Pegxit Pressure

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Abstract

We develop a simple model that highlights the costs and benefits of fixed exchange rates as they relate to trade, and show that negative export-price shocks reduce fiscal revenue and increase the likelihood of an expected currency devaluation. Using a new high-frequency data set on commodity-price movements from the classical gold standard era, we then show that the model's main prediction holds even for the canonical example of hard pegs. We identify a negative causal relationship between export-price shocks and currency-risk premia in emerging market economies, indicating that negative export-price shocks increased the probability that countries abandoned their pegs.

Keywords: currency risk; commodity prices; exchange-rate devaluation

JEL classification: F31; F33; F36; F41; N10; N20

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1 Introduction

A recurrent feature of the international monetary system over the past 150 years has been the use of fixed exchange rates to anchor currency values and prices. Fixed exchange rates have some macroeconomic benefits (Edwards et al. 2003; López-Córdova and Meissner 2003; Husain et al. 2005), but abandoning a fixed-exchange rate regime is a commonly observed policy decision in open economies (Obstfeld and Rogoff 1995; Reinhart and Rogoff 2009). This decision is frequently followed by a currency devaluation, which can result in significant reductions in employment and output (Kaminsky and Reinhart 1999; Gupta et al. 2007). Given the fragility of fixed exchange rates, countries often turn to hard pegs and currency unions. But as shown by Schmukler and Servén (2002) and Mitchener and Weidenmier (2015), even hard pegs have rarely been viewed as credible arrangements by financial markets.

In this paper, we identify one reason why countries abandon pegs and devalue their currencies: shocks to the value of their output. We take the perspective that fixed exchange rates are often adopted to facilitate external trade, and explore how exogenous fluctuations in export prices affect the probability of expected currency devaluation. To do so, we first solve a long-run model with flexible prices where a government chooses an optimal policy by weighing the costs and benefits of abandoning a fixed exchange rate. The cost of leaving the peg is that trade is lower outside of a fixed exchange-rate regime, reducing government tax revenues and increasing fiscal pressure.[1] The benefit of leaving the peg is that, in

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[1] There are a variety of reasons why trade may be larger under a peg, including lower exchange rate volatility and transaction costs. The empirical literature on the classical gold standard suggests that trade was larger under pegs due to transactions costs (López-Córdova and Meissner, 2003).

real terms, the government faces lower domestic-currency debt payments following devaluation, reducing the real debt burden and easing fiscal pressure. Optimal policy balances these two effects for a fixed level of debt and a fixed devaluation.

The main contribution of the model is to highlight how permanent shocks to the international price of exports affect the probability of leaving a currency peg. When export prices are sufficiently low, the costs of a reduction in trade after leaving the peg are small and offset by the fixed benefit from lower real-debt payments following devaluation. If export-price shocks are permanent, a negative price shock will increase the probability that export prices are sufficiently low in the future to induce a peg exit, and therefore cause an immediate increase in currency risk. We solve this structural model of abandoning a peg in closed form to show how negative (positive) shocks to the price of a country's exports increase (decrease) the probability of leaving a peg and devaluing its currency.

We then show empirically, using both structural and reduced-form models, that this mechanism is relevant for "pegxit pressure" using currency risk, a closely followed indicator of expected currency devaluation by economic agents, policy makers, and market participants. We employ novel high-frequency panel data that includes monthly measures of commodity and manufactured goods world prices, countries' principal exports, and currency risk measured from market expectations, for more than 40 years and 21 countries to test whether export-price shocks influence currency risk.

Our sample period, 1870-1913, is a particularly well-suited laboratory for understanding why countries abandon hard pegs for several reasons. First, many

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countries pegged to gold to facilitate trade.[2] Second, both capital and goods markets were unfettered and integrated (Eichengreen, 1998). Finally, many countries, particularly those in the periphery, had relatively unspecialized production structures, exposing them to external trade shocks that were plausibly exogenous (Williamson, 2013). Trade in this early era of globalization is well described by the Heckscher-Ohlin model of comparative advantage in factor endowments.[3] Since many countries specialized in exports of raw materials and minerals, we are able to exploit the so-called "commodity lottery" in our identification strategy. That is, commodity prices determined in world markets provide a reasonably exogenous source of variation for measuring the benefits of fixed exchange rates since countries specialized in exporting products based on their pre-determined factor endowments. We focus on the prices of the principal export, instead of export prices or terms-of-trade, as a way to isolate exogenous monthly variation and identify the causal impact of the principal-export price on currency risk under fixed exchange rates.[4]

Our empirical analysis shows a negative and statistically significant causal relationship between the price of principal exports and currency risk, a result that is robust to alternative specifications, including those with country and year fixed effects that account for omitted covariates. Furthermore, we show that the ef-

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[2]See, for example, Eichengreen (1998), López-Córdova and Meissner (2003), Mitchener and Weidenmier (2008), Mitchener et al. (2010), Mitchener and Voth (2011).

[3]See Blattman et al. (2007), Findlay and O'Rourke (2003), Mitchener and Yan (2014) and O'Rourke and Williamson (1994).

[4]An alternative empirical strategy would be to predict departures from the gold standard using principal-export prices. However, as we later show in Table 12, there were only a few "pegxits" before this international monetary system was abandoned in 1914. Instead, we focus on currency risk spreads since they measure expected currency devaluation, which for pegs, includes the probability of abandoning gold as well as changes in the value of currency following exit.

fects are driven by countries in the periphery rather than the core countries of the gold standard. In particular, for a periphery country that is formally on gold, we find that a one-standard-deviation decrease in the annual growth rate of principal-export prices increases the currency risk spread by 8 basis points.[5]

The main contribution of our paper is to identify a novel real mechanism, both theoretically and empirically, that explains the dynamics of currency risk. This research contributes to the large literature on how unsustainable pegs collapse, which has focused on monetary, fiscal, and financial causes, where it is often difficult to perform causal inference. First-generation models of currency crises highlight a fiscal mechanism where government expenditures need to be financed with inflation-related revenues (for example, seigniorage), but inflation is incompatible with fixed exchange rates under capital mobility (Krugman 1979; Flood and Garber 1984; Calvo 1987; Broner 2008).[6] However, government expenditure shocks are frequently endogenous or coincide with other shocks such as wars, natural disasters and policy shifts, making it challenging to identify, empirically, how important this fiscal mechanism is in driving currency risk.[7] To address this identification issue, we focus on a model and an estimation strategy that turns to fiscal shocks emanating from the revenue side of the ledger. Doing so allows us to iden-

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[5]From a trader's perspective, small differences in spreads can lead to large profits. Our objective is not to explain the cross-section of currency risk spreads, which is much larger in magnitude. Rather, we aim to uncover the causal effect of realized price fluctuations on currency risk spreads, on top of other factors that are already priced in.

[6]Another class of models, known as second-generation models, shows that crises can be unpredictable and caused by self-fulfilling expectations, often independently of fundamentals (Obstfeld 1986; Angeletos et al. 2007). So-called third-generation models explore how the financial sector interacts with currency crises and how these crises propagate into the real economy. Examples include Corsetti et al. (1999), Krugman (1999) and Aghion et al. (2004).

[7]In related theoretical contributions, Rebelo and Végh (2008) study optimal policy when there are output costs from abandoning a peg, while Aizenman and Glick (2008) show that a fixed exchange rate can lead to a costly exit following a large enough adverse real shock.

tify a plausibly exogenous source of variation in revenues, global commodity-price shocks, which can be causally tested to see whether they influence the decision to abandon a peg.[8]

We also contribute to the literature on the optimality of exchange-rate regimes in response to real and nominal shocks (Kollmann 2002; Gali and Monacelli 2005; Schmitt-Grohé and Uribe 2016). We identify the response of currency risk to an exogenous real shock during the classical gold standard which suggests that price fluctuations in a country's principal export(s) impose limits on using fixed exchange rates as a commitment device (Chernyshoff et al., 2009; Bordo and Rockoff 1996; Obstfeld and Taylor 2003). Furthermore, our study shows that debt and real shocks put a strain on existing institutions. Flandreau et al. (1998) document that fluctuations in the cost of servicing debt affected the stability of the European countries during the gold standard. We study a similar mechanism, but focus on country-specific export-price shocks. In that sense, our results are also related to the literature on the trilemma (Obstfeld et al., 2005). In an environment of perfect capital mobility, we document that country-specific external shocks that change the relative value of monetary autonomy affect the probability of exchange-rate instability.

Finally, our study contributes to the understanding of the operation and performance of the classical gold standard in the periphery. Economic historians have noted how the gold standard influenced trade flows and how terms-of-trade shocks influenced the pace and pattern of economic development; however, to our

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[8]See Kaminsky et al. (1998) for a survey of empirical work on predictors of currency crises for the late 20th century. Tables A1 and A4 in Kaminsky et al. (1998) report that only one study considers export prices (Kamin, 1988). No studies cited in this survey consider the price of the principal exogenous export.

knowledge, this paper is the first to analyze and account for how trade shocks affected the durability of the gold standard on the periphery.[9] That said, our focus on shocks to a country's principal-export price is related to earlier work including Blattman et al. (2007), Williamson (2008) and Reinhart et al. (2016), and our contribution is to relate the effects of principal-export price shocks to currency risk. Further, the role of debt is related to the work of Bordo and Meissner (2006), which documents that an important share of public debt was denominated in domestic currency. The mechanism through which governments benefit from devaluation in our model works through the reduction of real payments of debt denominated in domestic currency but, more generally, it applies also to other sources of inflation-related revenues, including seigniorage and the reduction of real payments on nominal government contracts and wages.[10]

2   Model

This section derives a simple, long-run model of endogenous currency risk with flexible prices. Capital markets are assumed to be frictionless. All agents have perfect information and are risk neutral. All variables are measured in terms of the numeraire, gold, except where noted.

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[9]See López-Córdova and Meissner (2003), Estevadeordal et al. (2003), Flandreau and Maurel (2005), Mitchener and Weidenmier (2008) and Mitchener et al. (2010).

[10]See Burnside et al. (2001) and Burnside et al. (2006) for theoretical and empirical analysis of these alternative mechanisms in the late 1990s Asian Crisis.

2.1 Production and prices

Consider a small, open economy, producing an amount, y, of a tradable good with a price in terms of gold, P_t, that is exogenous to the economy and determined in international markets. For simplicity, we abstract from output fluctuations and focus on the dynamics of a single tradable good.[11] We further assume that PPP holds. The price of the tradable good fluctuates according to the following process:

$$dP_t = \mu P_t dt + \sigma P_t dZ_t, P_0 > 0, \tag{1}$$

where μ and σ represent constant mean and volatility of the commodity price growth rate, and Z_t is a wiener process. In other words, P_t follows a geometric Brownian motion with percentage drift μ and volatility σ.

2.2 Government

The government appropriates a constant fraction τ of tradable output as tax revenues and has a subjective discount factor given by ρ, which is also the risk-free rate. The expected discounted value of fiscal revenue from potential output at $t = 0$ is given by $\frac{\tau P_0 y}{\rho - \mu}$. We consider a government that issues debt at $t = 0$ to finance a public investment that generates a return of r_g per unit of time. The expected discounted benefit of issuing debt equals:

$$E\left[\int_0^\infty r_g e^{-\rho t} dt\right] = \frac{r_g}{\rho}. \tag{2}$$

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[11]More generally, we could have included other tradable goods at the expense of notational simplicity. In the model presentation, we will refer to output and exports interchangeably, but the crucial assumption for our results is that the price of tradable output, P_t, is exogenously determined in world markets, independently of whether it is ultimately traded. Similarly, we could have included non-tradable goods without changing any of the results.

We assume that the government issues long-term debt in the form of a perpetuity of amount D with debt service C, both denominated in local currency, and therefore nominal variables. This debt is not subject to default, but given that it is denominated in domestic currency, it is subject to currency risk. The debt service C is the only nominal rigidity in the model and plays an important role in the government's optimal policy, as we outline next.[12]

Let S_t represent the domestic price level. At $t = 0$, the government sets a rule whereby the amount of currency issued is directly tied to the numeraire good, gold. That is, the government promises to keep the domestic price level S_t equal to the international price level of 1, and implements a hard peg.[13] However, the government can not commit to this policy. In fact, there exists a threshold level of export prices, P^F, at which it is optimal for the government to devalue the currency, which happens at time $T^F = inf\left\{t \geq 0 | P_t \leq P^F\right\}$, when this international price first falls to P^F.

This policy is determined endogenously based on the trade-off between costs and benefits derived from leaving the hard peg. We assume that once the gov-

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[12]We focus our analysis on currency risk rather than country or political risk. In the empirical section of the paper, we argue that our measure of risk premia does not include sovereign risk. Although there is a large empirical literature indicating the existence of original sin (i.e., inability to issue foreign debt denominated in home currency), most economies in the late 19th century, including those on the periphery, funded part of their public debt by issuing long-term bonds in domestic currency in the home market, if not in London. Accominotti et al. (2011) reports that a substantial share of foreign public debt was denominated in domestic currency during this period, including in the 6 periphery countries in our sample for which they report data. According to the series "Share of foreign debt serviced in gold or gold currency (%)" from the Global Finance database, available at http://eh.net/database/global-finance/, the share of debt denominated in domestic currency in this period was 27% for Argentina, 80% for Austria-Hungary, 59% for Denmark, 31% for Greece, 73% for Italy, 49% for Russia.

[13]To simplify the analysis, we abstract from the monetary mechanism through which prices are set, which can be made explicit using a simple cash-in-advance model under PPP, where inflation rates are equal to exchange rate depreciation.

ernment leaves the hard peg, it devalues its currency and it does not return.[14]
The cost of devaluation is related to an increase in exchange-rate volatility and
transaction costs (Rose, 2011), which negatively affects trade and permanently
reduces taxable output by a fraction $\lambda \in [0, 1]$.[15] However, if the currency deval-
ues, the real value of the debt service goes down to $\frac{C}{S_t}$, where $S_t = S > 1$ is the
domestic price level after devaluation. This reduction in debt payments gives the
government the incentive to leave the peg and devalue the currency.

For simplicity, we assume the government runs a balanced budget. In par-
ticular, we assume that the government can raise lump-sum taxes or give back
transfers to the private sector (Ψ_t) such that it does not accumulate assets or issue
new debt over time:[16]

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[14]The assumption of lack of commitment follows Bordo and Kydland (1995). We abstract
from escape clauses as our export price shocks are arguably not indicative of the emergencies
discussed in Bordo and Kydland (1995), e.g., wars. Instead, we focus on the strategic and
irreversible decision of the government to abandon the peg. Together with the assumptions of
flexible export prices and purchasing power parity, this means that our mechanism is driven
by long-run considerations related to trade, and not short-term considerations associated with
competitive devaluations or currency wars. The assumption that the currency devalues after
leaving gold is motivated by the positive and persistent currency risk premia found for this
period by Mitchener and Weidenmier (2015).

[15]We assume that this permanent cost can not be avoided by fixing the currency at a new,
lower, value. Note that one common form of taxation during the gold standard era consisted of
import tariffs. In the model tax revenues fluctuate with export prices, not import prices. Under
the assumption of balanced trade, the value of imports is equal to the value of exports. More
generally, our assumptions capture that the government obtains tax revenues from economic
activity that depends on whether the country fixes its exchange rate, which are related to trade.

[16]Any payments in gold-denominated debt are included in Ψ_t. We focus on domestic currency
public debt since the government can not affect the real payments on gold-denominated debt
through devaluation. The assumption that the government has access to lump-sum taxes and
is running a balanced budget is done for simplicity and would not change the results in this
paper. Furthermore, it would be possible to add seigniorage revenues as an additional benefit
for the government from leaving the peg. More generally, this model captures that there are
some benefits to independent monetary policy that are not available under a peg, and that the
government faces a trade-off between these benefits and the output costs associated with leaving
the peg.

$$\dot{a}_t = \rho a_t + \tau P_t y + \Psi_t - C = 0, \text{under peg}, \tag{3}$$

$$\dot{a}_t = \rho a_t + \tau P_t y \left(1 - \lambda\right) + \Psi_t - \frac{C}{S} = 0, \text{following pegxit.} \tag{4}$$

Before providing the mathematical details to solve the model, we develop the intuition for our main result - that an exogenous decline in the price of exports increases the probability of leaving the peg and devaluing currency, while an increase in the price of exports leads to a decline in the probability of leaving the peg and devaluation. In other words, we show how exogenous output and fiscal-revenue shocks affect currency risk. The benefit of devaluation is that the government faces lower real domestic-currency debt payments. The cost is that abandoning a fixed exchange rate lowers taxable output. Optimal policy balances these two effects for a pre-determined amount of debt service, C, and a fixed devaluation following the abandonment of the peg. Nominal debt service and fixed devaluations play an important role in our model. Together, they imply that the benefit of abandoning a currency peg is independent from current export prices. This contrasts with the costs of leaving a peg which fluctuates with the international price of exports. As a consequence, if the government leaves the peg when the price of exports is high, it loses significant tax revenues and these costs do not compensate the fixed benefit from abandoning the peg. On the other hand, when the price of exports declines substantially, the cost of leaving the peg is small and is more than compensated by the fixed benefit associated with the reduction of real-debt payments. Finally, if export prices are subject to permanent shocks, then negative shocks to prices increase the probability of reaching the lower bound on prices such that the gov-

ernment abandons the peg. Therefore, negative shocks to export prices increase the probability that a country leaves the peg and devalues in the future, while the symmetric holds for positive shocks.

2.3 Pricing sovereign debt and currency risk premia

In this section we solve for the economy's currency risk premia. Using Ito's lemma, the value of public debt D satisfies:

$$\rho D = C + \mu P D_P + \frac{1}{2} \sigma^2 P^2 D_{PP}, \tag{5}$$

which in turn can be written as:

$$D(P) = A_0 + A_1 P + A_2 P^X, \tag{6}$$

where X is the negative root to the equation $\frac{\sigma^2}{2} X (X - 1) + \mu X - \rho = 0$ given by $X = \frac{1}{2} - \frac{\mu}{\sigma^2} - \sqrt{\left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right)^2 + \frac{2\rho}{\sigma^2}} < 0$.[17]

To determine the constants A_0, A_1 and A_2 we make use of boundary conditions. To obtain A_0 and A_1, note that when P goes to infinity, the country does not leave the peg and its domestic price level is fixed at 1. Therefore, the currency-risk premium is zero and the value of debt is just the discounted value of present value of real payments C:

$$lim D(P)_{P \to \infty} = \frac{C}{\rho}. \tag{7}$$

From this boundary condition we can see that $A_0 = \frac{C}{\rho}$ and $A_1 = 0$. When

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[17]See Leland (1994) or Shreve (2004).

the country abandons the peg, we assumed that the domestic price level jumps to $S > 1$, and that the country does not return to the peg. Then, the debt payments following a peg are permanently reduced in real terms to $\frac{C}{S}$, which implies that:

$$lim D\left(P\right)_{P \to P^F} = \frac{C}{\rho S}. \tag{8}$$

From these two boundary conditions we obtain that $A_2 = \frac{C}{\rho} \frac{1-S}{S} \left(P^F\right)^{-X}$. Using these results we can rewrite the value of the debt as:

$$
\begin{aligned}
D_t\left(P\right) &= E\left[\int_t^{T^F} C e^{-\rho(u-t)} du\right] + E\left[\int_{T^F}^{\infty} \frac{C}{S} e^{-\rho(u-t)} du\right] \\
&= \frac{C}{\rho}\left[1 - \frac{S-1}{S}\left(\frac{P_t}{P^F}\right)^X\right],
\end{aligned} \tag{9}
$$

where $E_t\left[e^{-\rho\left(T^F-t\right)}\right] = \left(\frac{P_t}{P^F}\right)^X$. The term $\frac{S-1}{S}\left(\frac{P_t}{P^F}\right)^X$ corresponds to the currency risk premium. The market value of debt denominated in domestic currency is then equal to a riskless perpetual bond, minus the currency risk premium associated with devaluation. Note that P^F is constant and does not depend on current macroeconomic conditions.

For a given C, the currency-risk spread is given by $CRS_t\left(P\right) = \frac{C}{D_t(P)} - \rho$:

$$CRS_t\left(P_t\right) = \rho\left[\frac{1}{1 - \frac{S-1}{S}\left(\frac{P_t}{P^F}\right)^X} - 1\right], \tag{10}$$

where $\frac{\partial CRS}{\partial P_t} < 0$. In words, lower international prices are associated with higher risk of a country leaving the currency peg and devaluing the currency, which is

reflected in risk-neutral risk premia.[18]

2.4 Decision to pegxit

In the previous section, we have priced domestically-denominated debt under the assumption that the government devalues its currency if export prices are too low. We now solve for the optimal decision when to devalue and, in particular, for the threshold level of international prices that induces a "pegxit". First, note that the sovereign government's wealth can be written as:

$$
W_t(P) = E\left[\int_t^\infty \tau P_t y e^{-\rho(u-t)} du\right] - D_t(P) +
$$
$$
E\left[\int_t^\infty r_g D_t(P_t) e^{-\rho(u-t)} du\right] - E\left[\int_{T^F}^\infty \lambda \tau y P_t e^{-\rho(u-t)} du\right]
$$
$$
= \tau \frac{P_t y}{\rho - \mu} - \frac{\tau \lambda y P^F}{\rho - \mu}\left(\frac{P_t}{P^F}\right)^X + \frac{C}{\rho}\left(\frac{r_g}{\rho} - 1\right)\left[1 - \frac{S-1}{S}\left(\frac{P_t}{P^F}\right)^X\right], \quad (11)
$$

where $E_t\left[\int_{T^F}^\infty P_t e^{-\rho(u-t)} du\right] = E_t\left[P^F e^{-\rho(T^F - t)}\right] = P^F\left(\frac{P_t}{P^F}\right)^X$.

We assume that the government wishes to maximize its wealth. Government wealth depends positively on tax revenues, the public investment returns, the reduction in debt payments from devaluation, and negatively on the costs of devaluation and debt payments. The pegxit policy will be defined by a boundary level for the international price such that the government devalues the currency. Taking first-order conditions of wealth with respect to the international price, we

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[18]Given that $X = \frac{1}{2} - \frac{\mu}{\sigma^2} - \sqrt{\left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right)^2 + \frac{2\rho}{\sigma^2}} < 0$, we can see that $\frac{\partial X}{\partial \mu} < 0$ and $\frac{\partial X}{\partial \sigma} > 0$. Furthermore, $\frac{\partial CRS}{\partial X} > 0$. Therefore, the higher the volatility of the international price, the larger the spread and the lower the growth rate of the international price, the lower the currency risk.

obtain:

$$\frac{\partial W}{\partial P} = \tau \frac{y}{\rho - \mu} - \frac{X\tau\lambda y}{\rho - \mu} \left(\frac{P_t}{P^F}\right)^{X-1} - \frac{C}{\rho} \frac{S-1}{S} \left(\frac{r_g}{\rho} - 1\right) \frac{X}{P^F} \left(\frac{P_t}{P^F}\right)^{X-1}. \quad (12)$$

Using the smooth-pasting condition:

$$\frac{\partial W}{\partial P}_{P=P^F} = \frac{\tau y}{\rho - \mu} (1 - \lambda), {}^{19} \quad (13)$$

we obtain:

$$P^F = C \frac{\frac{S-1}{S} \left(\frac{r_g}{\rho} - 1\right) X (\rho - \mu)}{\lambda \tau y \rho (1 - X)}. \quad (14)$$

Note that the export-price lower bound before a country floats its currency, P^F, depends only on parameters.[20] Figure 1 shows that P^F depends positively on the risk free rate, ρ, and the currency devaluation, S. P^F depends negatively on the return to public debt, r_g, the tax rate, τ, the growth rate of export prices, μ, the volatility of the export price, σ and the output cost after leaving the peg, λ. Intuitively, anything that makes the post-devaluation worse, for example, higher output costs, is associated with lower P^F and a lower probability of pegxit. Anything that improves the government's situation following devaluation, for example, a higher devaluation rate S, increases P^F, and implies a higher probability of pegxit.

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[19]This condition ensures continuity in the value of wealth at the time of pegxit.

[20]We take the coupon, C, and debt level, D, as given for simplicity, but we can easily solve for the country's debt capacity and coupon by maximizing the wealth of the country gross of the market value of debt.
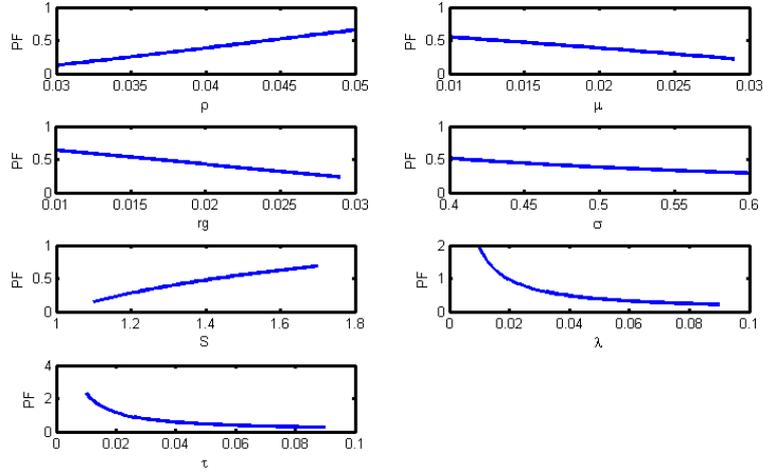
Figure 1: Comparative Statics for export-price lower bound: ρ is risk free rate, r_g is return on public spending financed with debt, S is post-float currency devaluation, τ is tax rate, μ is the growth rate in principal-commodity price, σ is volatility of principal-commodity price and λ is the reduction in exports after devaluation.

3   Empirical Analysis

We turn now to testing empirically whether export prices have a causal impact on currency risk, using structural and reduced-form models.

3.1   Data and empirical strategy

We employ a new high-frequency data set, from the classical gold standard period, to study the impact of international-price fluctuations on currency risk. We use weekly data on short-term interest rates to obtain monthly currency risk spreads as in Mitchener and Weidenmier (2015). Currency risk spreads are defined as a country's short-term open market or bank rate, denominated in domestic currency, minus the short-term gold denominated domestic UK trade bill. These three-month, prime-quality trade bills are very liquid and not subject to default

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risk.[21] We combine these data with newly collected monthly data on the prices of internationally-traded goods from *the Economist*, as well as with information on the principal exports and imports for each of the countries in our sample.[22]

To identify the principal exports for each economy, we computed export weights from data gathered by the British Board of Trade (various years), Jacobson (1909), Mitchell (1982), Mitchell (2007a), and Mitchell (2007b). The first two publications provide detailed information on exports and imports by product for most of the countries in our sample between 1870 and 1909. Appendix B provides detailed information on the sources and the method used to determine the principal export for each country.[23]

The sample includes 21 economies and 8901 country-month observations spanning January 1870 - December 1913. Table 1 summarizes the data while Table 2 reports the three principal exports of each country, with the goods rank-ordered by their export share. As is common for the literature on the gold standard, Table 2 also denotes whether an economy is designated as part of the "core" or the "periphery". Following Bordo and Flandreau (2003), we use a country's capital importer/exporter status and its standard of living (measured by GDP/capita) to assign countries to one of these two groups.

Empirically testing the effects of international price shocks on currency risk requires some further consideration of some of the model assumptions, in particular,

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[21]See Neal and Weidenmier (2003) and Mitchener and Weidenmier (2015) for further details on the data.

[22]We use end of the month observations for all variables. To maximize coverage, when the end of the month observation is missing for currency risk we opt to use the first weekly observation of the following month (769 observations). If that is also not available, we use the average of the current month (13 observations). Argentina (190 observations), Greece (294 observations) and Japan (268 observations) account for most of these instances.

[23]Although one of our economies is a colony (India), and another a Grand-Duchy (Finland), we will use the words country and economy interchangeably to facilitate exposition.

Variable	Obs	Mean	Std. Dev.	Min	Max
Month-year	8901			1870m1	1913m12
Currency risk	8901	1.96%	2.18%	-3.12%	13%
Export-Price index	8901	92.6	24.3	44.4	211.2
Export-Price index yearly growth rate	8748	1.07%	14.7%	-50%	150%

Table 1: Summary Statistics for monthly data

as they relate to what is exported and who exports it. First, there is substantial variation in the principal export in different countries, but some exports are manufactured goods and not commodities. Second, commodities are more important for countries in the periphery. Economies in the core have more diversified production structures, including substantial shares of manufactures or semi-manufactures. These two facts suggest that the proposed mechanism identified in the model may operate more strongly in the periphery. Exogeneity of export-price movements is also more plausible in the periphery since specialization is largely determined by endowments, and these are in turn driven by exogenous factors such as climate and geography. To account for this heterogeneity, we allow estimated coefficients to differ across the core and the periphery in our empirical specifications. Finally, note that a few countries had near monopolies in the production of some goods.[24]

The mechanism highlighted in the theoretical model works through exogenous income shocks together with the existence of some domestic-currency denominated debt. In this section we use export-price data and currency risk to test the model with structural and reduced-form specifications that are theoretically grounded. In

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[24]Two noteworthy cases are Chile for nitrate and the Netherlands for quinine (Peruvian bark grown in Java.). We do not have monthly prices for Peruvian bark, and use the Netherlands' second largest export instead. Note that the Netherlands pose an additional challenge related to the fact that most of their exports are also imports going through its harbors. We address the issue of monopoly power and re-exporting in a specification where we replace nitrate with copper for Chile, and where we drop the Netherlands from our sample of countries.

Country	Principal Exports	Max (%)	Average (%)	Core	Periphery
Argentina	**Wool**, Wheat, Beef	50	33		X
Austria-Hungary	**Timber**, Sugar, Flour	23	11		X
Belgium	**Flour**, Coal, Iron	15	9	X	
Bulgaria	**Wheat**, Barley, Animals	82	59		X
Chile	**Nitrate**, Copper, Coal	81	74		X
Denmark	**Butter**, Flour, Beef	65	35		X
Finland	**Timber**, Tar, Pitch		46		X
France	**Wool mf.**, Silk mf., Cotton mf.	15	11	X	
Germany	**Iron prod.**, Wool mf., Flour	15	12	X	
Greece	**Iron**, Olive oil, lead	30	22		X
India	**Cotton**, Rice, Tea	49	28		X
Italy	**Silk**, Olive oil, Hemp	49	40		X
Japan	**Silk**, Tea, Rice	60	47		X
Mexico	**Silver**, Coffee, Copper	84	50		X
Netherlands	Drugs, **Flour**, Iron prod.	22	11	X	
Norway	**Timber**, Iron, Oats	52	37		X
Romania	**Wheat**, Barley, Flax	59	44		X
Russia	**Wheat**, Flax, Barley	31	26		X
Sweden	**Timber**, Iron, Oats	49	45		X
Switzerland	**Cotton mf.**, Silk, Timber	24	20	X	
USA	**Cotton**, Wheat, Beef	34	29	X	

Table 2: Table of countries and principal exports, rank-ordered by share of an economy's total exports. Max (%) represents maximum share of principal-export weight between 1880 - 1913; average (%) represents average share of the principal export for the period with available data; mf. stands for manufactures. Principal exports used in baseline regression specifications are identified in bold. For some economies the price of the principal export is not available at a monthly level. Appendix B reports all the sources and methods used to determine the principal exogenous exports and price series. A country is defined as part of the core if it had an average real GDP per capita equal or larger than 2500 international GK 1990 dollars between 1870 - 1913 (data from the Maddison Project, 2013 version), and is a capital exporter (the exception to this rule is the USA, which was a capital importer until 1900. Denmark and Argentina both exceed the income threshold but are capital importers for most of our sample.).

section 4 we show suggestive evidence of the underlying mechanism, in particular how international prices affect currency risk through real GDP.

To illustrate how currency risk and export prices are related, Figure 2 plots currency risk (solid line) against the growth rate in the price of Chile's principal exports, nitrate (dashed line) and copper (dotted line). Consistent with the model, we can see from this figure that Chile's currency risk is negatively correlated with the growth rate of the international price of copper: the correlation coefficient is -0.17 and significantly different from zero at the 1% level.[25] Turning to our sample of 21 economies, the correlation between currency risk and the yearly growth rate in the price of the principal export is -0.05 and significantly different from zero at the 1% level. The correlation between currency risk and the price of the second main export is -0.04 and significantly different from zero at the 1% level.

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[25]Although copper is not Chile's principal export, it is more exogenous than Chile's most important commodity export at the time, nitrate. The unconditional correlation coefficient between currency risk and the growth rate of the price of nitrate is 0.02, and not significantly different from zero between 1870 and 1913.
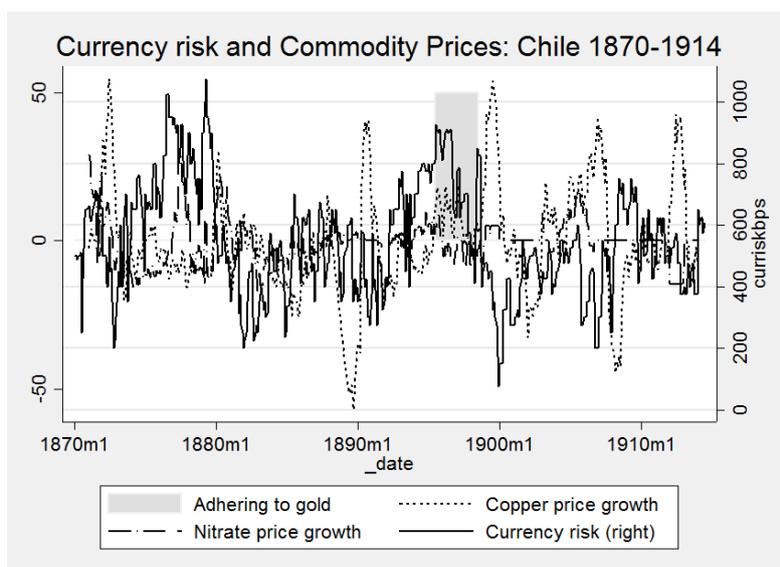
Figure 2: Currency risk (solid line on right axis) and yearly export-price growth rate for copper (dotted line on left axis) and nitrate (dashed line on left axis) for Chile.

Chile's abandonment of gold in the 1890s, one of the few exits from a hard peg during the classical gold standard era, shows how negative export-price shocks contribute to the breaking of a peg and how this is captured by measured currency risk. Chile had rejoined the gold standard on June 1, 1895, only to abandon it three years later in July 1898. In this period, Chile suffered a number of negative shocks, including a border dispute with Argentina that resulted in an arms race and an increased defense budget; however, Collier and Sater (1996) stress the role of export-price shocks in making a bad situation worse.
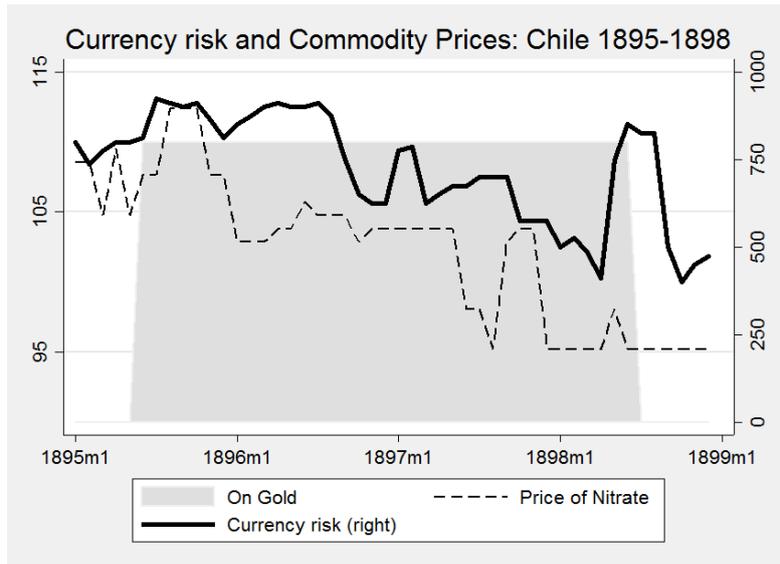
Figure 3: Currency risk (solid line on right axis, measured in basis points), Nitrate price index (dashed line on left axis, average 1913 = 100). Adherence to gold (shaded area) is also plotted.

Figure 3 plots our measure of currency risk (solid line) together with the price index for nitrate, Chile's most important export by value. Chile's adherence to the gold standard is also plotted. Between June 1895 and July 1898, we can see that the price of nitrate fell by 11.5%. The price of copper, Chile's second most important export, also decreased 3% between May 1898 and July 1898. Unsurprisingly, currency risk peaked just as Chile abandoned gold, while its exchange rate devalued from 13.64 pesos per pound between 1897-1898 to 16.55 pesos per pound in 1899.

3.2 Structural analysis

In this section we investigate if currency risk is related to the price of exports using a specification derived directly from our theoretical model. Our model es-

tablished that, everything else equal, permanent, negative price shocks increase currency risk, while permanent, positive price shocks decrease currency risk. The structural specification can be obtained by taking a first-order Taylor approximation of equation (10):

$$CRS_t(P_t) = \frac{\rho \frac{S-1}{S} \left(\frac{P_t}{P^F}\right)^X}{1 - \frac{S-1}{S} \left(\frac{P_t}{P^F}\right)^X} \approx \rho \frac{S-1}{S} \left(\frac{P_t}{P^F}\right)^X, \tag{15}$$

when CRS is relatively small.[26] This equation can then be estimated for each country using non-linear least squares:

$$CRS_t = \alpha P_t^X + \epsilon_t, \tag{16}$$

where t stands for month-year, $\alpha = \rho \frac{S-1}{S} \left(P^F\right)^{-X}$ and, according to the theoretical model, $X < 0$.[27]

In our baseline specifications, we report results using the raw data instead of extracting permanent components of prices. In our theoretical model we assume that the export-price growth rate follows a random walk, and all shocks are permanent. Using the raw data is conservative in the sense that any bias goes against finding a relationship between export prices and currency risk. Moreover, it is relatively more transparent than transforming the data.

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[26]We opt for the first order approximation instead of estimating equation (10) directly due to the discontinuity in this equation when the denominator approaches zero.

[27]In the model we assumed that after a country leaves the peg, its currency devalues. For some countries measured currency risk is occasionally slightly negative which in the model would be consistent with an expected appreciation of the currency following an exit. In other words, our coefficient α would change sign. This coefficient instability poses a challenge for our estimation in countries with a higher proportion of negative currency risk. Countries in our core are more likely to experience negative currency risk: France (282 observations), Belgium (213), Netherlands (210), Germany (194). Countries with 51-100 observations of negative currency risk: Switzerland, Norway, Austria-Hungary, United States and Denmark; Countries with 1-50 observations of negative currency risk: Finland, India, Italy, Romania, Russia, Sweden.

Table 3 collects the estimated parameter X for each country, together with its robust standard error. Countries are rank-ordered by the magnitude of this coefficient, which according to the model, should be smaller than zero. We can see that for most countries in our sample, and especially for those located in the periphery, this coefficient is indeed smaller than zero and statistically different from zero.[28]

Country	X coefficient	Robust Standard Error	Core
France	3.33***	0.45	X
USA	0.78***	0.30	X
Bulgaria	0.21***	0.08	
Italy	0.11	0.27	
Chile	0.02	0.10	
Russia	0.01	0.10	
Mexico	-0.09	0.33	
Netherlands	-0.12	1.53	X
Belgium	-0.24	1.49	X
Germany	-0.46	0.72	X
Norway	-0.55***	0.20	
Denmark	-0.74***	0.26	
Finland	-0.76***	0.19	
Japan	-0.96***	0.15	
Sweden	-1.04***	0.18	
Argentina	-1.32***	0.06	
Romania	-1.40***	0.12	
Greece	-1.45***	0.10	
India	-1.68***	0.36	
Austria-Hungary	-1.94***	0.26	
Switzerland	-2.65***	0.46	X

Table 3: Country-by-country regression of CRS_t on the principal-export price using non-linear least squares as defined in equation (16). Coefficient α not reported. *** p<0.01, ** p<0.05, * p<0.1.

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[28]The coefficient X for France stands out as a clear outlier. Most of France's currency risk observations are of negative currency risk. Performing a sample split for France on this dimension, we obtain that this coefficient is 0.08 for positive currency risk observations (115), and 0.7 for negative currency risk observations (282). Estimated α coefficients are positive throughout, with the exception of France, when currency risk is negative, and Belgium.

Although this exercise confirms a crucial result from the model, it does not take into account omitted variables affecting all countries simultaneously, or whether having a formal commitment to gold plays a role. To investigate these issues, we obtain a linear specification by applying logs to both sides of equation (15):

$$log\left(CRS_{c,t}\right) \approx log\left(\rho\right) + log\left(\frac{S_c - 1}{S_c}\right) + X_c log\left(P_{c,t}\right) - X_c log\left(P_c^F\right), \qquad (17)$$

where c corresponds to country, t stands for month-year, ρ is the risk free rate, $\frac{S_c-1}{S_c}$ captures country-specific devaluation following the peg, $P_{c,t}$ captures the price of the main export and P_c^F captures the country-specific price of exports at which the government floats the currency. Assuming that ρ, X and P^F are time-invariant, as in the model, this equation can be estimated on our full panel of countries as:

$$log\left(CRS_{c,t}\right) = \alpha + \gamma_c + \beta log\left(P_{c,t}\right) + \epsilon_{c,t}, \qquad (18)$$

where the country fixed effect γ_c captures all the time-invariant country and product-specific factors.[29]

For some countries, in particular those in the core, measured currency risk is occasionally slightly negative. Applying logs would yield in a number of missing observations (1677 of 8901). Thus, in our main structural panel specification, we follow Burbidge et al. (1988) and take the inverse hyperbolic sine of currency risk:

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[29]Note that the model implies that our slopes β are country specific. Wooldridge (2005) shows that traditional country fixed-effects methods can be used to estimate the population-averaged β, even if slopes are country-specific and correlated with covariates.

$$H(CRS_{c,t}) = \frac{log\left[\theta CRS_{c,t} + \left(\theta^2 CRS_{c,t}^2 + 1\right)^{0.5}\right]}{\theta}, \qquad (19)$$

where $\theta = 1$.[30] Unlike the log, this transformed variable is also defined at zero and at negative values. With the exception of values close to zero, it is approximately equal to $log\left(2CRS_{c,t}\right)$ and can be interpreted similarly as the log. Alternative ways of dealing with negative observations, such as, adding a constant to the currency risk premia so that it is always positive, or truncating the data to observations for which currency risk is greater than zero, both yield similar estimates, as we report below.

Table 4 collects the results of estimating the specification given by equation (18). All regressions include year fixed effects, country fixed effects and standard errors clustered at the country level, except when noted. Column (1) of Table 4 shows the coefficients of the regression of currency risk on export prices, when we absorb exclusively time-invariant country fixed effects. Looking at column (1) of Table 4, we can see that, on average, when a country's principal-export price decreases by 10%, currency risk rises by 5.6%. This effect is significantly different from zero at the 1% level, but reduced in magnitude when controlling for year fixed effects, as shown in column (2).[31]

Specifications in columns (3)-(6) include country fixed effects and year fixed effects and allow the β coefficient to differ depending on whether an economy is part of the core or periphery. As noted above, this latter distinction is potentially important because the peripheral countries have less diversified production struc-

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[30]θ is a dampening parameter and results are robust to using alternative values for θ. See Carroll et al. (2003) for an application in the household finance literature and further discussion.

[31]We obtain effects of similar magnitude if we censor observations to be positive (5%), or if we add a constant to all currency risk spreads, such that they are always positive (2.6%).

tures and are also more likely to be price-takers in world markets. Column (3) shows coefficients for the interaction between the price of the principal export and a dummy variable that takes the value of 1 if the country is in the core, and zero otherwise, such that the coefficient on the export price alone captures our coefficient of interest for the periphery. As expected, this coefficient is negative for the periphery but not for the core countries. In particular, we find that a 10% decrease in the price index of the principal export in the periphery causes an increase of 2.8% in currency risk spreads.

Since our model examines currency risk from the perspective of abandoning a peg, column (4) explicitly takes this into account by interacting export prices with a dummy variable capturing the period when a country was adhering to the gold standard.[32] For the periphery, it is possible to see that formally pegging to gold makes the causal impact of prices stronger, as the coefficient β is further reduced. In columns (5) and (6), we perform our regression on two sub-samples, in and out of gold. We can see that the effect for peripheral countries is of similar magnitude across samples.

Our theoretical model highlights the role of export-price shocks in determining currency risk, and the corresponding empirical estimates confirm the main prediction of the model. That said, currency traders of the late 19th century may have factored in other country-specific, time-varying factors when assessing the durability of gold standard pegs that are not captured in the empirical estimates of the structural model. Furthermore, the structural estimation assumes that export

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[32]If there are some benefits to smoothing exchange rates a similar mechanism to the one we modeled may also operate outside of a formal currency peg. In particular, note that countries can shadow the gold standard even if they do not explicitly adopt it. Dates of gold-standard adherence are collected in Table 12.

	(1)	(2)	(3)	(4)	(5) On Gold	(6) Not on Gold
Export price	-0.56***	-0.12	-0.28*	-0.27	-0.30	-0.32*
	(0.16)	(0.14)	(0.15)	(0.19)	(0.18)	(0.16)
Export price x Core			0.66**	1.50***	0.74**	1.36***
			(0.27)	(0.26)	(0.29)	(0.35)
Gold				0.27		
				(0.68)		
Export price x Gold				-0.03		
				(0.16)		
Core x Gold				3.85***		
				(1.27)		
Export price x Core x Gold				-0.84***		
				(0.28)		
Year fixed effects		X	X	X	X	X
Constant	3.60***	0.94	0.83	-0.32	0.62	2.49***
	(0.72)	(0.81)	(0.82)	(1.01)	(0.78)	(0.78)
Observations	8,901	8,901	8,901	8,901	5,926	2,975
Adjusted R-squared	0.024	0.21	0.22	0.22	0.22	0.25
Number of countries	21	21	21	21	21	16

Table 4: Regression of $H(CRS_{c,t})$ on the log of principal-export price, where $H(CRS_{c,t})$ is defined in equation (19). Core takes on a value of 1 for the core countries, zero otherwise. Gold takes on a value of 1 if the country has a formal gold commitment in place, zero otherwise. x represents interaction. All regressions include country-fixed effects. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors in parentheses clustered at the country level.

price shocks are permanent, which may not necessarily be the case. To investigate these issues further, in the next subsection we explore a reduced-form empirical approach to study the relationship between export prices and currency risk.

3.3 Reduced-form analysis

Our reduced form empirical model can be specified according to the following equation:

$$CRS_{c,t} = \alpha + \phi_t + \mu_c + \beta X_{c,t} + \gamma Z_{c,t} + \epsilon_{c,t}, \tag{20}$$

where $CRS_{c,t}$ represents currency risk spreads, c corresponds to country, t stands for month-year, ϕ_t captures time fixed effects, μ_c summarizes country fixed effects, $X_{c,t}$ refers to measures of the price of the principal export, and finally $Z_{c,t}$ contains country controls that vary monthly or annually. We test if β is less than zero, which according to the model, would suggest a negative relationship between export prices and currency risk. In our baseline specification, we begin by examining the annual movements in currency risk and export prices and regress currency risk on the annual growth rate in the price of the principal export.[33]

Table 5 reports the coefficients of regressions of average currency risk at year y (measured in basis points) on the annual growth rate of the average export price in the same year y and measured in percentage points. Column (1) shows that the average effect across countries is negative but small, and not statistically different

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[33]The yearly growth rate of export prices has been used in applied research that explores variation from exogenous commodity prices (Bazzi and Blattman, 2014; Caselli and Tesei, 2016). Furthermore, it makes less restrictive assumptions on the permanent nature of export price shocks. One-month fluctuations in the level of export prices may not be sufficient to affect currency risk in the market, perhaps because they are the consequence of other temporary shocks; one-year growth rates are more likely to capture permanent changes in prices.

from zero. On the other hand, once we introduce the core-periphery distinction in our sample, column (2) shows that a 10 percentage point decrease in the growth rate of the price of the principal export of a country in the periphery is associated with an increase of average currency risk of about 10 basis points.[34] This effect is also present when we consider one-year lagged growth in prices as in columns (3)-(4). In column (5), instead of distinguishing core and periphery using dummy variables, we multiply the growth rate of export prices with the country-specific average share for the principal export as described in Table 2. Conditioning the effect on the share of exports magnifies the response of currency risk to export-price shocks in periphery countries, where the principal export accounts for a larger share of total exports, and increases the magnitude of the estimated coefficient β.

Although there are reasons one might prefer the annual estimates, Table 6 reports on similar specifications, but using changes in monthly prices of principal exports. We regress the level of currency risk on the one year percent change in prices, both measured at the end of the month. As shown in columns (1) and (2), the coefficient of interest for the periphery remains negative and statistically different from zero at least at the 10% level. As discussed above, we are also interested on whether the mechanism is stronger with or without a currency peg. In column (3), we allow for interactions between gold, core and the price of export. For the periphery, it is possible to see that adhering to gold increases the causal impact of prices on currency risk since the coefficient on export prices interacted

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[34]If we do not control for year fixed effects, the effect size is even larger, up to 24 basis points following a 10 percentage point decrease in the growth rate of the principal-export price. Note that our measure of currency risk is relative to the UK short-term open market rate, such that any common shocks affecting the UK and the countries in our sample are already captured without year fixed effects. In this context, year fixed effects capture any common shocks to all countries, except the UK.

	(1)	(2)	(3)	(4)	(5)
Export-price growth rate	-0.33	-0.96***		-1.04***	
	(0.32)	(0.30)		(0.30)	
Export-price growth rate x Core		1.83***		1.91***	
		(0.50)		(0.51)	
Export-price growth rate$_{y-1}$			-0.85**	-0.86**	
			(0.32)	(0.32)	
Export-price growth rate$_{y-1}$ x Core			1.07**	1.03**	
			(0.51)	(0.47)	
Export-price growth rate x export-share					-2.21**
					(0.78)
Year fixed effects	X	X	X	X	X
Constant	106.59***	98.90***	353.65***	358.48***	105.81***
	(31.86)	(31.74)	(33.74)	(32.89)	(32.12)
Observations	741	741	729	729	741
Adjusted R-squared	0.44	0.45	0.45	0.46	0.45
Number of countries	21	21	21	21	21

Table 5: Regression of average currency risk at year y (measured in basis points) on the annual growth rate of the average export price at year y. All regressions include country fixed effects. Core takes on a value of 1 for the core countries, zero otherwise. x represents interaction. Country-specific average export share reported in Table 2. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors in parentheses clustered at the country level.

with gold is also negative. Summing the coefficients for export-price growth rate and export-price growth rate interacted with gold in the periphery, we obtain a coefficient of -0.68, which is significantly different from zero at the 1% level according to a joint significance test. This coefficient implies that, on average, a one standard deviation in the yearly growth rate of the price of the principal export (14.7%), increases currency risk in the periphery, while adhering to gold, by about 10 basis points. In columns (4) and (5), we alternatively examine the sub-samples in and out of gold. They show that the effect of export prices is stronger when peripheral countries formally adhere to gold.

3.4   Discussion

Our empirical analysis suggests a causal mechanism through which exogenous fluctuations of export prices affect currency risk. Our identifying assumptions are that: (i) countries specialize in different products due to pre-determined factor endowments and (ii) the prices of these products are determined in world markets and therefore exogenous to price-taking countries.

Although we find statistically significant estimates, the quantitative impact of export price changes on currency risk are relatively small. However, given our estimation strategy, this is not surprising for two reasons. First, our results capture the effect of the principal export on currency risk, but countries often export a range of products, and their relative importance can change over time. Since we hold the principal export fixed for every country in our sample, our estimates likely understate the the "true" effect.[35] Second, we are not attempting to explain the

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[35]For example, as discussed in appendix B, although butter is the main export for Denmark in our full sample, before 1890 flour represented a larger share of Danish exports.

	(1)	(2)	(3)	(4)	(5)
				On Gold	Not on Gold
Export-price growth rate	-0.80**	-0.44*	-0.19	-0.54***	-0.08
	(0.38)	(0.24)	(0.40)	(0.19)	(0.41)
Export-price growth rate x Core	0.52	1.03**	0.78	1.05***	0.31
	(0.44)	(0.39)	(0.63)	(0.34)	(0.72)
Gold			-1.68		
			(21.31)		
Export-price growth rate x Gold			-0.49		
			(0.38)		
Core x Gold			22.98		
			(31.15)		
Export-price growth rate x Core x Gold			0.48		
			(0.56)		
Year fixed effects		X	X	X	X
Constant	197.20***	88.18***	81.05***	114.27***	326.71***
	(0.31)	(26.96)	(26.44)	(3.75)	(10.22)
Observations	8,748	8,748	8,748	5,878	2,870
Adjusted R-squared	0.01	0.27	0.27	0.23	0.31
Number of countries	21	21	21	21	16

Table 6: Regression of the level of currency risk (measured in basis points) on the yearly growth rate of the principal-export monthly price. Core takes on a value of 1 for the core countries, zero otherwise. Gold takes on a value of 1 if the country has a formal gold commitment in place, zero otherwise. x represents interaction. All regressions include country-fixed effects. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses clustered at the country level.

cross-sectional variation of currency risk, which depends, among other things, on the constant mean and volatility of the export-price series, but instead identify the causal impact of realized export prices. We take a conservative approach that controls for country and year fixed effects together with standard errors clustered at the country level, and find that the principal-export price has a causal impact on currency risk, particularly for the periphery, as well as when countries formally adhered to gold.

4 Extensions and robustness

In this section, we present suggestive empirical evidence on the operation of the mechanism in the model, extend our empirical analysis to consider the boom-bust nature of commodity prices, and report on a battery of robustness checks, including investigating the role of lagged effects and monthly growth rates as well as additional country-specific covariates.

4.1 Inspecting the mechanism in the model

In the model, we show that negative shocks to the price of principal exports have several consequences. They decrease the value of output, which puts fiscal pressure on the government in the form of reduced revenues, and they raise the probability that the government turns to revenues that are inconsistent with the peg (eg., lower real debt-service payments, seigniorage), thereby increasing currency risk. The model permits us to derive structural and reduced-form estimates that, together with the exogeneity of export prices (i.e., determined in world markets), allows us to establish a causal relationship between export prices and

currency risk. The empirical results in the previous section show that this causal relationship is negative and statistically significant.

To shed some additional light on the model's underlying mechanism, this section investigates how export-price shocks affect currency risk through output. In the model, tax revenues are determined by output, which in the presence of nominal debt, leads to changes in expected policy that translate into currency risk. To implement this empirically, we focus on output rather than revenue since this variable provides a more general representation of the mechanism and since it can be taken to the data with minimal additional assumptions. That is, changes in output due to export price shocks are likely to affect revenues, but they may also induce a wide array of additional policy responses including changes to taxation and expected inflation - outcome variables that are significantly more difficult to estimate.[36] Therefore, we focus our attention on how exogenous export price shocks determine output and how output affects currency risk.

To do so, we present two-stage least squares (2SLS) estimates, where the first stage explores the relationship between export prices and output and the second stage examines the relationship between output (GDP) and the currency risk spread. To be clear, we are using the exogeneity of export prices to iden-

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[36]For example, government revenues may respond endogenously to a negative price shock as the government increases taxes in order to keep total revenue from decreasing. This shock would still increase the likelihood of abandoning the gold standard since the government may be more likely to raise revenues through inflation in the future due to both fiscal and political pressures. On the role of debt, although we highlight the domestic-currency denominated debt, other, potentially omitted, sources of inflation-related revenues, such as seigniorage and the reduction of real payments on nominal government contracts (e.g., public wages), would yield similar results. Furthermore, it is the interaction between these two factors that drives the mechanism, which further complicates the analysis. Although interesting, obtaining exogenous variation related to tax revenues or nominal debt, and their relationship to future policy decisions, would require additional empirical assumptions together with detailed new data, which is beyond the scope of this paper.

tify whether their variation causally influences output, and this in turn induces changes in currency risk spreads. Ideally, we would employ output data at the monthly or quarterly frequency so we could exploit the full variation of our new commodity price data set, but country-level estimates for 19th century GDP are only available annually, so these estimates are thus estimated at that frequency.[37] All estimates include country fixed effects, year fixed effects and standard errors clustered at the country level.

Panel A of Table 7 reports first-stage OLS estimates of the effect of export-price growth rates, times the export-share, on GDP growth rates.[38] Column (1) reports results for all countries and years. Column (2) focuses only on countries in the periphery while column (3) restricts the analysis for periods for which countries in the periphery adhered to the gold standard. The estimated coefficients are positive and different from zero at least at the 5% statistical significance level, and suggest that export prices determine GDP growth rates. These findings are consistent with our formulation of export-price fluctuations as shocks to the value of output.

In panel B we explore this channel further and report the second-stage results, where we instrument GDP growth rates with export-price growth rates times the export-share of the principal export. The estimated 2SLS coefficients are negative

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[37]We obtain annual real per capita GDP from *Barro-Ursua Macroeconomic Data* (2010), and complement it with data from Maddison (2013) and Pisha et al. (2015). We use per capita nominal GDP for Romania due to data limitations, however results are robust to removing Romania from the analysis.

[38]We follow Brückner et al. (2012) and use $\widetilde{X}_{c,t} = s_c \times X_{c,t}$ as a measure of the price shock, where s_c is the country-specific average export-share of the principal export in our data, and $X_{c,t}$ is the principal export price growth rate. Using export-price growth rates, without taking into account the export share, yields similar results but lower first-stage F-statistics.

	(1)	(2)	(3)
Panel A: First-stage estimates			
Export-price growth rate x export-share	0.13**	0.17***	0.22**
	(0.06)	(0.06)	(0.09)
First-Stage F-statistic	5.8	9.2	6.5
Panel B: 2SLS estimates			
Instrument: export-price growth rate x export-share			
GDP growth rate	-15.75*	-14.04**	-8.39**
	(8.14)	(5.60)	(4.19)
Only periphery		X	X
Adhering to Gold Standard			X
Observations	767	521	298
Number of countries	21	15	15

Table 7: Panel A: Regression of real GDP per capita growth rate at year y on the annual growth rate of the average export price times the export-share. Panel B reports 2SLS estimates of the effect of export-prices on currency risk through GDP growth rates. All regressions include country fixed effects and year fixed effects. Definition of core and periphery, as well as country-specific average export shares reported in Table 2. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses clustered at the country level.

and different from zero at standard levels of statistical significance.[39] In particular, we find that a one-percentage point (exogenous) increase in GDP growth rates reduces currency risk by 8 to 16 basis points. These estimates show that GDP growth caused by export-prices reduces currency risk, a result that is again consistent with the mechanism in the model through which exogenous output shocks affect currency risk.

4.2   Booms and busts

We follow the methodology in Jacks (2013) and identify whether a particular export is experiencing a price boom or bust using the Christiano and Fitzgerald (2003) band-pass filter. We decompose the time-series of export prices to extract the cyclical component and create monthly dummies to capture booms and busts in export prices.[40] Table 8 collects the results for peripheral countries under the gold standard and shows that export-price booms are associated with decreases in currency risk while export-price busts are associated with increases in currency risk. These coefficients are larger than our baseline results, but in our regression with standard errors clustered at the country level, not very precisely estimated.[41] Column (3) allows for the interaction of booms or busts in the two main exports. It shows that simultaneous busts in the prices of the two most important exports

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[39]The implicit exclusion restriction is that international prices affect currency risk exclusively through per capita GDP. One potential issue with the estimates of panel B is that the first stage F-statistic is relatively small. This is partly due to the fact that we are unable to assemble higher-frequency GDP data for this period and thus can not exploit the full variation in export prices contained in our database as we do in the earlier empirical sections of the paper.

[40]We look at deviations from the medium-run cycle in logged prices for export, subtract sample mean of deviations and divide by their standard deviations, to obtain a standardized measure of short-run deviations. A boom is identified as a deviation that is above the threshold of the 10 % tail of a normal distribution, a bust has a symmetric definition.

[41]Coefficients for the core countries are small and not statistically different from zero.

	(1)	(2)	(3)
Principal-export price boom	-6.28	-12.92	-10.03
	(17.87)	(14.30)	(14.40)
Second-export price boom		-19.19	-16.06
		(26.16)	(30.24)
Principal-export price boom x Second-export price boom			-17.74
			(36.34)
Principal-export price bust	23.19**	22.67*	8.96
	(10.68)	(12.33)	(12.78)
Second-export price bust		10.88	-0.87
		(16.13)	(18.07)
Principal-export price bust x Second-export price bust			63.20
			(38.92)
Constant	199.60***	202.76***	203.68***
	(2.17)	(4.03)	(4.19)
Observations	3,503	3,401	3,401
Adjusted R-squared	0.00	0.01	0.01
Number of countries	15	15	15

Table 8: Regression of the level of currency risk (measured in basis points) on dummy variables that capture booms and busts in export prices. Only periphery countries during the Gold Standard. For column (3), the coefficients for the limited occurrences of booms in one main export, and busts in the other, are not reported. All regressions include country fixed effects. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors in parentheses clustered at the country level.

cause an increase in currency risk of 71 basis points, while simultaneous booms cause a decrease in currency risk of 44 basis points. An F-test for the joint significance of simultaneous bust events rejects that these are different from zero at the 5% statistical significance level, while we can not reject that simultaneous boom events have no impact on currency risk at standard levels of statistical significance.

4.3 Robustness checks

To understand how price shocks are transmitted into currency risk we exploit the high-frequency time-series dimension in the data and regress currency risk

spreads (measured in basis points) on the one-month growth rate of the principal-export price, including up to 12 lags. Results are reported in Table 9. Column (1) reports β coefficients pooled for core and periphery while columns (2) and (3) allow the β coefficient to be different between core and periphery (core coefficients not reported). Additionally, column (3) uses only observations for countries that are on the gold standard at time t. The main message of this table is that all the lagged monthly growth rates in export prices negatively impact currency risk levels at t. An F-test that these monthly growth rates are all equal to zero is rejected at the 1% level. These export-price effects are stronger when focusing on periphery countries, and even stronger when focusing on periphery countries that adhere to gold.

Table 10 reports similar regressions, but considers up to 6 lags and 6 leads. We can use these results to perform a simple falsification test since leads of the monthly growth rate of prices should not be related to past currency risk. Again, all the lag coefficients are negative. Some of the lead coefficients are initially negative, but turn zero after 3 months. Focusing on countries in the periphery that adhere to gold, we can see that lag coefficients are larger and more precisely estimated than lead coefficients, particularly for lags longer than 2 months, and that leads from 3 months onwards are not significantly different from zero. We find that, even after controlling for leads, lags of export-price growth rate have a causal impact on currency risk, while leads do not cause currency risk. These results are consistent with our theory and other empirical results for the relationship between export

prices and currency risk.[42]

As a further robustness check, we augment our baseline model and include institutional variables, country-specific events and macroeconomics variables that may also be drivers of currency-risk spreads. Although some of these may be of interest in their own right, we see them as conditioning variables and do not take a stand on whether they are endogenous or exogenous. Crucially, if export prices are exogenous, these variables should not affect our coefficient of interest. We include monthly dummies that capture conflict (civil and foreign wars), whether a country has a central bank or a stock market, or whether it is experiencing default. As Table 16 in appendix C shows, the coefficient of export prices is relatively unchanged.[43]

Finally, we include data on the trade balance and on the government bond spread over consols from Ferguson and Schularick (2006). It may be important to control for the former as negative shocks to export prices may lead to a deterioration of the trade balance. Under a formal commitment to gold, this may put pressure on the gold reserves and make leaving a peg more likely. Controlling for the spread of government bonds over consols may also be important since it allows us to explicitly test whether our measure for currency risk is capturing an effect independent of country or political risk. Given that these data vary at the yearly level, we augment our annual data specification reported in Table 4. Table 11 shows that the relationship between trade balance and currency risk is negative, but the coefficient for the growth rate in the price of exports is not sensitive

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[42]The fact that lags and leads close to t are of similar magnitude may indicate measurement error in the historical price series, auto-correlation on the monthly price growth rate series, or both. We see it as an additional reason to focus on yearly growth rates as we did in the baseline specifications outlined in Section 3.3.

[43]See Mitchener and Weidenmier (2015) for details and sources for these variables.

	(1)	(2)	(3)
	Pooled	Core vs Periphery	Core vs Periphery on Gold
Export-price growth rate$_t$	-0.04	-0.35	-0.39
	(0.20)	(0.26)	(0.29)
Export-price growth rate$_{t-1}$	-0.04	-0.44	-0.80
	(0.35)	(0.45)	(0.53)
Export-price growth rate$_{t-2}$	-0.25	-0.63	-1.09*
	(0.42)	(0.54)	(0.53)
Export-price growth rate$_{t-3}$	-0.30	-0.78	-1.31**
	(0.43)	(0.54)	(0.50)
Export-price growth rate$_{t-4}$	-0.32	-0.82*	-1.33***
	(0.37)	(0.40)	(0.33)
Export-price growth rate$_{t-5}$	-0.31	-0.61*	-0.97***
	(0.28)	(0.32)	(0.21)
Export-price growth rate$_{t-6}$	-0.37	-0.64	-0.60*
	(0.34)	(0.41)	(0.34)
Export-price growth rate$_{t-7}$	-0.16	-0.29	-0.34
	(0.34)	(0.39)	(0.39)
Export-price growth rate$_{t-8}$	-0.26	-0.50	-0.39
	(0.34)	(0.39)	(0.33)
Export-price growth rate$_{t-9}$	-0.01	-0.45	-0.42
	(0.32)	(0.36)	(0.30)
Export-price growth rate$_{t-10}$	-0.33	-0.72**	-0.79**
	(0.28)	(0.31)	(0.35)
Export-price growth rate$_{t-11}$	0.02	-0.37	-0.49*
	(0.26)	(0.30)	(0.26)
Export-price growth rate$_{t-12}$	-0.18	-0.41	-0.60
	(0.23)	(0.29)	(0.41)
Year fixed effects	X	X	X
Constant	87.75***	89.42***	113.07***
	(27.59)	(26.70)	(3.08)
Observations	8,732	8,732	5,870
Number of countries	21	21	21
Adjusted R-squared	0.26	0.27	0.23

Table 9: Regression of the level of currency risk (measured in basis points) on the monthly growth rate of the principal-export price. Columns 2 and 3 allow the β coefficient to be different if country is part of the periphery or the core (core coefficients not reported). Column 3 uses only observations for countries that are on the Gold Standard at t. All regressions include country fixed effects. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses clustered at the country level.

	(1)	(2)
	Core vs Periphery	Core vs Periphery on Gold
Export-price growth rate$_t$	-0.41	-0.44
	(0.29)	(0.37)
Export-price growth rate$_{t-1}$	-0.39	-0.71
	(0.45)	(0.55)
Export-price growth rate$_{t-2}$	-0.56	-0.97*
	(0.51)	(0.54)
Export-price growth rate$_{t-3}$	-0.67	-1.13**
	(0.48)	(0.49)
Export-price growth rate$_{t-4}$	-0.70*	-1.12***
	(0.35)	(0.34)
Export-price growth rate$_{t-5}$	-0.52**	-0.85***
	(0.24)	(0.16)
Export-price growth rate$_{t-6}$	-0.60**	-0.54**
	(0.28)	(0.20)
Export-price growth rate$_{t+1}$	-0.52*	-0.57*
	(0.27)	(0.28)
Export-price growth rate$_{t+2}$	-0.82***	-0.80***
	(0.23)	(0.28)
Export-price growth rate$_{t+3}$	-0.36	-0.32
	(0.28)	(0.28)
Export-price growth rate$_{t+4}$	0.21	0.49
	(0.26)	(0.35)
Export-price growth rate$_{t+5}$	0.32	0.42
	(0.29)	(0.28)
Export-price growth rate$_{t+6}$	0.25	0.24
	(0.29)	(0.23)
Year fixed effects	X	X
Constant	89.48***	495.08***
	(27.52)	(7.57)
Observations	8,692	5,792
Number of countries	21	21
Adjusted R-squared	0.26	0.23

Table 10: Regression of the level of currency risk (measured in basis points) on the monthly growth rate of the principal-export price. Columns 1 and 2 allow the β coefficient to be different if country is part of the periphery or the core (core not reported). Column 2 uses only observations for countries that are on the Gold Standard at t. All regressions include country fixed effects. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses clustered at the country level.

	(1)	(2)	(3)	(4)	(5)
Export-price growth rate	-0.88**	-0.89**	-1.81***	-0.78**	-0.75*
	(0.31)	(0.35)	(0.51)	(0.35)	(0.39)
Export-price growth rate x Core	1.62*	2.08**	1.80***	1.95**	1.16*
	(0.80)	(0.73)	(0.52)	(0.71)	(0.59)
Trade balance % of exports	-0.26		-0.41	-0.50	
	(0.25)		(0.38)	(0.29)	
Sovereign bond spread		0.00	0.19	0.01	
		(0.08)	(0.16)	(0.09)	
Reserves % of GDP					-12.90***
					(3.34)
Year fixed effects	X	X		X	X
Constant	266.19***	227.71***	216.89***	223.74***	213.41***
	(24.46)	(29.12)	(34.22)	(29.63)	(19.14)
Observations	499	417	417	417	402
Adjusted R-squared	0.45	0.45	0.07	0.46	0.61
Number of countries	16	16	16	16	13

Table 11: Regression of the level of currency risk on the annual growth rate of the principal-export price. The dummy variable Core takes on a value of 1 for the core countries identified in Table 2, zero otherwise. x represents an interaction. All regressions include country fixed effects. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses clustered at the country level.

to the inclusion of these controls, and even more precisely estimated than before. The coefficient for the spread of government bonds is not significantly different from zero in all specifications, suggesting that currency risk is not explained by sovereign-bond spreads. In column (5), we also control for reserves as a share of GDP using data from Accominotti et al. (2011). Unsurprisingly, reserves are an important determinant of currency-risk spreads. However, our coefficient of interest is again unchanged.

In appendix C, we further show that our results are also robust to using deseasonalized price series, removing near monopolists and famous re-exporters, augmenting the number of exports, adding principal imports for each country, and

allowing estimated coefficients on export prices to differ across manufactures and commodity exporters.

5   Conclusion

We show theoretically and empirically that export-price shocks affect the expectation of currency devaluation. Using a simple model of strategic exit from a hard peg, we show that export prices are negatively related to the risk of "pegxit" and currency devaluation. The intuition behind our main theoretical result is that negative export-price shocks decrease government revenues, making it more likely that the government devalues domestic currency in order to decrease real debt-service payments, and ease fiscal pressures.

We test for the existence of this mechanism during the classical gold standard era, a period when hard pegs were the very foundation of the international monetary system. Under the identifying assumption that world prices are exogenous for price-taking economies, we find a negative causal relationship between the price of exports and currency risk, that is consistent with our theoretical results. This negatively-signed relationship is driven by countries on the periphery, and the effects are stronger when countries adhered to the gold standard.

Our model suggests several interesting extensions that could be pursued in future work. On the production side, we assumed long-run flexible prices and that devaluation decreases tax revenues from economic activity related to trade. Although these two assumptions are consistent with the classical gold standard era, it would be interesting to incorporate price-stickiness into the model and to study the mechanism through which currency devaluation can affect economic

activity. Another interesting avenue for future research is to consider banks and firms balance-sheet currency mismatches, that can turn a currency devaluation into a banking crises.

Some of these extensions lend themselves to empirical work within the classical gold standard era. We have focused our empirical analysis on the principal export for each country. Although this was motivated by our theoretical approach as well as our desire to identify causal effects using an exogenous source of identification, including the full portfolio of exports and imports would allow us to assess the magnitude of the impact of trade shocks on currency risk. Finally, we have taken a partial equilibrium perspective on currency risk, where countries take international prices for their exports as given, and focused on shocks that propagate through trade. Besides participating in a global goods market for their exports, countries in the gold standard were linked also through imports as well as immigration and capital flows. In future work, we plan to study these relationships further.

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Appendix A   Periods of gold standard adherence

Country	Gold dates
Argentina	1870m1 - 1876m6*, 1883m7 -1885m1 and 1899m11 - 1914m6
Austria-Hungary	1892m8 - 1914m6
Belgium	1878m11 - 1914m6
Bulgaria	1902m11 - 1912m10
Chile	1895m6 - 1898m7
Denmark	1873m5 - 1914m6
Finland	1877m12 - 1914m6
France	1878m11 - 1914m6
Germany	1871m10 - 1914m6
Greece	1885m1 - 1885m8*, 1910m3 - 1914m6
India	1898m1 - 1914m6
Italy	1883m2 - 1894m12
Japan	1897m9 - 1914m6
Mexico	1905m4 - 1913m12
Netherlands	1875m6 - 1914m6
Norway	1873m5 - 1914m6
Romania	1890m4 - 1914m6
Russia	1897m1 - 1914m6
Sweden	1873m5 - 1914m6
Switzerland	1878m12 - 1914m6
USA	1879m1 - 1914m6

Table 12: De jure gold adherence dates are from Mitchener and Weidenmier (2015), except * from Eichengreen et al. (2005).

Appendix B Prices and principal exports

In this Appendix, we describe the sources and calculations used to create our series for principal exports and export prices.

B.1 Price series notes

We collected a number of monthly price series for different products from *the Economist*'s Monthly Trade Supplement and Weekly Price Current. We select the price series that maximizes data coverage and consistency throughout our sample (1870-1913). This is important as some price series change units or definitions.[44] We also use a price index for British textile exports from Silverman (1930) that is available between 1880 - 1913 to proxy for cotton and wool manufactures.[45] We create price indices for each relevant product-price series that take on the value of 100 for the average of the 1913 price. We select 1913 as our base year because the initial date for which we have data varies across goods whereas this date is available for all goods. The list below provides details on the particular price series taken from *the Economist* (as displayed therein):

Beef: Inferior.

Butter: Prices series for Dutch (including Friesland) and Danish butter.

Coal: Best Wallsend London.

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[44] We have confirmed that our empirical results hold in sub-samples that exclude any product definitional changes.

[45] Since the main source of *monthly* variation in cotton and wool textiles would come from changes in the prices of the commodity input, it is not surprising that our empirical results are robust to proxying the price of cotton manufactures with a cotton price index that is available between 1870 and 1914 (the monthly correlation between the cotton index and the monthly index for textile products price index is 0.76), and the price of wool manufactures with a wool price index that is available between 1870 and 1914 (the monthly correlation between the price of wool and the price of textile products is 0.78.).

Coffee: Between 1870-1881, Jamaica Fine Ord. to Fine. Between 1881-1913, Ceylon, Plantation. Low mid changed to Santos Good Average in 1908.

Copper: Between 1870-1881, Copper: Tough Cake. Between 1881-1913, Chili Bars changed to G.M.B in 1899, Standard in 1912.

Cotton: Between 1870-1881, Mule No 40, Fair, 2nd quality, Manchester Markets. Between 1881-1913, Yarn-40 Mule Twist.

Flax: Between 1870-1881, Friesland. Between 1881-1913, Petersburg 12-head, changed to Riga, ZK in 1895.

Flour: Town Made 2ends, changed to Town House holds in 1910.

Hemp: Between 1870-1881, Manilla. Between 1881-1913, St Petersburg Clean Raw.

Iron: British mid.

Lead: English Pig.

Nitrate: Saltpetre English refined.

Oats: Gazette Averages (English Grain) - Oats.

Olive Oil: Between 1870-1881, Olive, Gallipoli. After 1881, Olive Levant/ After 1885 changed to Spanish, 1911 to Palm. Lagos.

Rice: Rangoon.

Silver: London market price.

Silk: Between 1870-1881, Raw Cossimbuzar. Between 1881-1913, Cossimbuzar.

Sugar: Between 1870-1881, Bengal Good Yellow and White. Between 1881-1902, West India Refining. Between 1902-1913, West India Syrups.

Timber: Prices series for Swedish, Norwegian and Finnish timber from the Weekly Price Current.

Tea: Tea Congou - 1905 changed to Fr. Gd..

Textiles: Average export prices from foreign trade statistics for cotton cloth, woolen and worsted yarn and goods, and for linen and jute piece goods.

Wheat: Between 1870-1881, Wheat Gazette Average. Between 1881-1913, Gazette Averages (English Grain).

Wood: Price series for Norwegian, Swedish and Finnish timber.

Wool: Sydney Unwashed/Changed to NS.Wles Greasy Average in 1891.

Wheat: Gazette Averages (English Grain) - Wheat.

B.2 Principal exports

For most countries in our sample, we primarily rely on detailed trade data published in the British Board of Trade (various years) *Statistical Abstract*, henceforth SA, to identify principal exports. We supplement and cross-check our estimates with information found in Mitchell (2007b), Mitchell (1982), Hanson (1980), as well as country-specific sources. Appendix Table 1 shows each economy's largest export for 1870, 1880, 1890, 1900 and 1910 (when available). The list below summarizes our findings:[46]

Argentina: Wool. Mitchell (2007b) reports that the average value of wool exports for Argentina between 1870 and 1914 was 40.2 million gold pesos, compared to 35.7 million gold pesos for wheat and 22.4 million gold pesos for hides and skins. According to SA, wool accounted between 49.9% of Argentina's exports in 1889 and 19.9% in 1904.

Austria-Hungary: Wood. According to SA, wood is the largest export for Austria-Hungary in our sample (largest export for 14 years). Sugar follows

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[46]Imports and source data available on request.

closely (11 years). Hanson (1980) reports that for 1900 the largest export for Austria was raw sugar (37.9 million U.S. dollars), followed by cotton manufactures (4.6 million U.S. dollars). Given that we do not have price data on Austrian-Hungarian wood, we use the price of Swedish wood as a proxy.

Belgium: Flour. According to SA, flour is the largest export for Belgium in our sample (largest export for 11 years), followed by coal and iron.

Bulgaria: Wheat. According to SA, wheat is consistently the largest export for Bulgaria. Chirot (1991) reports that wheat sales represented 70% of Bulgaria's export totals around 1900.

Chile: Nitrate. Mitchell (2007b) reports that the average value of copper exports between 1870 and 1914 was 29.6 million gold pesos of 18 pence, which is smaller than the value of nitrate exports for the same period (125.4 million gold pesos of 18 pence).

Denmark: Butter. According to SA, flour and butter are the most representative exports for Denmark. Flour accounts for a larger share of exports early in our sample period, whereas butter dominates after 1890. We use the monthly price of Dutch butter to proxy for Danish butter, for which we only have data from 1894 onwards. The correlation coefficient between Danish and Dutch butter following 1894 is 0.87.

Finland: Wood. Hjerppe (1989) report that timber and wood products accounted for 46% of Finnish exports between 1869-1913.

France: Textile manufactures. According to SA, wool, silk and cotton manufactures represent the largest exports for France, followed by wine and hides. Hanson (1980) reports that for 1900 the largest export for France are silk

manufactures (61.5 million U.S. dollars), followed by cotton manufactures (34.9 million U.S. dollars). Given that we do not have monthly data for France's textile manufactures we proxy the price of France's largest export with an index for textile products from Silverman (1930).

Germany: Iron products. According to SA, iron products are the largest export for Germany for 13 years, followed by wool manufactures and flour. Hanson (1980) reports that for 1900 the largest export for Germany are cotton manufactures (67.1 million U.S. dollars), followed by raw sugar (51.5 million U.S. dollars).

Greece: Iron. According to SA, the main export are dried fruits, for which we do not have monthly price data, followed by ore (as high as 30% of exports in 1895). Blattman et al. (2007) reports that fruits & nuts account for 59% of Greece's exports between 1898 and 1902. The second largest export is lead, accounting for 14.1%.

India: Cotton. Mitchell (1982) reports that the average value of cotton exports between 1870 and 1913 was 167.3 million rupees. Rice accounts for the second largest export, averaging 128.2 million rupees, followed by opium, jute, cotton manufactures, tea and jute manufactures. Blattman et al. (2007) reports that rice accounts for 21.1% of Indias's exports between 1898 and 1902. Other important exports include cotton (16.9%), cotton manufactures (13.8%), jute (13.7%), tea (12.2%), opium (11.7%) and jute manufactures (10.6%).

Italy: Silk. SA reports that silk, raw and thrown waste cocoons account for the largest share of Italy's exports, followed by silk manufactures. Hanson (1980) reports that for 1900 the largest export for Italy are silk manufactures (86.6

million U.S. dollars), followed by cotton manufactures (11.8 million U.S. dollars).

Japan: Silk. Mitchell (1982) reports that the average value of raw silk exports between 1870 and 1913 was 46.15 million yen, followed by cotton yarn & fabrics (25.9%) and silk fabrics (19%). We confirmed this using SA.

Mexico: Silver. Mitchell (2007b) reports that the average value of silver exports between 1870 and 1913 was 52.5 million pesos, much larger than the second largest export, coffee (6.7 million pesos).

Netherlands: Flour. SA reports that drugs are the largest export for the Netherlands, followed by flour and wheat. Hanson (1980) reports that for 1900 the largest export for Netherlands are cotton manufactures (16.2 million U.S. dollars), followed by Dyes and Dyestuffs (9.1 million dollars). Given that the Netherlands monopolizes the market for Peruvian bark, we select flour as the main export, for which we have monthly prices.

Norway: Wood. SA reports that wood and fish are the largest exports for Norway. Blattman et al. (2007) reports that wood and products accounted for 44.2% of Norway's exports between 1898 and 1902. Fish accounts for the largest percentage of exports during this period (50.1%), but we do not have monthly data for Norwegian fish and opt to use Norwegian timber instead.

Romania: Wheat. SA reports that wheat is the largest export for Romania, followed by maize, barley and flax. Chirot (1991) reports that wheat sales represented 80% of Romania's export totals around 1900.

Russia: Wheat. SA reports that wheat is the largest export for Russia followed by flax and barley. Blattman et al. (2007) reports that grain accounted for 63.0% of Russia's exports between 1898 and 1902, 65.0% between 1878 and 1882.

Sweden: Wood. SA reports that wood is the largest export for Sweden, followed by iron products, oats and butter. Johansson (1967) reports that, between 1891 and 1895, wood products accounted for 28% of Sweden's exports.

Switzerland: Textile manufactures. SA reports that silk and cotton manufactures represent the largest exports for Switzerland. Hanson (1980) reports that in 1900 the largest export for Switzerland are silk manufactures (40.7 million U.S. dollars), closely followed by cotton manufactures (32.9 million U.S. dollars).

United States of America: Cotton. SA reports that cotton is the largest export for the USA, followed by wheat and meat and sausages. Mitchell (2007b) reports that the average value of cotton exports between 1870 and 1913 was 250 million U.S. dollars, larger than the second largest export, wheat (averaging 108 million U.S. dollars).

Top Exports (ordered)	1870	1880	1890	1900	1910
Argentina		Wool, Hides, Meat	Wool, Hides, Maize	Wheat, Wool, Hides	Wheat, Maize, Wool
Austria-Hungary	Flour, Animals+, Coal	Grain and Flour, Sugar*, Wood	Sugar*, Barley, Animals+	Wood, Sugar*, Eggs	
Belgium	Flax, Coal, Hides	Grain and Flour, Flax hemp and jute, Wollen yarn	Machinery, Grain and Flour, Coal	Machinery, Coal, Iron products	
Bulgaria			Wheat, Maize, Animals	Wheat, Animals, Maize	
Chile		Copper, Nitrate	Nitrate, Copper	Nitrate, Copper	Nitrate, Copper
Denmark	Wheat flour meal, Bacon and Hams, Rye meal	Wheat flour meal, Rye meal, Bacon and Hams	Butter, Animals, Meats and Sausages	Butter, Eggs, Horses	
Finland	Timber and wood products, butter, iron; no data by year				
France	Silk manuf, Wool manuf, Wine	Wool manuf, Wine, Silk manuf	Wool manuf, Silk manuf, Wine	Silk manuf, Wine, Wool manuf	
Germany	(1872) Grain and Flour, Coal, Animals	Silk manuf, Grain and Flour, Wool manuf	Iron products, Wool manuf, Cotton manuf		
Greece	Fruit, Lead products, Olive and palm oil		Currants and raisins, Ore, Olive and palm oil	Currants and raisins, Ore, wine	
India	Cotton, Opium, Rice	Opium, Cotton, Rice	Cotton, Rice, Cotton manuf	Rice, Cotton, Tea	Cotton, Rice, Jute manuf
Italy	Raw silk, Olive and palm oil, Grain and Flour	Raw silk, Olive and palm oil, Wine	Raw silk, Fruit, Olive and Palm oil	Raw silk, silk manuf, Fruit	
Japan	Raw silk	(1882) Raw silk, Tea, Rice	Raw silk, Tea, Copper and copper manuf	Silk, silk manuf, cotton yarn	Raw silk, cotton yarn, silk manuf
Mexico	Silver	Silver, Iron ore, Copper	Silver, Coffee, Lead	Silver, Coffee, Copper	Silver, Copper, Coffee
Netherlands	Sugar, Coffee, Raw cotton	Iron products, Grain and Flour, Drugs	Drugs, Iron products, Wheat	Drugs, Wheat, Iron products	
Norway	Beer, Wood, Trainoil	Wood, Fish and Seafood, Trainoil	Fish and sea food, wood, Trainoil	Fish and sea food, wood, Woodwares	
Romania		(1882) Wheat, Maize, Barley	Wheat, Maize, Oleaginous Seeds	Wheat, Oleaginous Seeds, Maize	
Russia	Wheat, Flax, Oleaginous Seeds	Wheat, Oleaginous Seeds, Rye	Wheat, Flax, Wood	Wheat, Rye, Wood	
Sweden	Wood, Oats, Lucifer matches	Wood, Iron products, Oats	Wood, Iron products, Butter	Wood, Iron products, Butter	
Switzerland	(1871) Wood, Cheese, Cotton manuf	Wood, Cheese, Cotton manuf	Cotton manuf, Silk manuf, Watches and clocks	Silk manuf, Cotton manuf, Watches and clocks	
United States of America	Cotton, Wheat, Mineral refined oil	Cotton, Wheat, Indian corn	Cotton, Meat and sausages, Wheat flour meal	Meat and sausages, Cotton, Indian corn	

*Sugar: raw and refined   + Animals: except horses

Appendix Table 1: Top exports for each country at different years.

Appendix C Additional empirical results

In this Appendix, we show that our results are also robust to the following alternative specifications: using deseasonalized price series; removing near monopolists and famous re-exporters; augmenting the number of exports; adding principal imports for each country; and allowing estimated coefficients on export prices to differ across manufactures and commodity exporters.

Some of the monthly variation in commodity prices may reflect seasonality in supply and demand and thus be predictable from the currency traders' perspective. Supply seasonality is associated with the natural growth or extraction calendars, while demand seasonality comes from general economic activity. This seasonality in international supply and demand may affect the price of exports for our countries at the monthly frequency, but is not necessarily associated with the permanent shocks we considered in our theoretical model, and therefore may not be causing currency risk. As a consequence, using seasonally unadjusted data can potentially bias the β coefficient estimated using the panel defined by equation (18). Table 13 reproduces the structural analysis from Table 4 but uses deseasonalized price data. It shows that results are virtually unchanged.

In Table 14, we investigate the robustness of the reduced-form results by studying more exogenous exports, but also a larger number of exports and imports. In Column (1), we replace some of the main exports in Table 2 by main exogenous exports. To be exact, we replace nitrate with copper for Chile and remove the Netherlands from our sample. We can see that the effect size for the periphery is

	(1)	(2)	(3)	(4)	(5)	(6)
					On Gold	Not on Gold
Export price	-0.56***	-0.10	-0.24	-0.24	-0.27*	-0.29*
	(0.15)	(0.14)	(0.15)	(0.18)	(0.15)	(0.15)
Export price x Core			0.61**	1.47***	0.70**	1.31***
			(0.27)	(0.24)	(0.29)	(0.31)
Gold				0.13		
				(0.59)		
Export price x Gold				-0.00		
				(0.14)		
Core x Gold				4.00***		
				(1.23)		
Export price x Core x Gold				-0.87***		
				(0.27)		
Year fixed effects		X	X	X	X	X
Constant	3.56***	0.87	0.72	-0.43	0.56	2.78***
	(0.68)	(0.80)	(0.80)	(1.00)	(0.71)	(0.68)
Observations	8,901	8,901	8,901	8,901	5,926	2,975
Adjusted R-squared	0.03	0.21	0.22	0.22	0.22	0.25
Number of countries	21	21	21	21	21	16

Table 13: Regression of $H(CRS_{c,t})$ on the log of principal export price (deseasonalized), $H(CRS_{c,t})$ defined in equation (19). Core takes on a value of 1 for the core countries, zero otherwise. Gold takes on a value of 1 if the country has a formal gold commitment in place, zero otherwise. x represents interaction. All regressions include country fixed effects. *** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses clustered at the country level.

robust to using more exogenous exports and to removing a notable re-exporter.[47] In Column (2), we add the second largest export to the principal export identified in Table 2, while in Column (3) we add the main import together with the principal export. Finally, in Column (4) we include the 3 main exports and the 3 main imports. The coefficient on the primary export is negative throughout. In general, only export-price growth rate coefficients are significantly different from zero for the periphery, which is consistent with our focus on principal exports as a crucial determinant of income and economic activity.

In Table 15, we allow the estimated coefficient on export-price growth to differ between manufactures and commodity exporters. Belgium, Denmark, France, Germany, Netherlands and Switzerland are classified as countries for which the principal export is a manufacture while the remaining countries are commodity exporters. The first line collects the results for commodity exporters. We can see that the coefficient is negative throughout, and that the effect of export prices is stronger while on gold. This negative coefficient is further reduced if we remove the United States from the set of commodity exporters, or consider only periphery countries. Finally, Table 16 reports that our results are robust to including monthly dummies capturing institutional variables and country-specific events as described in Section 4.

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[47]We have also ran specifications removing other potential exporters with market power, for example, the USA in the market for cotton, or Russia in the market for wheat, and found similar results.

	(1)	(2)	(3)	(4)	(5)
Exogenous export-price growth rate	-0.50**				
	(0.19)				
Exogenous export-price growth rate x Core	1.22***				
	(0.35)				
Export 1 price growth rate		-0.39	-0.41	-0.44*	-0.75**
		(0.24)	(0.26)	(0.25)	(0.29)
Export 1 price growth rate x Core		0.82*	0.92**	0.79*	1.15**
		(0.40)	(0.40)	(0.39)	(0.44)
Import 1 price growth rate			-0.09	0.03	0.01
			(0.12)	(0.12)	(0.13)
Import 1 price growth rate x Core			0.52***	0.23	0.27
			(0.16)	(0.18)	(0.33)
Export 2 price growth rate		-0.24*		-0.16	-0.10
		(0.13)		(0.10)	(0.09)
Export 2 price growth rate x Core		0.73**		0.44	0.21
		(0.29)		(0.27)	(0.37)
Import 2 price growth rate				-0.30*	-0.20
				(0.16)	(0.17)
Import 2 price growth rate x Core				0.58***	0.39*
				(0.20)	(0.22)
Export 3 price growth rate					-0.09
					(0.12)
Export 3 price growth rate x Core					0.30
					(0.36)
Import 3 price growth rate					-0.16
					(0.24)
Import 3 price growth rate x Core					0.36
					(0.26)
Year fixed effects	X	X	X	X	X
Constant	98.11***	250.15***	245.53***	302.73***	171.37***
	(27.10)	(40.36)	(33.95)	(8.20)	(18.18)
Observations	8,374	8,359	8,447	7,877	6,854
Adjusted R-squared	0.27	0.27	0.26	0.27	0.30
Number of countries	20	21	21	21	19

Table 14: Regression of the level of currency risk (measured in basis points) on the yearly growth rate of the principal exports and imports price, where 1 stands for principal, 2 for second principal, and 3 for third principal. Core takes on a value of 1 for the core countries, zero otherwise. Gold takes on a value of 1 if the country has a formal gold commitment in place, zero otherwise. x represents interaction. All regressions include country fixed effects. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors in parentheses clustered at the country level.

	(1)	(2)	(3)
Export-price growth rate	-0.73*	-0.30	-0.15
	(0.37)	(0.27)	(0.40)
Export-price growth rate x Manufacture	0.34	0.67	0.01
	(0.43)	(0.41)	(0.43)
Gold			-0.62
			(21.24)
Export-price growth rate x Gold			-0.27
			(0.49)
Manufacture x Gold			-8.63
			(34.90)
Export-price growth rate x Gold x Manufacture			0.79
			(0.62)
Year fixed effects		X	X
Constant	197.17***	86.70***	239.17***
	(0.30)	(27.41)	(23.52)
Observations	8,748	8,748	8,748
Adjusted R-squared	0.00	0.26	0.26
Number of countries	21	21	21

Table 15: Regression of the level of currency risk (measured in basis points) on the yearly growth rate of the principal-export monthly price. Manufacture takes on a value of 1 if principal export is a manufactured good, zero if it is a commodity. Gold takes on a value of 1 if the country has a formal gold commitment in place, zero otherwise. Core takes on a value of 1 for the core countries, zero otherwise. x represents interaction. All regressions include country fixed effects. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors in parentheses clustered at the country level.

	(1)	(2)	(3)	(4)	(5)	(6)
Export-price growth rate	-0.44*	-0.44*	-0.44*	-0.42	-0.72*	-0.42
	(0.24)	(0.25)	(0.24)	(0.25)	(0.38)	(0.25)
Export-price growth rate x Core	1.03**	1.03**	1.03**	0.99**	0.45	0.99**
	(0.39)	(0.39)	(0.39)	(0.39)	(0.44)	(0.39)
Intra-state war		4.76			-8.89	3.41
		(41.51)			(43.31)	(40.35)
Inter-state war		-12.99			-9.21	-13.88
		(31.97)			(34.15)	(32.29)
Central bank			0.05		-35.67**	0.06
			(18.81)		(16.86)	(18.89)
Stock market			9.34		-9.16	8.66
			(18.89)		(25.57)	(19.33)
Default				115.35	238.94***	115.88*
				(67.27)	(60.55)	(66.66)
Year fixed effects	X	X	X	X		X
Constant	88.18***	88.15***	82.41***	86.57***	224.29***	81.16***
	(26.96)	(26.88)	(27.85)	(27.08)	(26.55)	(28.00)
Observations	8,748	8,748	8,748	8,748	8,748	8,748
Adjusted R-squared	0.27	0.27	0.27	0.27	0.04	0.27
Number of countries	21	21	21	21	21	21

Table 16: Regression of the level of currency risk (measured in basis points) on the yearly growth rate of the principal-export monthly price. The dummy variable Core takes on a value of 1 for the core countries identified in Table 2, zero otherwise. x represents an interaction. All regressions have country fixed effects. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors in parentheses clustered at the country level.