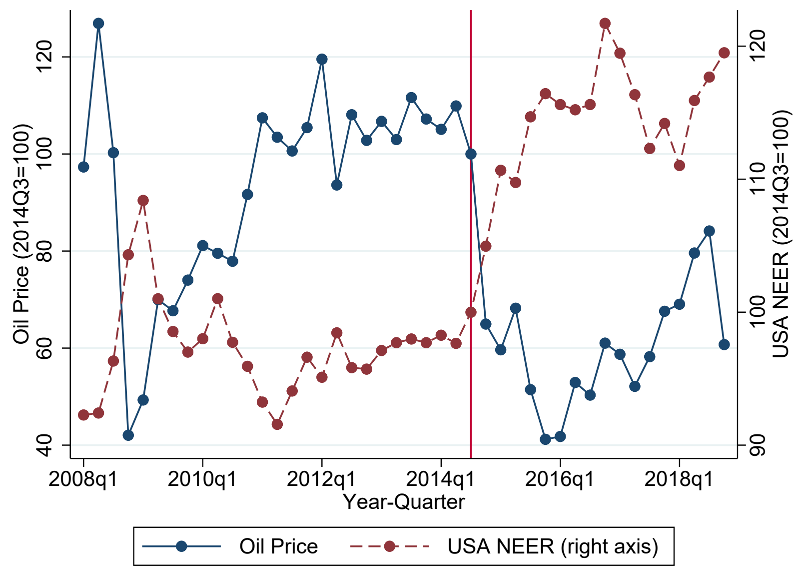
In principle, external adjustment to such adverse shocks can be facilitated by a flexible exchange rate, which allows the domestic currency to depreciate against foreign currencies such that relative price changes result in an expenditure-switching effect, thereby leading to higher exports and a shift in the composition of domestic consumption away from foreign goods toward domestic goods. Unfortunately, however, dollarization in Ecuador led to an even more painful adjustment process owing to the lack of exchange rate flexibility as an external shock absorber.[19]

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 apprecia-

[18]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.

[19]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).

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.

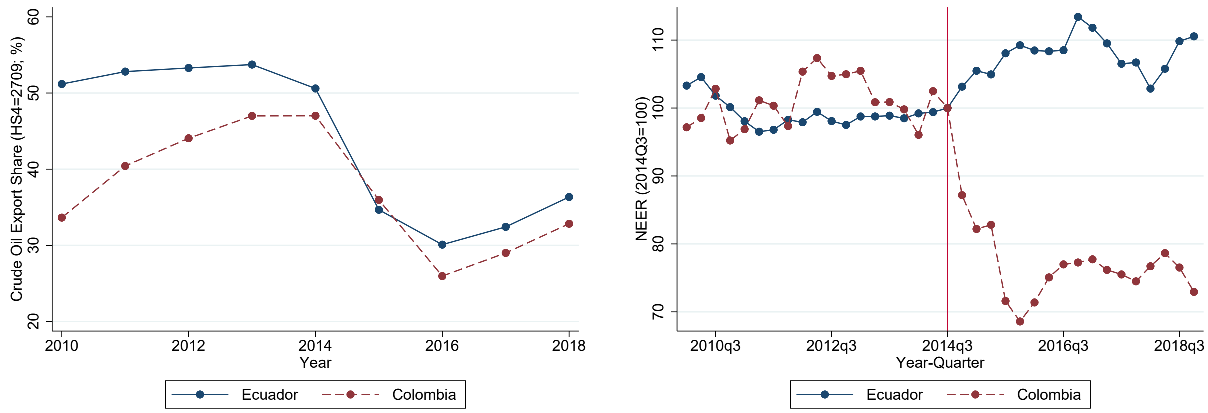
tion in the nominal exchange rate for a dollarized country like Ecuador. Indeed, Figure 4-(b) displays a notable appreciation in Ecuador's nominal effective exchange rate (NEER) by around 10% over the period, which is in stark contrast to Colombia—a neighboring country with a similar share of oil exports but with the flexible exchange rate regime—whose NEER *depreciated* by 30%.[20]

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 because of DNWR (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

[20] 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 4: Oil Export Share and Nominal Effective Exchange Rate: Ecuador and Colombia

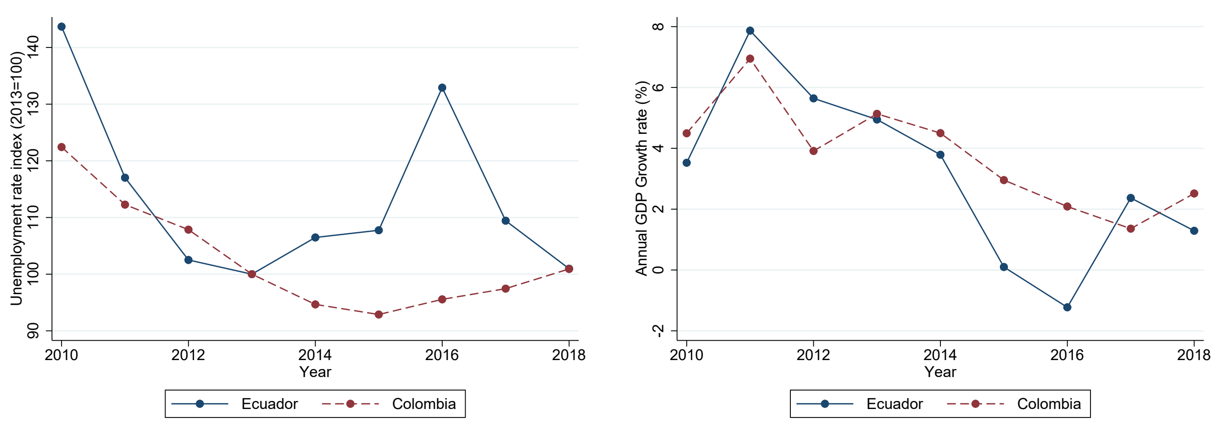


(a) Oil Export Share

(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.

increase in unemployment rate (Figure 5-(a)) and a steeper decline in economic growth (Figure 5-(b)) since 2014.[21] 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 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.[22] The monthly remuneration is the base pay, not including benefits, bonuses, or raises.[23] The

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

[22] 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.

[23] 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.

payroll dataset is used to measure the extent of DNWR and its association with minimum wages in Ecuador (in Section 4) and to analyze the impacts of the adverse shocks during 2014-16 on employment adjustment (in Section 6).[24]

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"[25]; we drop negative observations of monthly remuneration and exclude observations if days worked is fewer than 0 and more than 30[26]; we then convert monthly remuneration into monthly wages using the information on days worked for each individual[27]; 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 23,038,772 observations. The average nominal wage growth rate is 12.2 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, 67.1 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	Mean	SD	10th	25th	50th	75th	90th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Wage Growth Rate	23,038,772	12.2%	67.1%	-0.13%	0%	8.9%	11.8%	30.7%

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

[24]Note that we use a more comprehensive sample, covering entire private and public sector firms, in Section 4 where we analyze the extent of DNWR 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).

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

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

[27]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 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.

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"[28]; 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[29]; 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: 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.

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). 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 UMW 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.

[28]Note that only 6.0 percent of total observations is dropped.
[29]The number of dropped observations is almost negligible.

3.2 Ecuadorian and Colombian Customs Datasets

To explore the pattern of export 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.[30] 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 adds up to 98 percent of the official export value compiled by the UN Comtrade database over the period 2010-2018.[31] 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.[32]

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

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

[31] 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 cleaned dataset with that from the UN Comtrade database excluding flower exports (HS4 code=0603).

[32] 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.

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 its export prices in US dollar terms.

4 Downward Nominal Wage Rigidity

This section begins by exploring 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.[33] For all job-stayers in the payroll dataset in 2013, we calculate 12-month nominal wage growth rates between 2012 and 2013.[34]

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	10.2%	20.0%	69.8%	15.4%
Less than MW	0.01%	0.01%	99.98%	42.6%
Equal to or More than MW	15.9%	31.4%	52.7%	0.01%

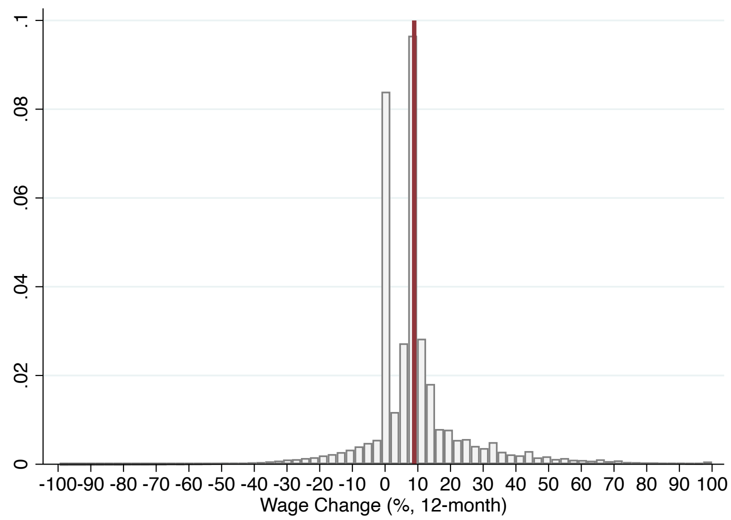
Notes: Columns (1), (2), and (3) show the percentage of employees receiving nominal wage cuts, freezes, and increases in the year 2013. In column (4), we present the percentage of the nominal wage increase that is equal to the growth rate of the minimum wage in the year 2013. Different samples are presented across rows. "All" indicates that the sample consists of all workers. "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 UMW level—i.e. $318 in the year 2012.

Figure 6 plots the distribution of 12-month nominal wage changes for all workers in

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

[34] 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.

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 UMW from $292 in 2012 to $318 in 2013 (i.e., 8.9%).

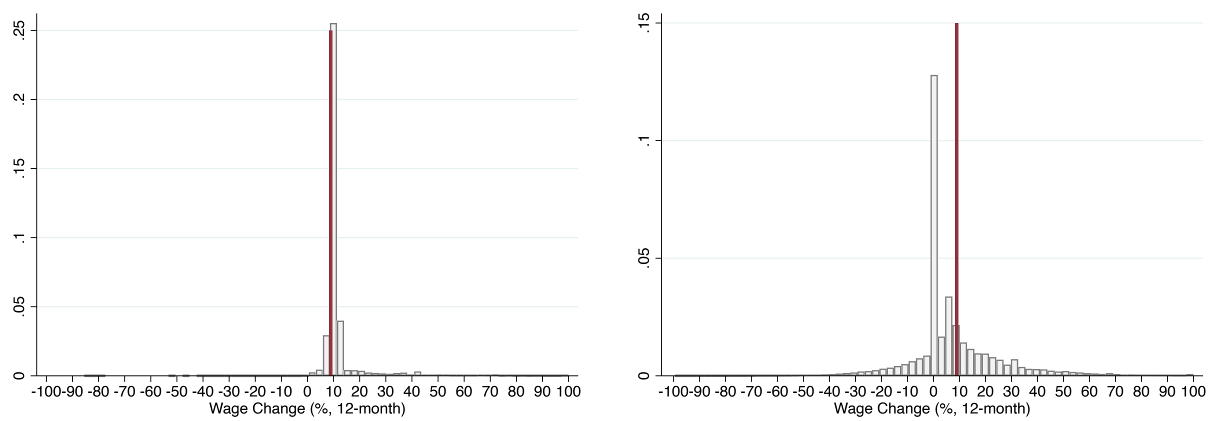
the sample in 2013.[35] There are several notable patterns from the nominal wage change distribution in Figure 6 (see also corresponding row "All" in Table 5). First, there is a clear asymmetry in the nominal wage changes such that only 10.2 percent of workers who remained employed over the 12-month period in the same job received a nominal 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 DNWR such that the percentage receiving wage cuts was about 11 percent in periods of low inflation and much lower in periods of high inflation.[36] Second, the wages for 20.0 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

[35] Appendix B provides additional information by breaking down all workers into public and private sector workers.

[36] 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 DNWR in Ecuador, their results are based mostly on developed countries and hence are not directly comparable to ours.

support the existence of DNWR in Ecuadorian labor markets. Third, 15.4 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 Security Institute (IMSS).

Figure 7: 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 UMW (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 UMW from $292 in 2012 to $318 in 2013 (i.e., 8.9%).

The fact that about 15 percent of the entire 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. Figure 7 plots the distribution of 12-month nominal wage changes by wage level in the sample in 2013: Figure (a) is restricted to workers who received less than the 2013 UMW level, i.e. $318, in the year 2012 and Figure (b) is restricted to workers who received equal to or more than the 2013 UMW. Table 5 presents the percentages of workers who received nominal wage changes of "less than" (and "equal to or more than") the 2013 UMW level in the year. Almost all workers (i.e., 99.98 percent) who earned less than the 2013 UMW in 2012 received wage increases; 42.6 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 the next year's minimum wage. Hence, the minimum wage law contributed to DNWR to a great extent. For workers who received equal to or more than the 2013 UMW in 2012, the percentage whose nominal wages were cut, frozen, or increased was 15.9%, 31.4%, and 52.7%, respectively. It is worth mentioning that only a small portion of workers received wage reductions (i.e., DNWR can also be identified) in this group, possibly owing to the wage spillover effects from the minimum wage increase (Choi, Rivadeneyra and Ramirez, 2021).[37]

The following econometric specification further helps assess the extent to which the increase in minimum wage level contributed to DNWR in a formal way whreby confounding factors that stem from individual as well as firm characteristics are adequately controlled:

$$\text{WG}_{ift} = \beta_1 \text{MW}_{ift} + \beta_2 \text{Switcher}_{ift} + \beta_3 \text{Male}_i + \beta_4 \text{MW}_{ift} \times \text{Switcher}_{ift} + \psi_{ft} + \varepsilon_{ift} \quad (1)$$

where the dependent variable WG_{ift} is year-over-year growth rate in average monthly wage level over the past four quarters (i.e., compared to the same quarter of the previous year) for an employee i employed in firm f in time t. MW_{ift} is an indicator variable that equals 1 if an employee i's wage level in the previous year is lower than the minimum wage level in the current year. Switcher_{ift} is an indicator variable that equals 1 if an employee i is employed in firm f that is different from the one a year ago. Male_i is an indicator variable that equals 1 for male employees. $\text{MW}_{ift} \times \text{Switcher}_{ift}$ is an interaction between MW_{ift} and Switcher_{ift} variables. ψ_{ft} denotes firm-time fixed effects. Standard errors are clustered at the firm and time levels.

Table 6 summarizes the estimation results from the pre-shock period sample, confirming that minimum wage workers indeed experienced around $20 \sim 30$ percent higher wage growth than non-minimum wage workers on average.[38] This is not surprising since, unlike non-minimum wage workers that might have experienced wage reduction or freeze, minimum wage workers were bound to get a pay increase at least as much as the minimum wage increase that turns out to have been substantial over the period. We take this as strong evidence that justifies our approach later in Section 5 that a firm with a higher share of minimum wage workers is likely to have faced more severe DNWR (or stronger upward wage pressure) after the shock.

[37] Appendix B confirms that such a pattern continued during the recession after the shock.

[38] Interestingly, the results also show that those who switch jobs tend to experience a higher wage growth, likely reflecting that a move to a job with higher pay dominates a move to a lower-paying job.

Table 6: Wage Growth by Worker Charateristics: 2011Q1-2013Q4

	Dependent Variable: Wage Growth Rate			
	(1)	(2)	(3)	(4)
MW_{ift}	31.52***	29.42***	29.46***	21.82***
	(0.816)	(0.752)	(0.753)	(0.586)
Switcher_{ift}		17.71***	17.69***	8.913***
		(0.745)	(0.746)	(0.977)
Male_{i}			0.813*	0.642
			(0.402)	(0.408)
$\text{MW}_{ift} \times \text{Switcher}_{ift}$				24.03***
				(1.113)
Fixed Effects:				
Firm-Time	Yes	Yes	Yes	Yes
Observations	24,603,354	24,603,354	24,603,354	24,603,354
R-squared	0.030	0.030	0.030	0.031

Notes: The dependent variable is year-over-year growth rate in monthly wage level over the past four quarters (i.e., compared to the same quarter of the previous year). MW_{ift} is an indicator variable that equals 1 if an employee's wage level in the previous year is lower than the minimum wage level in the current year. Switcher_{ift} is an indicator variable that equals 1 if an employee is employed in a firm different from the one a year ago. Male_{i} is an indicaotr variable that equals 1 for male employees. $\text{MW}_{ift} \times \text{Switcher}_{ift}$ is an interaction between MW_{ift} and Switcher_{ift} variables. The sample includes all the employees over the period 2011-2013 that were employed both in a given quarter and four quarters ago such that wage growth is well defined. All columns include firm-time fixed effects. Standard errors are clustered at the firm and time levels. *** p<0.01, ** p<0.05, * p<0.1.

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

5.1.1 Event Study Analysis

We begin with 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. 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:

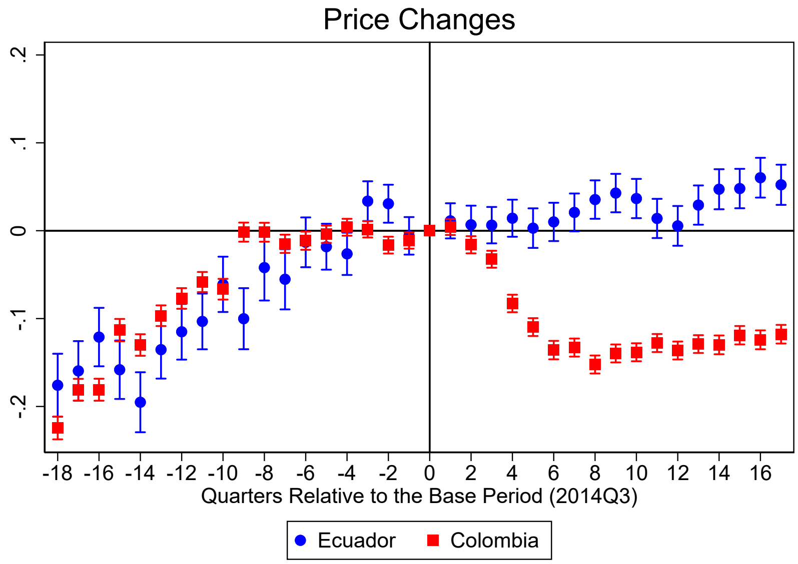
$$\ln \text{Y}_{fjkt} = \sum_{s \neq 2014Q3} \beta_s \times \mathbb{1}\{s = t\} + \psi_{fjk} + \varepsilon_{fjkt} \tag{2}$$

where the dependent variable, $\ln \text{Y}_{fjkt}$, is the log of export unit price (in USD) of firm f's export product (HS6 code) j to importing country k in time t. Export unit price is 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_{fjk}, 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 (2) 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 reasonably attributed to their exchange rate divergence.

The event-study analysis results for Ecuador and Colombia are described separately in Figure 8. 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

Figure 8: Event Study Analysis: Export Price Dynamics in Ecuador and Colombia



Notes: The figure plots event-study analysis results from equation (2) 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).

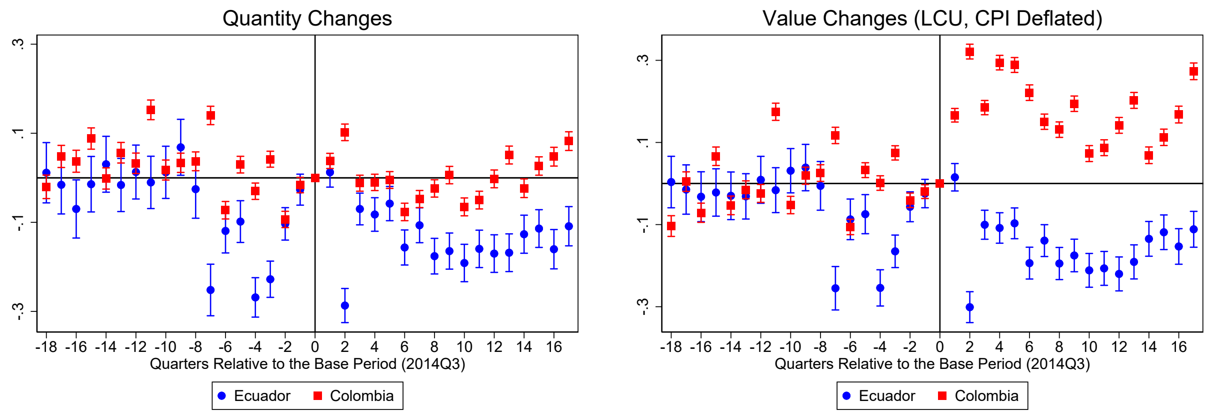
average export prices in Ecuador had been on an increasing trend until around 2014Q3, and then stabilized over the next four years with a few upticks. This is in stark contrast to the case of Colombia, illustrated with red squares. Although the pre-trend average export price in Colombia before the adverse oil price shock appears very close to that in Ecuador, it declined significantly after the shock.[39]

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. This is confirmed in panel (a) of Figure 9 that summarizes estimation results from equation (2) by replacing the dependent variable with the log of export quantity.

Moreover, valuation effects from the sharp depreciation of the Colombian peso further suggest that overall export receipts in each country's domestic currency increased in Colombia relative to that in Ecuador. To verify this, we repeat the event-study analysis in equation (2) 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

[39] Appendix A confirms the robustnes of the results to the sample restrictricted to manufacturing exports as well as to the nearest neighbor matching sample.

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



(a) Volume Dynamics

(b) Value Dynamics

Notes: The figure plots event-study analysis results from equation (2) where the dependent variables are the log export volume in panel (a) and the log export value in the local currency unit (LCU) deflated by domestic CPI in panel (b), respectively. 95% confidence intervals are represented by bars. The results are illustrated separately for Ecuador (blue circles) and Colombia (red squares).

by the domestic consumer price index (CPI).[40] Panel (b) of Figure 9 illustrates the event-study analysis results for real export value regressions. As earlier, coefficient estimates on time dummy variables for Ecuador and Colombia are represented by blue circles and red squares, respectively. 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.

5.1.2 Difference-in-Differences

One disadvantage of the event-study approach is that all the time-varying shocks in a separate regression of equation (2) 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'

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

datasets in the following difference-in-differences specification:

$$\ln \mathrm{Y}_{fjkt} = \beta \mathrm{ECU}_f \times \mathrm{Post}_t + \psi_{jkt} + \psi_{fjk} + \varepsilon_{fjkt} \quad (3)$$

where f 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 is the log of export price. ECU_f is an indicator variable that equals 1 if firm f is Ecuadorian and 0 Colombian. Post_t is an indicator variable that equals 1 if the time t is after 2014Q4 and 0 otherwise. ψ_{jkt} and ψ_{fjk} 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.

Table 7: Export Price Changes across Exchange Rate Regimes, 2010Q1 - 2018Q4

	Dependent Variable: Log of Export Price				
	(1)	(2)	(3)	(4)	(5)
$\mathrm{ECU}_f \times \mathrm{Post}_t$	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_f is an indicator variable that equals 1 if a firm f 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.

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 7 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 (2). Column (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 (3) 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.

Table 8: Export Volume and Value Changes across Exchange Rate Regimes, 2010Q1 - 2018Q4

Panel (A)	Dependent Variable: Log of Export Volume (Quantity)				
	(1)	(2)	(3)	(4)	(5)
$ECU_f \times Post_t$	-0.052***	-0.052***	-0.115***	-0.072***	-0.151***
	(0.012)	(0.013)	(0.019)	(0.015)	(0.028)
Observations	1,367,652	1,367,652	1,340,569	1,367,113	996,023
R-squared	0.903	0.903	0.911	0.904	0.930
Panel (B)	Dependent Variable: Log of Export Value (LCU, CPI deflated)				
	(6)	(7)	(8)	(9)	(10)
$ECU_f \times Post_t$	-0.087***	-0.276***	-0.356***	-0.293***	-0.366***
	(0.011)	(0.013)	(0.018)	(0.014)	(0.026)
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
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

Notes: The dependent variables are the log of export volume (quantity) in Panel (A) and the log of export value in local currency unit (LCU) deflated by domestic CPI in Panel (B). ECU_f is an indicator variable that equals 1 if a firm f 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.

Next, we repeat running the regression of equation (3) by replacing the dependent variable first with the log export quantity and then with the log export value in LCU deflated by domestic CPI. Table 8 summarizes estimation results on β, yielding negative and statistically significant coefficient estimates across columns (2) through (5) in both tables. This suggests that exporters in Colombia were able to benefit from domestic currency depreciation in the form of an increase in export volume which, in turn, is translated into an increase in real export revenue in domestic currency, up to nearly 40 percent more than what exporters in Ecuador experienced due to the absence of exchange rate flexibility.

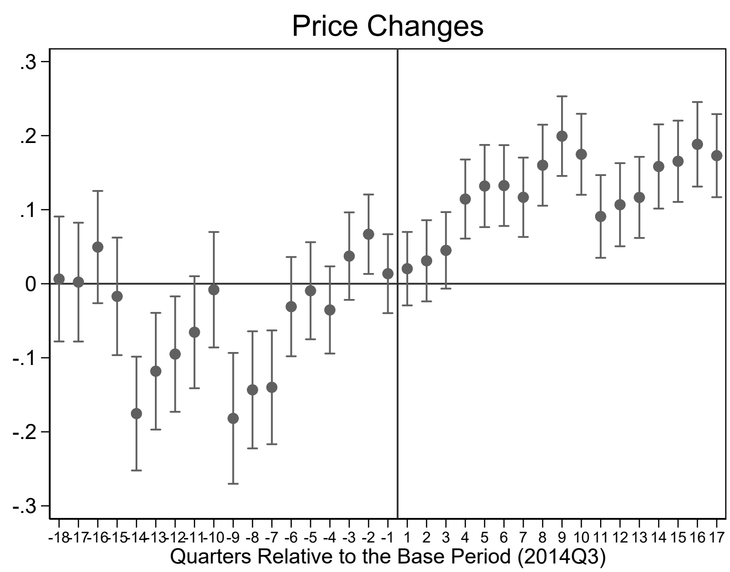
5.1.3 Dynamic Treatment Effects

Although time-varying product or country shocks were effectively taken care of in the previous difference-in-differences estimation strategy, there remains a quesion regarding the exact timing of the divergence between Ecuadorian and Colombian exporters' pricing behavior before and after the adverse oil price shock. As such, we specify the following regression to capture the dynamics of treatment effects:

$$\ln \mathrm{Y}_{fjkt} = \sum_{s \neq 2014Q3} \beta_s \mathbb{1}\{s = t\} \times \mathrm{ECU}_f + \psi_{jkt} + \psi_{fjk} + \varepsilon_{fjkt} \tag{4}$$

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.

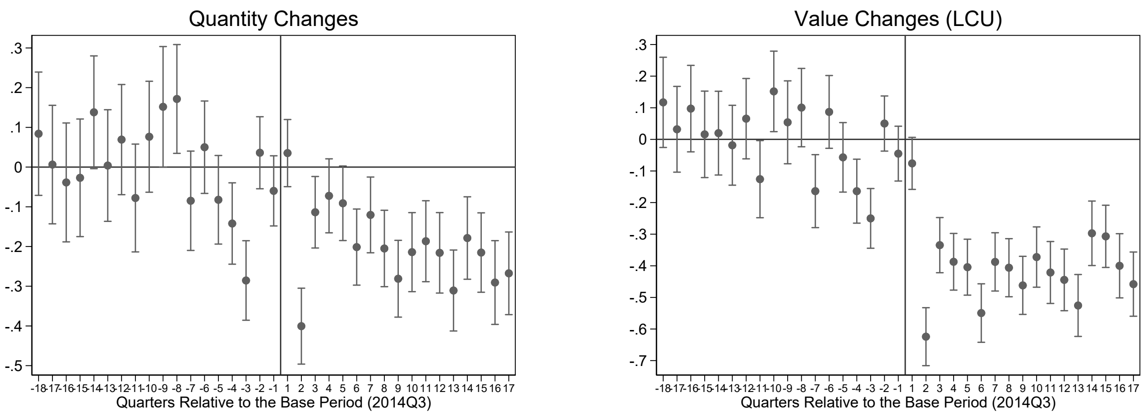
Figure 10: Dynamic Treatment Effects: Export Price Dynamics in Ecuador vs. Colombia



Notes: The figure plots coefficients estimate on β_s's from the dynamic treatment effects analysis as specified in equation (4) where the dependent variable is the log export price (in USD). 95% confidence intervals are represented by bars.

The coefficient estimates on β_s from equation (4) are described in Figure 10. 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 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 in four quarters after the shock likely reflects the price stickiness in dollar-invoiced exports.

Figure 11: Dynamic Treatment Effects: Export Volume and Value Dynamics in Ecuador vs. Colombia



(a) Volume Dynamics

(b) Value Dynamics

Notes: The figure plots coefficients estimate on β_s's from the dynamic treatment effects analysis as specified in equation (4) where the dependent variables are the log export volume (quantity) in panel (a) and the log export value in the local currency unit (LCU) deflated by domestic CPI in panel (b), respectively. 95% confidence intervals are represented by bars.

We repeat the specification in equation (4) by replacing the dependent variable first with the log export quantity and then with the log export value in the LCU deflated by domestic CPI. Figure 11 summarizes the estimation results, confirming that average export volume and value movements in the two countries were mostly statistically not very different until 2014, after which Colombia's export volume and value increased persistently relative to Ecuador's export volume and value due to elastic export demand and further amplified by the valuation effects associated with the depreciation of the Colombian peso.

5.1.4 Panel Regression with Macroeconomic Variables

One potnetial concern regarding our identifying assumption is that the estimated time coefficient may capture different events or policies that happened during 2014-2016 in Ecuador and Colombia and thus the observed difference in export price adjustment dynamics after the shock may not be attributed solely to their exchange rate divergence. To verify further the validity of our identifying assumption and hence the role of the exchange regime in export price divergence between the two countries after the shock, we run a set of horse race regressions with the nominal effective exchange rate index measure along with other potentially relevant country-time level macroeconomic variables. The idea is to identify the key macro variable that can explain variation in export prices over time across countries. Specifically, we perform a complementary analysis by running the following regression:

$$\ln \mathrm{Y}_{fjkt} = \beta_{\mathrm{NEER}}\mathrm{NEER}_{ct} + \sum_{X} \beta_X X_{ct} + \psi_{jkt} + \psi_{fjk} + \varepsilon_{fjkt} \quad (5)$$

where f indicates a firm in country c, either Ecuador or Colombia, j means a product (HS-6-digit level), k represents the destination country, and t is time (i.e., year-quarter). The dependent variable is the log of export unit price (in USD). NEER_{ct} is a country-quarter-level nominal effective exchange rate index in log. X_{ct} is a set of potentially relevant country-quarter-level variables, including a size of fiscal expenditure (in percent of GDP) in log; economic policy uncertainty index value; year-on-year growth in domestic credit to private sector; public debt-to-GDP ratio in log. ψ_{jkt} and ψ_{fjk} 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 results summarized in Table 9 confirm the major role of NEER in explaining exporter-product-destination country-level export price movements over time. By contrast, the estimated coefficient on fiscal policy—either measured by the size of fiscal expenditure or public debt—is statistically insignificant. Although the estimated coefficient on policy uncertainty is statistically significant, it turns out to have little to do with diverging export price movements across countries because the measure co-moved in two countries over the sample period. Likewise, the positive and statistically significant coefficient estimate on credit growth cannot explain export price movements as it moved in wrong directions across countries—increased in Colombia but declined in Ecuador after the shock. Considering that two countries' NEER started diverging substantially after the shock as shown in Figure 4-(b), we take this result as strong evidence reaffirming our interpretation of the main results—that is, attributing the estimated time coefficient in the period after the shock to different exchange rate regimes.

Table 9: Determinants of Export Price Changes, 2010Q1 - 2018Q4

	Dependent Variable: Log of Export Price				
	(1)	(2)	(3)	(4)	(5)
NEER_{ct}	0.398***	0.386***	0.362***	0.391***	0.387***
	(0.036)	(0.035)	(0.035)	(0.036)	(0.041)
Fiscal expenditure_{ct}		0.032	-0.001	0.004	0.006
		(0.024)	(0.026)	(0.026)	(0.026)
Policy uncertainty_{ct}			-0.108***	-0.083***	-0.083***
			(0.030)	(0.030)	(0.030)
Domestic private credit_{ct}				0.002***	0.002***
				(0.001)	(0.001)
Public debt_{ct}					0.008
					(0.047)
Fixed Effects:					
Firm-HS6-Imp	Yes	Yes	Yes	Yes	Yes
HS6-Imp-Time	Yes	Yes	Yes	Yes	Yes
Observations	969,390	969,390	969,390	969,390	969,390
R-squared	0.916	0.916	0.916	0.916	0.916

Notes: The dependent variable is the log of export price. NEER_{ct} is a country-quarter-level nominal effective exchange rate index in log. Fiscal expenditure_{ct} is a size of country-quarter-level fiscal expenditure (in percent of GDP) in log. Policy uncertainty_{ct} is a country-quarter-level economic policy uncertainty index value. Domestic private credit_{ct} is a country-quarter-level year-on-year growth in domestic credit to private sector. Public debt_{ct} is a country-quarter-level public debt-to-GDP ratio in log. All columns include exporter-product-importer country and product-importer country-quarter fixed effects. Standard errors are clustered at the firm-product-country level. *** p<0.01, ** p<0.05, * p<0.1.

5.2 The Missing Role of Internal Devaluation

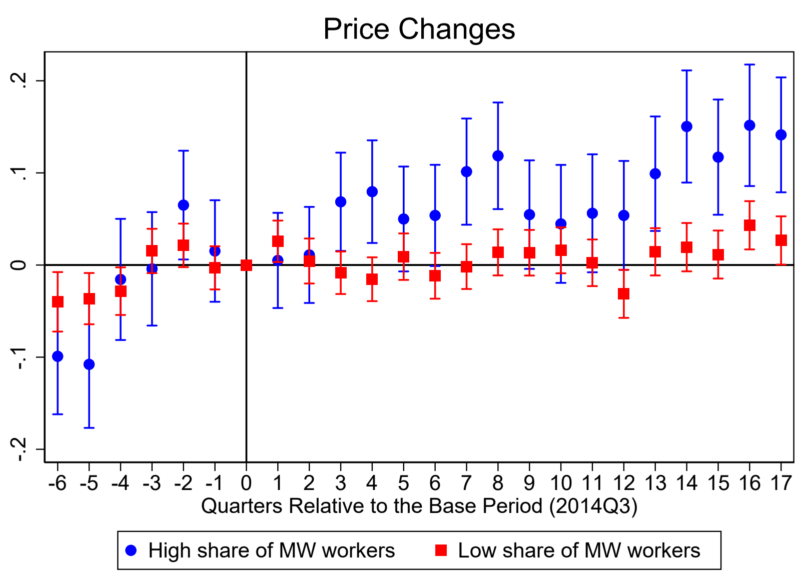
In principle, even under a fixed exchange rate system, exporters should be able to adjust their export prices by reducing labor costs (e.g., Decressin et al., 2015; Galí and Monacelli, 2016). However, this channel of internal devaluation was not available in Ecuador owing to the DNWR that stemmed from the binding minimum wage, as discussed in Section 4.[41] 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

[41] 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.

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 minimum wage workers"; those with a workforce of less than 50 percent minimum wage workers are defined as "exporters with a low share of minimum wage workers."[42] This categorization is based on our discussion in Section 4: 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 DNWR.

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



Notes: The figure plots event-study analysis results from equation (2) 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).

[42]More precisely, minimum wage workers are defined as workers whose wage levels in 2013 were lower than the 2014 UMW. We categorize firms into two groups based on their share of minimum wage workers in total workers as of 2013.

Then, 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 (2) 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.[43] Overall, the evidence suggests that internal devaluation was not a viable option for Ecuadorian exporters because of DNWR induced by a continued increase in the minimum wage.

6 Employment Adjustment

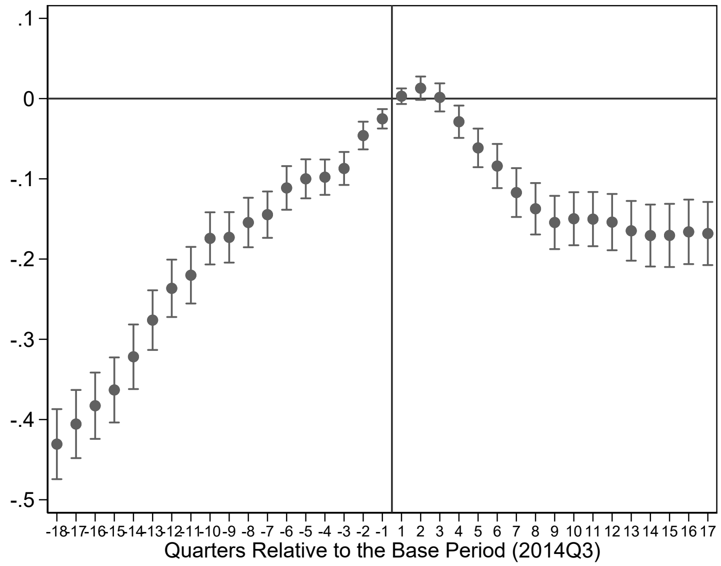
We have established that the combination of a rigid minimum wage system and full dollarization prevented Ecuadorian exporters from adjusting nominal wages (i.e., internal devaluation), and thus from adjusting export prices (i.e., external devaluation) in the period of the negative external shocks. In 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 firm-level event-study regression equation:

$$\ln \mathrm{E}_{ft} = \sum_{s \neq 2014Q3} \beta_s \times \mathbb{1}\{s = t\} + \psi_f + \varepsilon_{ft} \tag{6}$$

where the dependent variable is the log of employment for firm f in time t. ψ_f denotes firm fixed effects 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 firm level.

[43] 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 the two groups becomes even stronger.

Figure 13: Employment Changes within Firms in Ecuador



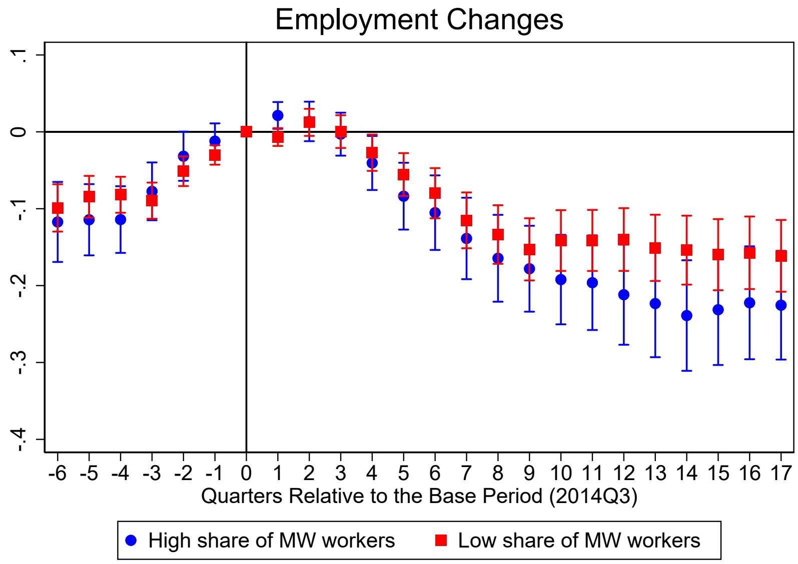
Notes: The figure displays the average firm-level log employment changes relative to the quarter of the exchange rate shock based on estimates of equation (6). 95% confidence intervals are displayed in bars.

Figure 13 shows estimates of β_s between 2010Q1 and 2018Q4, representing average log employment changes, relative to 2014Q3, within firms. Up until 2014Q3, 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 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).[44]

In Section 5.2, we reported that exporters with a high share of minimum wage workers, relative to those with a low share of minimum wage workers, were pressured to raise wages more and thus found it harder to lower export prices to remain international competitiveness. Had the mechanism worked, we expect that exporters with a high share of minimum wage workers would have reduced employment more than exporters with a low share of MW workers. To test this hypothesis, we run regression of equation (6) separately for two groups. Figure 14 shows the estimation results. Employment by ex-

[44] A further analysis on margins of employment adjustment is conducted in Appendix C.

Figure 14: 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 (6). 95% confidence intervals are displayed in bars. The level of the 2014Q3 (i.e., the UMW 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).

porters 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 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.

The results thus far have considred employment consequences at the firm level. One limitation of the firm-level analysis is that, to the extent that minimum wage workers are more likely to lose their jobs during recessions, the increased layoffs among firms with many minimum wage workers could simply reflect the compositional bias. To address such concerns, we also exploit rich information from our employer-employee matched dataset by tracing individual-level employment status including the minimum wage worker status, thereby explicitly controlling for a possible composition effect—that is, whether minimum wage workers are more likely to be laid off during recessions. Specifically, we consider the following individual-level linear probability model where the dependent variable, Stay_{ift}, is an indicator variable equal to 1 if a person i continues working for firm f in the next quarter and 0 if a person is employed by another company or unemployed in the next quarter. Therefore, the specification below aims to estimate the likelihood of staying in the same job next quarter conditional on being employed in a given quarter:

$$\text{Stay}_{ift} = \beta_1 \text{MW}_{it} + \sum_{s \neq 2014Q3} \beta_s \times \mathbb{1}\{s = t\} \times \text{HI}_f + \psi_i + \psi_f + \psi_t + \varepsilon_{ift} \tag{7}$$

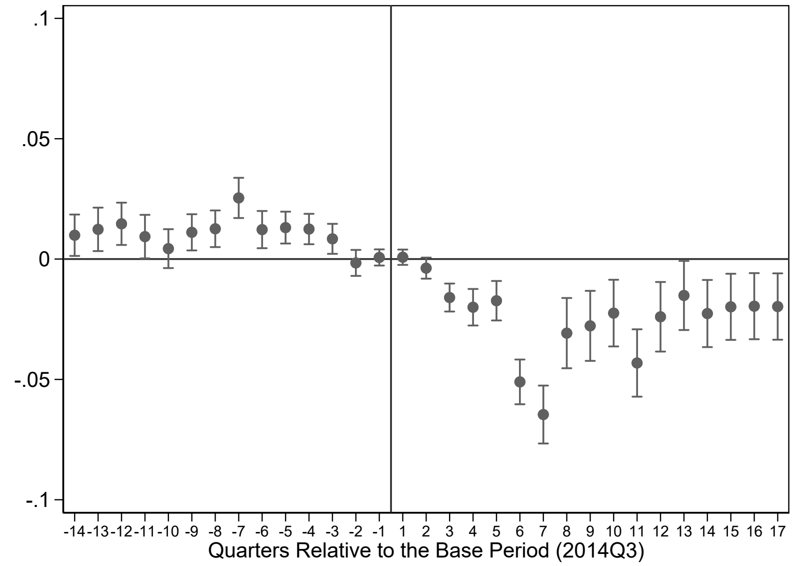
where MW_{it} is an indicator variable that equals 1 if a person i's wage level in the previous year was lower than the minimum wage level in the current year, which is included to directly control for possible composition effects. We can investigate whether differential patterns would be observed across firms with a high vs. low share of minimum wage workers, by introducing interaction between time dummies ($\mathbb{1}\{s = t\}$ is an indicator variable corresponding to a time dummy that equals 1 if the time (year-quarter) is t and 0 otherwise) and the HI_f indicator variable that equals 1 for firms with a share of minimum wage workers above 50% in the pre-shock period and 0 for firms with a share of minimum wage workers below or equal to 50% in the pre-shock period. ψ_i, ψ_f and ψ_t denotes individual-, firm-, and time-fixed effects, respectively.

Figure 15 clearly shows that, controlling for individual-, firm-, and time-fixed effects as well as the time-varying minimum wage worker status, workers employed by firms with a high share of minimum wage workers became increasingly more likely to leave a job starting in about three quarters after the shock, compared to peers employed by firms with a low share of minimum wage workers. To reiterate, we control for individual-level minimum wage worker status and thus the composition bias does not drive the result. This is consistent with the notion that firms with a high share of minimum wage workers were more likely to suffer from DNWR, and thus were hit harder and had to reduce employment more.

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 acted as sources of DNWR 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 Ecuado-

Figure 15: The Likelihood of Staying at a Job: High vs. Low Share of MW Workers



Notes: The figure plots coefficients estimate on β_s's from the dynamic treatment effects analysis as specified in equation (7) where the dependent variable is an indicator variable equal to 1 if a person continues working for a company in the next quarter and 0 if a person is employed by another company or unemployed in the next quarter. The results illustrate the time-varying employee-level likelihood of staying at a firm with a high share of minimum wage workers relative to that of staying at a firm with a low share of minimum wage workers. 95% confidence intervals are represented by bars.

rian 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 DNWR, mostly driven by stringent minimum wage regulations, which prevented Ecuadorian firms from adjusting wages flexibly. Third, combining Ecuadorian customs and payrolls datasets, 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 DNWR, which strongly support the theoretical predictions in the literature (Schmitt-Grohé and Uribe, 2013; Schmitt-Grohé and Uribe, 2016).

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Appendix

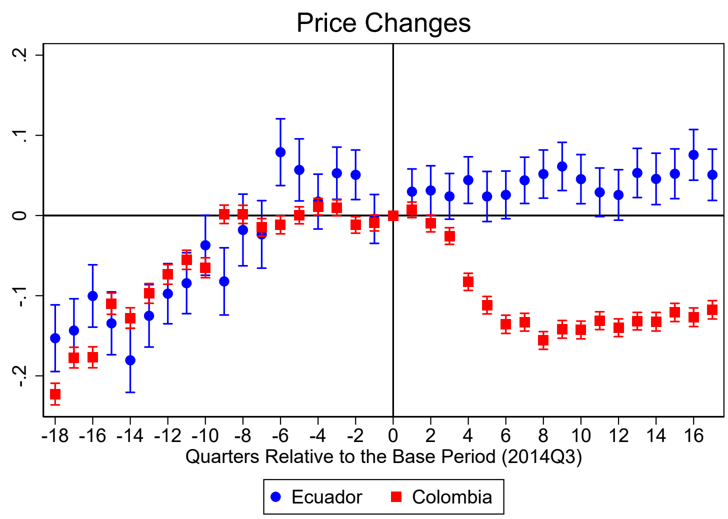
Appendix A: Robustness

This section provides additional empirical results for the robustness checks. First, we confirm the robustness of our baseline findings for the sample restricted to manufacturing exports. Secondly, we repeat our baseline estimation processes by applying the nearest-neighbor matching method. Throughout the analyses, we report price dynamics only for the sake of space. We conclude that all the results are almost identical to the baseline results both qualitatively and quantitatively.

A.1 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.1 is a manufacturing export version of Figure 8.

Figure A.1: Event-Study Analysis: Export Price Dynamics in Ecuador and Colombia: MFG only

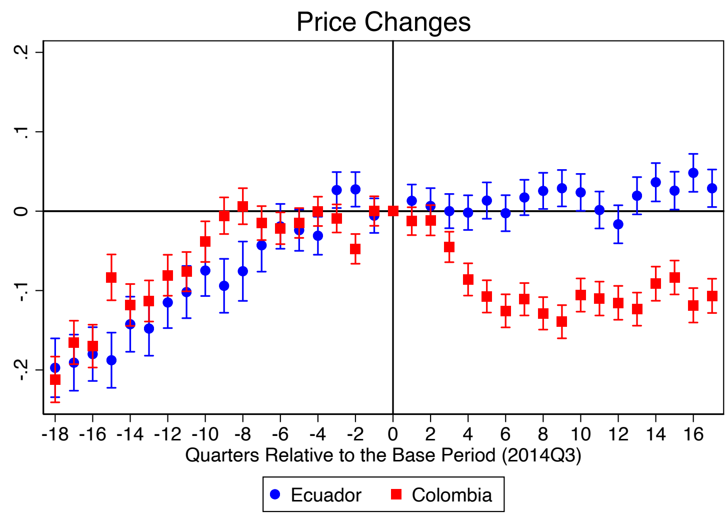


Notes: The figure plots event-study analysis results from equation (2) where the dependent variable is the log of export price (in USD). The results are illustrated separately for Ecuador (blue circles) and Colombia (red squares). The sample is restricted to manufacturing export transactions.

A.2 Nearest-Neighbor Matching

To enhance the credibility of the comparison between Ecuadorian and Colombian exporters, we adopt a one-to-one nearest-neighbor matching approach as a robustness check: for each Ecuadorian exporter, we search a control exporter (i.e., Colombian exporter) whose characteristics are most similar to those of the Ecuadorian exporter. More specifically, one year before the shock period, i.e., in the year 2013, we use three observable characteristics at the firm level in the customs dataset—export values, the number of HS6 products, and the number of destination countries—to find the closest Colombian exporter that is matched with every one of Ecuadorian exporters. Using this restricted sample, we repeat the analysis.[45] The result is shown below in Figure A.2, which is a nearest-neighbor matching version of Figure 8.

Figure A.2: Event-Study Analysis: Export Price Dynamics in Ecuador and Colombia: Matched Sample



Notes: The figure plots event-study analysis results from equation (2) 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 one-to-one nearest-neighbor matched sample.

[45]Please note that the sample is restricted to both Ecuadorian and Colombian firms that appear at least once in the 2013 sample, implying that the event-study result for Ecuadorian firms is not exactly the same as before.

Appendix B: Additional Details on DNWR in Ecuador

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 B.1 plots the distribution of 12-month nominal wage changes by sector—i.e., public and private—in the sample in 2013. In Table B.1, 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 8.9 percent in the private sector. Third, 36.9 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 19.6 percent; while only 1.1 percent of public sector workers received wage increases that are equal to the minimum wage growth rate.

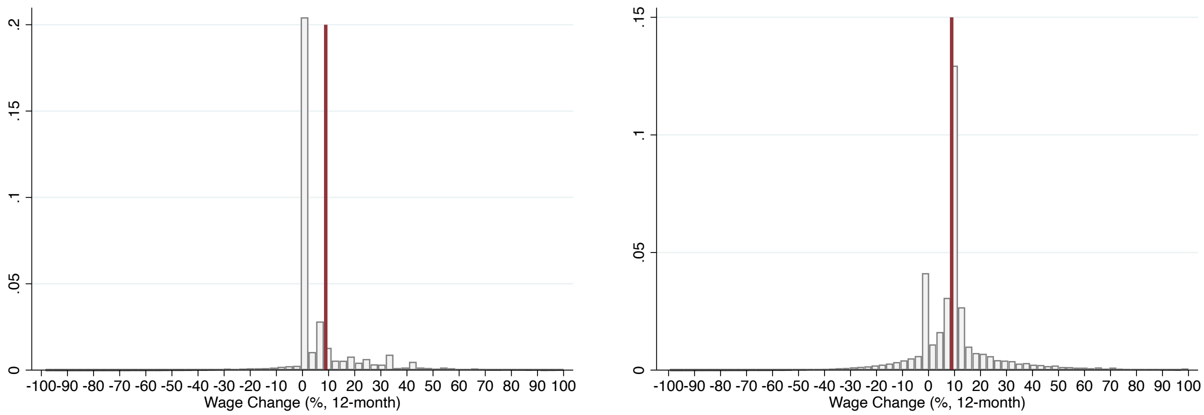
Table B.1: Percentage of Employees Receiving Nominal Wage Cuts, Freezes, and Increases, 2013

Sample	Wage Cuts (1)	Wage Freezes (2)	Wage Increases (3)	Wage Increases (=MW Growth) (4)
All	10.2%	20.0%	69.8%	15.4%
Public	5.1%	57.9%	36.9%	1.1%
Private	11.6%	8.9%	79.4%	19.6%

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.

We next check whether the nominal wages were downwardly rigid even during the recession (i.e., after 2014Q3) by exploring the full sample. Table B.2 summarize the pat-

Figure B.1: 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 UMW from $292 in 2012 to $318 in 2013 (i.e., 8.9%).

tern of nominal wage adjustments across years covering both pre-and post-shock periods. The percentage of workers receiving nominal wage cuts increased slightly after 2014, but a strong pattern of DNWR continued as the percentage of workers receiving a nominal wage cut ranged from 9.1% to 10.5% before the shock, while the percentage receiving a nominal wage cut ranged from 11.4% to 15.5% after the shock. Meanwhile, during the recession, the percentage of workers whose wages were frozen increased relatively more than the percentage whose wages were cut—the percentage of workers receiving a nominal wage freeze ranged from 13.3% to 20.0% and from 18.6% to 26.6% before and after the shock, respectively—meaning that wage freezes became more frequent than wage cuts. Finally, the indexation of wage changes to the minimum wage increases was even more frequent after the shock—the percentage of workers receiving a nominal wage increase equal to the minimum wage growth rate ranged from 12.1% to 15.4% and from 15.3% to 22.4% before and after the shock, repectively—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 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 regulation that is akin to that in Ecuador as discussed in Section 2.2.[46]

[46] According to Iregui, Melo and Ramírez (2012), who studied firms' wage adjustment practices in the

Table B.2: 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	9.1%	17.5%	73.5%	14.6%
2012	10.5%	13.3%	76.1%	12.1%
2013	10.2%	20.0%	69.8%	15.4%
2014	11.4%	18.6%	70.0%	15.8%
2015	13.7%	20.5%	65.8%	15.3%
2016	15.5%	24.5%	60.0%	17.0%
2017	12.2%	25.6%	62.3%	22.4%
2018	12.0%	26.6%	61.5%	21.6%

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.

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.

Appendix C: Margins of Employment Adjustment

In the main text, we have identified the negative employment impacts of the shock.[47] 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_{ft} 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_{ft} as the fraction of employed workers at time t that are separated from firm f in time $t+1$. We estimate the following event-study regression equation:

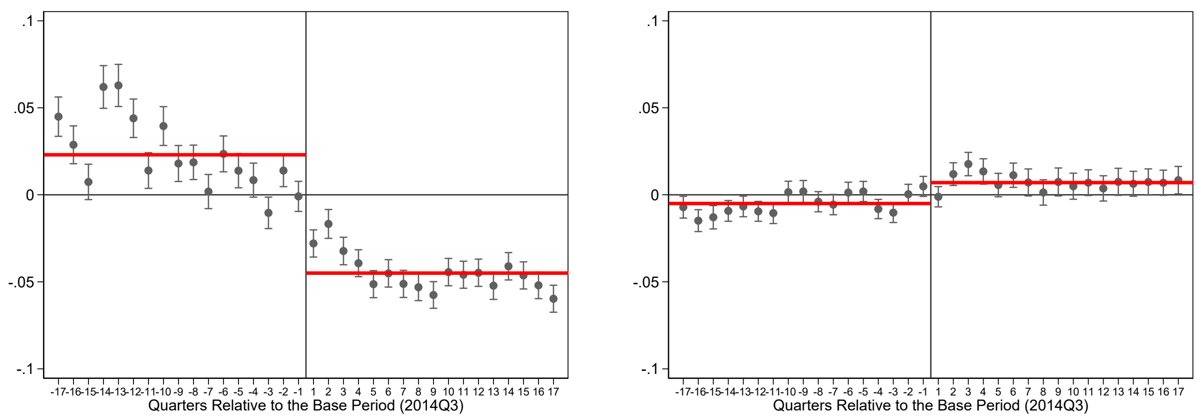
$$\ln \mathrm{Y}_{ft} = \sum_{s \neq 2014Q3} \beta_s \times \mathbb{1}\{s = t\} + \psi_f + \varepsilon_{ft} \tag{8}$$

where $\mathrm{Y}_{ft} \in \{\mathrm{NH}_{ft}, \mathrm{JS}_{ft}\}$.

Figure C.1 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.

[47] 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 D for more discussion on informal employment in Ecuador.

Figure C.1: New Hires and Job Separations within Firms in Ecuador



(a) New Hire Rates

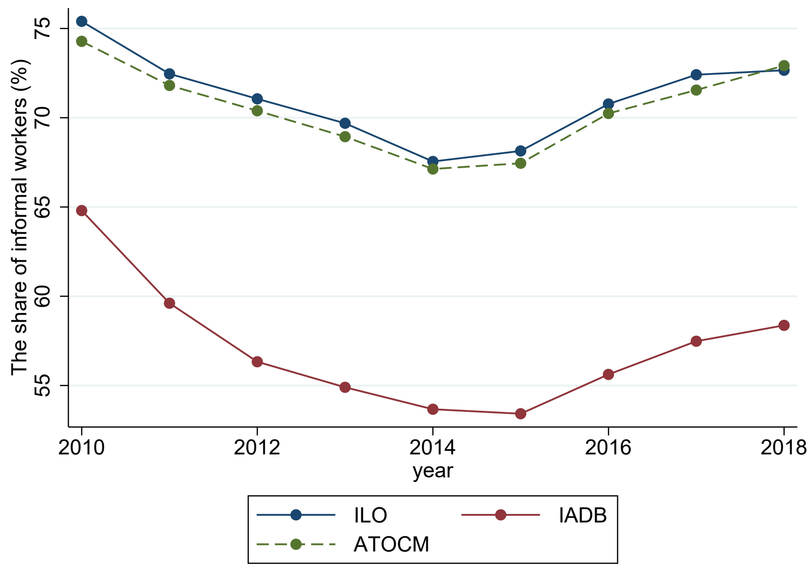
(b) Job Separation Rates

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 (8); figure (b) displays the changes of the job separation rate relative to the quarter of the exchange rate shock based on estimates of equation (8). 95% confidence intervals are displayed in bars. The red horizontal lines denote the averages before and after the shock (i.e., 2014Q3), respectively.

Appendix D: 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 D.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 D.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.[48]

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 (UMW). 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.

[48]The discussion 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.