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# Bilateral Exchange Rate Regimes

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# List of Abbreviations

| | |
|---|---|
| *AREAER* | Annual Report on Exchange Arrangements and Exchange Restrictions |
| *BOP* | Beginning of period |
| *CAEMC* | Central African Economic and Monetary Community |
| *CDIS* | Coordinated Direct Investment Survey |
| *CPI* | Consumer price index |
| *CPIS* | Coordinated Portfolio Investment Survey |
| *CU* | Currency Union |
| *EBA* | Extreme Bound Analysis |
| *ECCU* | Eastern Caribbean Currency Union |
| *ECB* | European Central Bank |
| *eERR* | Effective exchange rate regime |
| *EMU* | European Monetary Union |
| *EMS* | European Monetary System |
| *ERM* | European Exchange rate mechanism |
| *ERR* | Exchange rate regime |
| *EUR* | Euro |
| *FDI* | Foreign Direct Investment |
| *FF* | Freely Falling |
| *GDP* | Gross domestic product |
| *HI* | High income countries |
| *IFS* | International Financial Statistics |
| *IMF* | International Monetary Fund |
| *IRR* | Ilzetzki, Reinhart and Rogoff |
| *LCP* | Local Currency Pricing |
| *LOP* | Law of one price |
| *MOP* | Middle of period |
| *NSLT* | No separate legal tender |
| *OCA* | Optimal currency area |

| | |
|---|---|
| *OECD* | Organisation for Economic Cooperation and Development |
| *PCP* | Producer Currency Pricing |
| *PPML* | Pseudo Poisson Maximum Likelihood |
| *PPP* | Purchasing power parity |
| *RTA* | Regional and trade agreement |
| *SMOPEC* | Small open economy |
| *UNCTAD* | United Nations Conference on Trade and Development |
| *USD* | U.S. Dollar |
| *WAEMU* | West African Economic and Monetary Union |
| *WDI* | World Development Indicators |
| *WGI* | World governance index |

# Introduction

The availability of data has been a driving force in the field of modern economics at least since 1853 when the first professor of economics in the United States, James D. B. De Bow, conducted the first extensive study on the number of acres under agricultural cultivation. These data later transformed the political debate about slavery when Hinton Helper showed that the main problem of chattel slavery was not immorality but inefficiency (Appelbaum, 2019). As an even broader consequence, policymakers in the U.S. began to place their faith in free markets over the next seventy-five years. Appelbaum (2019) argues that even if the U.S. government initially expanded its role in the economy, the government remained a small and peripheral actor. This has changed following the Great Depression in the 1930s when the trust in free markets was badly shaken. The large inequalities of the early decade and the disasters of the 1930s and 1940s left people with little faith in the free markets. Interestingly, this new shift in public perception was also driven by the new data evidence when the economist Simon Kuznets for the first time estimated that the U.S. national income had fallen by half between 1972 and 1973.

The beliefs about the efficiency of free markets lie at the heart of every economic school. Classical economics treated the economy as a rocking chair that over time returned on its own to the same place without any interventions (Appelbaum, 2019). The Keynesian school's view of the economy was akin to a rocking chair that needed the government's hand to be put in its place, a view that became widespread following the Great Depression. This view has been overturned again later by advocates of faith in free markets in the 1960s, most notably by Milton Friedman. The following four decades between 1969 and 2008 were thus defined by a period of deregulation under the influence of free markets economists that were to end in the worst financial crisis since World War II. Regardless of which school gained most supporters in which period, the influence of economists grew with the growing availability of data (Appelbaum, 2019).

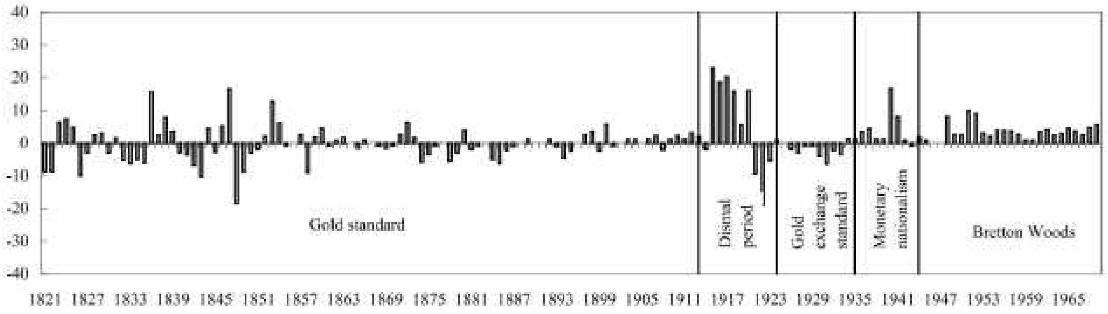


FIGURE 1: Great Britain: Wholesale and consumer prices (percent change per year) 1820–1969. Source: Ghosh et al. (2003, p. 8)

As the view on the role of free markets changed over history, the rules governing individual markets evolved accordingly. Among those markets, a market where the trading of currencies takes place is called foreign exchange market. As a matter of fact, the foreign exchange market is by far the world's largest market in terms of trading volume (Record, 2010). The set of rules and conditions under which the trading of foreign currencies takes place is being referred to as exchange rate regime or exchange rate arrangement. It is of little surprise that as the view on the role of free markets evolved, the design of the foreign exchange markets kept changing over time.

As an example, Figure 1 shows different monetary arrangements of the United Kingdom over time since the year 1821 and corresponding consumer price index (CPI). Historically, the shift to the gold standard since the 1870s is considered a starting point of the modern international monetary system. The use of gold was a way of global standardisation in international finance that brought expanding trade and financial linkages, but at the cost of pronounced real and financial volatility (Ghosh et al., 2003). The end of World War I saw attempts to re-establish the gold standard, with the additional use of foreign exchange securities used as an alternative to gold by most central banks. However, the gold exchange standard failed because the policy objectives shifted to domestic economic stabilisation. The countries' goal of maintaining the exchange rate peg was replaced by focus on domestic inflation, employment and financial stability (Ghosh et al., 2003).

The interwar experience of monetary nationalism and the resulting need for common worldwide "rules of the game" resulted in the Bretton Woods Agreement that governed the international monetary system for almost 25 years. Unlike the failure of the gold standard, the system collapsed as the policy goals shifted again, from maintaining the exchange rate pegs to domestic concerns such as fiscal constrains in the United States and inflation concerns in Germany (Ghosh et al., 2003). Since then, countries were free to choose their exchange rate regime. The different historical experiences with free floats, managed floats or pegs helped to shape countries' preferences towards floating versus flexible exchange rates for the years to come. The United States adopted free-floating exchange rates as these were deemed as a form of free market policies pursued in the United States at that time. Continental Europe – having historically less faith in free markets – saw the fixed exchange rates as essential to fostering greater cross-border trade and investment that later led to the creation of the European Monetary System (Ghosh et al., 2003).

Not only has the design of exchange rate arrangements frequently changed over time, these arrangements also had strong implications for countries' inflation, production and unemployment. However, the consequences of choosing given exchange rate regime became less obvious during the post Bretton Woods. Countries chose different exchange rate regimes, but the effects seemed to vary across countries. For example, while some countries fared well with the exchange rate peg for many years, other countries failed horribly. The judgment about the costs and benefits of different exchange rate regimes became more elusive.

At the same time as the design of these arrangements changed, also the data availability and measurement of these arrangements steadily evolved. Indeed, correct measurement is crucial in order to provide reliable answers on the effects of exchange rate arrangements in the post Bretton Woods period. The way to measure exchange rate arrangements lies at the heart of this thesis. This thesis addresses data measurement discrepancy that has not yet been considered in today's multilateral world: The observation that currently available unilateral exchange rate regimes classifications are uninformative about the exchange rate regime vis-à-vis other currencies.

We provide a novel measurement approach towards exchange rate regimes as an important determinant of countries' macroeconomic performance, vulnerabilities to crises or bilateral trade and investment. For example, the exchange rate arrangement of Bulgarian lev (BGN) is classified as a currency board against the Euro and the arrangement of Danish krone (DKK) is classified as a conventional peg against the Euro. This means that the unilateral classifications describe only the relationship of a currency vis-à-vis one anchor currency. We show that the classification of a currency vis-à-vis all other currencies is crucial if we want to analyse the economic consequences of choosing a given exchange rate regime.

Our contribution is important because the traditional unilateral exchange rate regimes classifications are not suitable to analyse bilateral outcome variables such as foreign direct investment or business cycles synchronization. Also, we show that these classifications might lead us to draw imprecise conclusions about the performance of unilateral outcome variables such as inflation. This thesis is divided into three separate chapters to investigate these claims one by one. Each chapter introduces a specific aspect of exchange rate regimes classification tailored to analysing regimes' effects on different macroeconomic outcomes: (i) bilateral *de-jure* exchange rate regimes allow us to capture policy announcements aimed to capture ex-ante expectations, (ii) bilateral *de-facto* exchange rate regimes aim to capture the actually implemented exchange rate regimes and (iii) effective exchange rate regimes that – similarly to effective exchange *rates* – assess the stability of an exchange rate regime relative to a basket of all bilateral regimes.

The first chapter entitled "Bilateral De-Jure Exchange Rate Regimes and Foreign Direct Investment: A Gravity Analysis" is a joint work with Philipp Harms. This paper introduces a novel dataset on *bilateral de-jure exchange rate regimes.* The new dataset accounts for the fact that officially pegging to one currency is uninformative about the exchange rate regime prevailing vis-à-vis other currencies, and it allows characterizing bilateral exchange rate regimes based on countries' ex-ante announcements rather than ex-post observations. We use this data to estimate the effect of expected exchange rate volatility on foreign direct investment (FDI).

Starting from a simple model that suggests that announced exchange rate stability enhances bilateral FDI flows, we provide empirical evidence that lends support to this claim: countries that are linked by a non-floating exchange rate regime seem to attract significantly more FDI from each other. In particular, relationships with no separate legal tender like currency unions are most favorable to FDI in both developed and developing countries. Moreover, we find substantial differences between developing and developed countries, with the effect of announced exchange rate stability being much stronger for the former group than for the latter.

The second chapter is a result of a joint work with Jia Hou entitled "The Effect of Exchange Rate Regimes on Business Cycle Synchronization: A Robust Analysis". This paper uses a new dataset on *bilateral de-facto* exchange rate regimes for the period 1973-2016 to study the effect of seven types of regimes on business cycle synchronization. Using the Extreme Bound Analysis (EBA) methodology, we find that the exchange rate regime is a robust determinant of business cycle synchronization.

Compared to country pairs with freely floating arrangements, we find that: (i) the correlation coefficient measuring business cycle synchronization is higher by around 0.12 points in countries with no separate legal tenders; (ii) other hard pegs such as currency board arrangements and de-facto pegs have also significantly more synchronised business cycles, but the size of the correlation coefficient is halved compared to countries with no separate legal tenders; (iii) the effect is not always linearly decreasing with the increasing exchange rate regime flexibility, since crawling pegs and crawling bands turn out to be insignificant, whereas the effect of moving bands as a more flexible type of exchange rate regimes is positive and significant; (iv) the effect is stronger for countries with high degree of financial openness and good institutional quality.

The third chapter of this thesis consists of a single-authored paper entitled "Effective Exchange Rate Regimes and Inflation". This paper introduces a new *effective* exchange rate regimes classification. Traditional classification approaches focus on finding one particular anchor currency with respect to which stability or flexibility of a currency is being defined, thus implicitly neglecting information on exchange rate regime relationships against all remaining currencies. Our new measure is constructed by weighting data on *bilateral* exchange rate regimes by the trade shares of all counterparties in a country's total trade, thus taking into account direct and indirect relationships against all currencies.

We show that the new effective approach is advantageous in order to correctly measure the effect of exchange rate regimes on inflation, because fixing an exchange rate regime to one currency does not completely anchor domestic prices in a multilateral world with large capital flows. We provide a detailed comparison of the new effective exchange rate regimes measure to the traditional classifications. We find that hard pegs are associated with significantly lower inflation compared to freely floating regimes. We also find that narrow and wide soft pegs are associated with significantly lower inflation rates. This challenges the established findings that soft pegs do not matter or are even detrimental to inflation performance. We find that the effect goes significantly beyond the pure money growth effect, with the size of inflation reduction being at least as strong as the effect stemming from inflation targeting policies.

Finally, the thesis ends with a brief final discussion summarising the most important results. The overall contribution of the dissertation will also be discussed, together with a review of implications for the work undertaken in Chapters 1 to 3 in particular.

# Chapter 1

# Bilateral De-Jure Exchange Rate Regimes and Foreign Direct Investment: A Gravity Analysis

by Philipp Harms* and Jakub Knaze†

## 1.1 Introduction

It is often claimed that exchange rate stability, by reducing uncertainty and lowering transaction costs, enhances foreign direct investment (FDI).[1] However, the empirical evidence on the relationship between exchange rate regimes and FDI is rather mixed, with some contributions supporting the notion of a positive effect and others denying any significant influence of the exchange rate regime on FDI.[2]

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[1]For example, when Jaguar Land Rover announced a large FDI investment in Slovakia, the official press release stated that: "As well as benefiting from lower labour costs in Slovakia, having a plant in the Eurozone will help insulate Jaguar Land Rover from currency movements" (The Telegraph, 2015).

[2]Faeth (2009) provides a survey on determinants of FDI, including exchange rate stability as a potentially relevant variable. Other studies on the determinants of bilateral FDI have been provided by Bloningen et al. (2007), Baltagi et al. (2007), Bénassy-Quéré et al. (2007) and Davies et al. (2008).

In this paper, we argue that the inconclusive evidence may be due to flaws in identifying the relevant exchange rate regime, and we introduce a new dataset that allows overcoming these drawbacks.

So far, the existing literature offers several approaches to analyze the relationship between exchange rate regimes and FDI. Those studies that explore whether exchange rate stability raises *aggregate* FDI inflows into a country focus on the question whether the domestic currency is pegged against one "anchor" currency (see Abbott et al., 2012 or Cushman and De Vita, 2017). However, this approach ignores the fact that officially pegging to one currency is uninformative about the exchange rate regime prevailing vis-à-vis *other* potential FDI source countries. Moreover, given the uncertainty about which currency is the relevant anchor, the resulting classification is subject to some arbitrariness and may undergo sudden changes.[3] An example from the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) demonstrates why the use of unilateral data can be misleading: Until the year 2006, AREAER classified Germany – being a member of the euro area – as having an exchange rate arrangement *with no separate legal tender*.[4] The AREAERs covering the years 2007 and later classify Germany as having a *freely floating exchange rate arrangement*, since the exchange rate of the euro against the US dollar and many other currencies is flexible. What is then the correct description of Germany's exchange rate arrangement? Both classifications are correct, depending on whether the respective counterparty of Germany is a member of the euro area or not.

Such problems can be mitigated by shifting the focus from *aggregate* to *bilateral* FDI flows, and by relating these flows to the stability of *bilateral* exchange rates.[5] In their analysis of the relationship between exchange rate stability and *goods trade*, Klein and Shambaugh (2006), Klein and Shambaugh (2008) and Dorn and Egger (2013) use "de-facto bilateral exchange rate arrangements" which are based on the approach of Shambaugh (2004). To our knowledge, nobody has extended this approach to the analysis of bilateral FDI flows so far.[6] Moreover, considering *observed* exchange rate volatility as a potential determinant of international

[3] The effort devoted by Ilzetzki et al. (2017) to identifying the correct anchor currency for a large set of countries illustrates the relevance of this claim.

[4] Throughout the paper, the terms "exchange rate regime" and "exchange rate arrangement" will be used interchangeably.

[5] Such studies have been made increasingly feasible by the growing availability of bilateral investment data which are based, e.g., on the IMF's Coordinated Direct Investment Survey (CDIS) and Coordinated Portfolio Investment Survey (CPIS).

[6] Busse et al. (2013) use data on *unilateral de-facto* exchange rate regimes to explain *bilateral* FDI flows.

*investment* – rather than trade – meets two important problems: First, fluctuations of the exchange rate are endogenous, potentially reacting to international capital flows and investment decisions. Second, and perhaps more importantly, investment decisions are based on expectations about the future, and *ex-ante announcements* about exchange rate policies should therefore be at least as relevant as *ex-post observations* on de-facto exchange rate volatility.[7]

Another strand of literature analyzes the effect of *currency unions* on FDI (see, e.g., Schiavo, 2007). However, while the sharing of a common currency represents a particularly strong ex-ante commitment to exchange rate stability, the findings of these studies are uninformative about the influence of *other* exchange rate arrangements. We argue that the potential benefits of exchange rate stability may not exclusively apply to countries that are in a currency union, but also to other types of hard pegs – e.g. currency boards. Moreover, similar benefits are likely to result from conventional pegged arrangements as long as the peg is not expected to change, and it should also hold – albeit to a smaller extent – for currencies whose exchange rate fluctuations are significantly dampened by the actions of some monetary authority, for example crawling pegs, crawl-like arrangements and exchange rates pegged within horizontal bands.

This brief review illustrates the desirability of using data on the stability of *bilateral* exchange rates that are based on *policy announcements* rather than observed exchange rate fluctuations, and that do not only focus on currency-unions as a special version of a fixed bilateral exchange rate. So far, such data does not exist, and this is the gap our paper tries to close.[8]

We estimate a gravity equation that includes the *bilateral de-jure exchange rate regime* as a potential determinant of bilateral FDI. The construction of these exchange rate regimes is based on an algorithm that processes data from the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER), and that combines information on each country's official exchange rate regime vis-à-vis all potential anchor currencies. Eventually, we come up with a *bilateral exchange rate flexibility index*, which ranges from one (hard pegs) to ten (pure

[7]In one of their robustness checks, Klein and Shambaugh (2006) also use a bilateral regime classification that is based on countries' *official announcements*. However, their analysis only distinguishes between pegs and non-pegs, while our taxonomy (introduced below) allows for a much richer set of regime choices.

[8]We thus follow up on Abbott et al. (2012) who caution that an exchange rate is usually pegged to only one currency, but is implicitly floating vis-à-vis many other currencies. In fact, the authors explicitly stress the desirability of examining the effect of *bilateral* exchange rate regimes.

floats), and a set of dummy variables that distinguish between seven bilateral exchange rate regimes.[9]

By applying our new dataset, we show that, compared to freely floating exchange rates, countries that are linked by a non-floating exchange rate regime attract significantly more FDI from each other. More specifically, we find that exchange rate regimes with no separate legal tender are most favorable to FDI. Once we focus on different country groups, it turns out that developing countries attract significantly more FDI flows under both conventional pegs and other soft pegs than under (official) floats. By contrast, the relationship between announced exchange rate stability and FDI is non-monotonic for developed economies. These results are robust with respect to various sample variations and the use of alternative empirical approaches.

The rest of the paper is structured as follows: Section 1.2 demonstrates why expected nominal exchange-rate volatility may matter for FDI. It presents a simple partial-equilibrium model which analyzes the decision of a firm that has to decide between different modes of market entry (exports vs. FDI) and faces a proximity/concentration trade-off. The volatility of the nominal exchange rate is relevant since firms have to set their prices one period in advance. Using this model, we derive the hypothesis that a lower expected volatility of the nominal exchange rate makes FDI more attractive relative to exports, regardless of whether an exporting firm would set its prices in the domestic or in the foreign currency. Section 1.3 describes the construction of the new dataset on *bilateral de-jure exchange rate regimes* and outlines our empirical methodology. Section 1.4 presents our estimation results, section 1.5 discusses further extensions, and section 1.6 concludes.

## 1.2 A simple model of expected nominal exchange rate volatility and FDI

### 1.2.1 Motivation

While the intuitive arguments brought forward in favor of a positive effect of exchange rate stability on FDI – the elimination of disturbances in relative prices

[9] Our data set on bilateral exchange rate regimes is available on the homepage of International Economics at Johannes Gutenberg University Mainz (http://www.international.economics.uni-mainz.de/).

and, possibly, currency conversion costs (Santos Silva and Tenreyro, 2010) – are compelling, there are few theoretical analyses of this relationship. This is surprising, since it is far from obvious why and how the volatility of a *nominal* variable should affect firms' choices between different production locations and different modes of market supply (exports vs. FDI). An exception is the study of Aizenman (1992). His model focuses on horizontal FDI and stresses the diversification of risks as the main reason of firms' internationalization. Aggregate investment is found to be higher under a fixed exchange rate regime than under a flexible regime. Since FDI is part of aggregate investment, it is also expected to increase if a fixed regime is adopted. However, the paper does not directly model the decisions of multinational enterprises. Moreover, it distinguishes only between two exchange rate arrangements: flexible and fixed regimes, describing a fixed exchange rate as an integration of national money markets, i.e. a currency union. Our model introduced below suggests that the potential benefits of expected exchange rate stability should be investigated for *all* types of regimes, not only for the special case of currency unions.

To analyze the influence of expected nominal exchange rate volatility on FDI, we present a simple partial equilibrium model that focuses on firms' choice between exports and horizontal FDI.[10] Combining the well-known proximity-concentration trade-off with the assumption of short-run price rigidity, we show that a higher variance of the nominal exchange rate induces firms to export instead of producing abroad. Ceteris paribus, we should thus expect countries with a fixed exchange rate vis-à-vis another country to attract more FDI from that country.

### 1.2.2 Model structure

We consider a representative firm that serves a foreign market, and that enjoys monopoly power with respect to the good it produces. Firm owners are risk neutral, hence managers are guided by the objective to maximize the firm's expected profit. In the foreign market, the firm faces a demand function that is characterized by a constant elasticity of demand, i.e.

$$X_t = (P_t)^{-\theta} \tag{1.1}$$

[10]Using the WTO's terminology, firms thus decide whether to supply foreign markets via "mode 1" or "mode 3".

In equation (1.1), $P_t$ represents the price faced by consumers, and $\theta > 1$ is the demand elasticity in absolute value. If the firm produces domestically, average costs equal marginal costs, and for simplicity we set them equal to one. However, exports are associated with trade costs, which raise the firm's effective marginal costs to a level of $\tau > 1$ (in domestic currency units). By contrast, if the firm produces abroad – i.e. engages in horizontal FDI – it faces a constant marginal cost of $\kappa$ (in foreign currency units). Moreover, it has to incur a fixed cost $C$ (in domestic currency units), which reflects the cost of running an additional facility, and which is at the heart of the well-known proximity/concentration trade-off (Brainard, 1997; Helpman et al., 2006).

Our crucial assumption is that the firm has to set its price one period before it observes the realization of the nominal exchange rate, and that it adjusts its supply to demand.[11] Exchange rate fluctuations are the only source of uncertainty, and the effect of such fluctuations on profits depends both on the firm's mode of entry and on its pricing strategy:

- If the firm supplies the market by producing abroad (**horizontal FDI**), there is no uncertainty with respect to the amount produced since – by assumption – demand only depends on prices, which are predetermined in the customers' currency. However, revenues have to be converted into the domestic currency by using the (ex-ante uncertain) nominal exchange rate.
- If the firm supplies the market by producing domestically and exporting, costs are denominated in domestic currency units. With respect to its pricing decision, the firm has the choice between two alternatives:
  - The firm can set the price in domestic currency-units (**Producer Currency Pricing, PCP**). In this case, the price faced by foreign customers – and thus their demand and the firm's output – depends on the nominal exchange rate.
  - Alternatively, the firm can set the price in foreign-currency units (**Local Currency Pricing, LCP**). In this case, the demand by foreign customers – and thus the firm's output – is predetermined. However, the size of revenues (denominated in domestic currency units) depends on the nominal exchange rate.

[11] By considering a firm's pricing decision in the presence of nominal rigidities, our analysis is reminiscent of Bacchetta and van Wincoop (2005) who, however, do not allow for the option of engaging in FDI.

In what follows, we will first consider the choice between PCP and LCP for an exporting firm. As we will show, the firm chooses PCP unless the exchange rate is expected to remain constant (in which case the firm is indifferent between PCP and LCP). In a next step, we will then focus on the export vs. FDI decision.

### 1.2.3 Exports vs. FDI

Using our assumptions on demand and cost functions, we start by defining an exporting firm's expected profit (as of period $t$) for the case of producer currency pricing and local currency pricing, respectively. We denote the price set by a firm choosing PCP – a "PCP-firm" – by $P_t^{PCP}$, and the price set by a "LCP-firm" by $P_t^{LCP}$. Recall that a firm that produces domestically and exports its output does not face a fixed cost, but that marginal costs including trading costs are given by $\tau$. Denoting a firm's profit by $\Pi$, we can thus write

$$\mathbf{E}_t(\Pi_{t+1}^{PCP}) = \left(P_t^{PCP} - \tau\right) \mathbf{E}_t \left[ \left( \frac{P_t^{PCP}}{E_{t+1}} \right)^{-\theta} \right] \tag{1.2}$$

$$\mathbf{E}_t(\Pi_{t+1}^{LCP}) = \left[\mathbf{E}_t \left(E_{t+1}\right) P_t^{LCP} - \tau\right] \left(P_t^{LCP}\right)^{-\theta} \tag{1.3}$$

Here, the (bold-type) letter $\mathbf{E}$ denotes the expectations operator, while $E_{t+1}$ reflects the nominal exchange rate in period $t+1$. Note that we are using the price notation, i.e. the nominal exchange rate reflects the price of the foreign currency in terms of domestic currency units, and an increase of $E_{t+1}$ reflects a *nominal depreciation* of the domestic currency. The crucial difference between the two pricing decisions is that, in case of PCP, the uncertainty stems from the effect of exchange rate fluctuations on demand. By contrast, there is no uncertainty about demand in the case of LCP, since the price is fixed ex-ante in the customers' currency. However, exchange rate fluctuations affect the difference between revenues and costs. For the sake of simplicity, we assume that $\mathbf{E}_t(E_{t+1}) = 1$.

In period $t$, the firm chooses its optimal price, accounting for the specific type of uncertainty that it is exposed to. Solving for the optimal price of a PCP-firm yields

$$P_t^{PCP,opt} = \frac{\theta}{\theta - 1}\tau \tag{1.4}$$

Substituting this into the definition of a PCP-firm's expected profit yields

$$\mathbf{E}_t(\Pi_{t+1}^{PCP,opt}) = \Theta\tau^{1-\theta}\mathbf{E}_t\left[(E_{t+1})^{\theta}\right] \tag{1.5}$$

with $\Theta \equiv \theta^{-\theta}(\theta-1)^{\theta-1}$. Performing the same steps for a LCP-firm yields the optimal price

$$P_t^{LCP,opt} = \frac{\theta}{\theta-1}\frac{\tau}{\mathbf{E}_t(E_{t+1})} \tag{1.6}$$

which equals $P_t^{PCP,opt}$, due to our assumption that $\mathbf{E}_t(E_{t+1}) = 1$. A LCP-firm's maximal expected profit is given by

$$\mathbf{E}_t(\Pi_{t+1}^{LCP,opt}) = \Theta\tau^{1-\theta} \tag{1.7}$$

Obviously, the two expressions for expected profits are not the same, and it is easy to show that $\mathbf{E}_t(\Pi_{t+1}^{PCP,opt}) > \mathbf{E}_t(\Pi_{t+1}^{LCP,opt})$ if $\mathbf{E}_t\left[(E_{t+1})^{\theta}\right] > 1$. Given the assumption that $\theta > 1$, it follows from Jensen's inequality that this inequality is satisfied. Hence, firms who decide to supply the foreign market by exporting (instead of engaging in FDI) choose to set prices in their own currency, i.e. select PCP, unless the exchange rate is fixed. In the latter case, the firm is indifferent between the two alternatives.[12]

We now turn to the scenario that the firm runs a facility abroad to supply the foreign market. In this case, it faces marginal costs $\kappa$ (in foreign currency units) and a fixed cost $C$ (in domestic currency units). The expected profit (in domestic currency units) of a firm engaged in foreign direct investment (an "FDI-firm") can thus be written as

$$\mathbf{E}_t(\Pi_{t+1}^{FDI}) = \mathbf{E}_t\left(E_{t+1}\right)\left(P_t^{FDI}-\kappa\right)\left(P_t^{FDI}\right)^{-\theta} - C \tag{1.8}$$

Apparently, the optimal price does not depend on the exchange rate, and we can easily derive

[12] As shown by Bacchetta and van Wincoop (2005), this result holds even if the firm's marginal cost function is non-linear, as long as the elasticity of costs with respect to output is smaller than $1 + 1/\theta$.

$$P_t^{FDI,opt} = \frac{\theta}{\theta - 1}\kappa \tag{1.9}$$

Substituting this expression into the definition of expected profits and using the assumption that $\mathbf{E}_t(E_{t+1}) = 1$ yields

$$\mathbf{E}_t(\Pi_{t+1}^{FDI,opt}) = \Theta\kappa^{1-\theta} - C \tag{1.10}$$

As we have seen above, an exporting firm strictly prefers PCP over LCP unless the exchange rate is fixed. To find out how exporting under PCP compares to (horizontal) FDI, we have to compare the expressions in (1.5) and (1.10). Such a comparison demonstrates that exporting is strictly preferred over FDI if

$$\Theta\tau^{1-\theta}\mathbf{E}_t\left[(E_{t+1})^{\theta}\right] > \Theta\kappa^{1-\theta} - C \tag{1.11}$$

To shed more light on the role of exchange rate volatility, we take a second-order approximation to $\mathbf{E}_t\left[(E_{t+1})^{\theta}\right]$ in the point $\mathbf{E}_t(E_{t+1}) = 1$. This yields

$$\mathbf{E}_t\left[(E_{t+1})^{\theta}\right] \approx 1 + \frac{\theta(\theta-1)}{2}Var_t(E_{t+1}) \tag{1.12}$$

where $Var_t(E_{t+1})$ is the (conditional) variance of the nominal exchange rate. Inserting (1.12) into (1.11), we find that horizontal FDI is strictly preferred over exporting with PCP if

$$Var_t(E_{t+1}) < \frac{2}{\theta(\theta-1)}\left[\left(\frac{\tau}{\kappa}\right)^{\theta-1} - 1\right] - \frac{2C}{(\theta-1)^{\theta}\theta^{1-\theta}\tau^{1-\theta}} \tag{1.13}$$

Figure 1.1 illustrates this relationship for $\theta = 2$ by depicting the RHS of (1.13) as a function of $\left(\frac{\tau}{\kappa}\right)$, the ratio of marginal costs of domestic production $\tau$ (including transport costs) over expected marginal costs of foreign production $\kappa$ in domestic currency units.[13]. The critical level of relative costs above which the firm prefers FDI over exporting, $\left(\frac{\tau}{\kappa}\right)^{crit}$, is determined by the point of intersection between the RHS and $Var_t(E_{t+1})$. Let's first consider the case of $Var_t(E_{t+1}) = 0$, i.e. a fixed exchange rate. In this case, horizontal FDI is preferred over exporting if marginal costs of production abroad ($\kappa$) are much lower than marginal costs

[13]To transform $\kappa$ into domestic currency units, we compute $E_{t+1}\kappa$. Recall that $\mathbf{E}_t(E_{t+1}) = 1$.

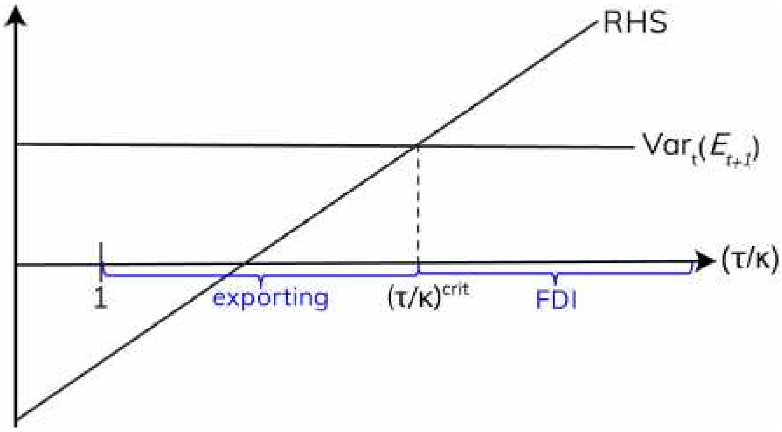



FIGURE 1.1: The critical level of relative domestic production costs (for $\theta = 2$). If $\left(\frac{\tau}{\kappa}\right) < \left(\frac{\tau}{\kappa}\right)^{crit}$ the firm supplies the foreign market by exporting its output. If $\left(\frac{\tau}{\kappa}\right) > \left(\frac{\tau}{\kappa}\right)^{crit}$ the firm serves the foreign market through a subsidiary, i.e. engages in FDI.

including transportation costs ($\tau$), such that cost savings per unit produced abroad dominate the fixed cost ($C$) associated with running an additional plant. This is the standard proximity-concentration trade-off. If the exchange rate is *not* fixed, the left hand side of the inequality in (1.13) is greater than zero, and exporting with PCP may become attractive relative to FDI even if a firm would have chosen FDI under a fixed exchange rate. Increasing $Var_t(E_{t+1})$ shifts the horizontal line upward and raises $\left(\frac{\tau}{\kappa}\right)^{crit}$: the more volatile the exchange rate, the greater the level of $\left(\frac{\tau}{\kappa}\right)$ at which exporting is still more attractive than FDI.

While our partial equilibrium model has considered the decision of only one firm, it can easily be extended to explain *total* bilateral FDI flows between two countries. Suppose that the fixed costs of running a foreign plant ($C$) differ across domestic firms. In this case, the critical threshold $\left(\frac{\tau}{\kappa}\right)^{crit}$ is firm-specific and increasing in $C$. If exchange rate volatility is high, only a small share of firms engages in FDI. Once the variance of the exchange rate declines, FDI becomes attractive for a larger number of firms, and aggregate (bilateral) FDI increases.[14] Note, finally,

[14]The same reasoning can be applied with respect to differences in *relative* costs $\left(\frac{\tau}{\kappa}\right)$ across firms. By contrast, the isolated effect of domestic production and trading costs ($\tau$) is more complex: equation (1.13) indicates that, for a given level of $\kappa$, a lower value of $\tau$ has an ambiguous effect on the attractiveness of FDI. Note, finally, that the negative relationship between exchange rate volatility and FDI holds even if the condition in footnote 11 is not satisfied. In that case, exporting firms decide to set their prices in the importers' currency (LCP). As a consequence, profits are a linear function of the exchange rate – as they are if firms engage in horizontal FDI. Expected profits are thus unaffected by the volatility of the exchange rate, and the choice between exports and FDI does not depend on the exchange rate regime. Under the (plausible) assumption that firms face different demand and cost structures, with some firms choosing PCP and others LCP, the expectation of a stable exchange rate has a positive influence on *aggregate* FDI.

that if we shift our focus from *horizontal* to *vertical* FDI, with firms selling their output exclusively on the domestic market, but possibly producing it abroad, it turns out that the volatility of the exchange rate does not matter. As we show in Appendix 1.A.1, this is because in case of vertical FDI, the nominal exchange rate affects firms' profits in a linear fashion. We are thus left with no clear hypothesis on the relevance of the exchange rate regime for *vertical* FDI, while our model suggests an unambiguously positive effect of exchange rate stability on *horizontal* FDI. Since there is no reason to believe that the relative importance of vertical vs. horizontal FDI is affected by factors that are correlated with the exchange rate regime, we argue that the mechanisms desribed by our model dominate the relationship between the exchange rate regime and total FDI flows.

We have thus derived a simple testable hypothesis: if we consider two country pairs which are identical except for the prevailing exchange rate regime, the countries that are linked by a fixed exchange rate should be characterized by more bilateral FDI . In fact, if we abandon the notion of a world with just two extreme exchange rate regimes (pegs and floats), the above result suggests a more nuanced version of the hypothesis: the more flexible the exchange rate regime – i.e. the more we depart from a credible peg – the lower the volume of bilateral FDI that we should observe. Note that all these statements refer to decisions at time $t$, i.e. firms have to form expectations about the variability of the exchange rate in period $t + 1$. We argue that this expectation crucially hinges on policy announcements, i.e. on the *de-jure* exchange rate regime in place.

## 1.3 Bilateral de-jure exchange rate regimes: data and methodology

### 1.3.1 Data on exchange rate regimes

The IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) has been tracking exchange arrangements and capital flow restrictions for all member countries starting as early as 1950. The AREAERs include country chapters that contain information about the exchange rate structure as reported by the member countries, thus providing us with *de-jure exchange rate regimes.* Starting in 2001, the IMF has been adding valuable information on members' de-facto exchange rate policies, as analyzed by IMF staff, thus also identifying

| 1998 System | 2009 System | Exchange rate flexibility (index) | Exchange rate regime |
|---|---|---|---|
| *Hard pegs* | | | |
| No separate legal tender | No separate legal tender | 1 | $Regime_1$ |
| Currency board arrangement | Currency board arrangement | 2 | $Regime_2$ |
| *Soft pegs* | | | |
| Conventional (fixed) peg | Conventional pegged arrangement | 3 | $Regime_3$ |
| - | Stabilized arrangement | 4 | $Regime_4$ |
| Crawling peg | Crawling peg | 5 | $Regime_4$ |
| Crawling band | Crawling-like arrangement | 6 | $Regime_4$ |
| Pegged within horizontal bands | Pegged within horizontal bands | 7 | $Regime_5$ |
| - | Other managed (residual) | 8 | $Regime_5$ |
| *Floating arrangements* | | | |
| Managed floating | Floating | 9 | $Regime_6$ |
| Independently floating | Free floating | 10 | $Regime_7$ |

Table 1.1: AREAER exchange rate arrangements based on old and revised methodology, mapping into a *exchange rate flexibility index* and *regime dummies* (source: AREAER, IMF)

members' *de-facto regimes*. These de-facto regimes may differ from countries' officially announced arrangements (IMF, 2001).

We use the *unilateral* de-jure exchange rate regimes published in the AREAER as the basic building block for our new *bilateral* dataset. The reason is that the *de-facto* regimes are mainly built on the behavior of the exchange rates observed *ex-post* and as such may not appropriately capture the potential effect of ex-ante announcements on firms' expectations. Of course, it is possible that the credibility of an announced regime breaks down – e.g. if a country decides (or is forced) to abandon a peg currently in place (for example as a result of a currency crisis). Moreover, a country may deliberately decide to implement an exchange rate regime that differs from the announced policy. We will later use two ways to account for these possibilities: first, we will exclude observations from countries that experienced a currency crisis in the years covered by our dataset. Second, we will use a set of *de-facto* bilateral exchange rate regimes based on the classification by Ilzetzki et al. (2017) which, in our interpretation, reflects the degree of exchange rate stability actually implemented (but not necessarily announced) by monetary authorities.

Based on the IMF's information on unilateral de-jure exchange-rate regimes, we construct a (bilateral) "exchange-rate flexibility index" ($ERflex$) running from 1 to 10, with 1 reflecting hard pegs with no separate legal tender and 10 the complete absence of any exchange-rate target, i.e. a pure float. The mapping of the IMF's definitions into that index is described in Table 1.1.[15] The last column of the table describes the mapping of the flexibility index into a – somewhat coarser – set of seven *dummy variables* that identify different (sets of) regimes ($Regime_i$).[16] Note that, while we adopt the IMF's terminology and categories, our classification characterizes *bilateral* exchange rate regimes. The construction of these bilateral relationships will be described in the following subsection.

#### 1.3.1.1 Constructing a dataset on bilateral de-jure exchange rate regimes

The basic structure of our algorithm builds on the observation that most countries that do not let their currency float freely are pegging it either to the U.S. dollar (USD) or to the euro (EUR).[17] Referring to the "exchange rate flexibility index" introduced above, the strength of the peg against the U.S. dollar or euro may take values between 1 (no separate legal tender) and 9 (managed floating). The USD/EUR exchange rate itself is freely floating and thus gets a value of 10. Therefore, all countries that are pegging against the U.S. dollar to some extent are at the same time implicitly freely floating against all Eurozone countries and all the euro peggers. Also, all countries pegging to the euro are at the same time implicitly floating against both the U.S. and all U.S. dollar peggers. However, this does not exhaust the set of potential constellations – in particular those situations when countries' currencies are pegged to the same anchor (USD or EUR), but differ in the strength of the commitment.

Table 1.2 illustrates our approach by means of a simple example containing six countries. The matrix shows that the United States as well as U.S.-dollar peggers such as Uzbekistan and Jordan are categorized as freely floating – i.e. exhibiting a value of 10 – towards the euro area countries Germany and Austria and a euro pegger such as Denmark. Further, Uzbekistan is classified as having a crawling peg against the US dollar and therefore takes a value of 6 vis-à-vis the USD. Jordan is classified as having a conventional peg against the US dollar and therefore takes a

[15]Starting in the year 2009, the IMF has revised its system for the classification of exchange rate arrangements. More specifically, "managed floating with no predetermined path for the exchange rate has become too heterogeneous" and there was a need to make a further distinction between formal fixed and crawling pegs, and arrangements that are merely peg-like or crawl-like (see IMF AREAER, 2009, page xliv (44) in Appendix). Table 1.1 refers to both the old and the new methodology.

[16]We do not map $ERflex_{ijt}$ into a full set of ten dummies because some exchange rate regimes (such as "crawl-like arrangements") have too few observations. In fact, the categories of "stabilized arrangements" and "other managed" regimes did not even exist before the year 2009.

[17]Of course, we also account for the (rather rare) cases that currencies are pegged against alternative anchors such as the Indian rupee, the South African rand or the Singapore dollar.

| | U.S. | Uzbekistan | Jordan | Germany | Austria | Denmark |
|---|---|---|---|---|---|---|
| U.S. | - | 6 | 3 | 10 | 10 | 10 |
| Uzbekistan | 6 | - | 6 | 10 | 10 | 10 |
| Jordan | 3 | 6 | - | 10 | 10 | 10 |
| Germany | 10 | 10 | 10 | - | 1 | 3 |
| Austria | 10 | 10 | 10 | 1 | - | 3 |
| Denmark | 10 | 10 | 10 | 3 | 3 | - |

Table 1.2: Computing bilateral exchange-rate regimes: an example

value of 3. What is then the implicit exchange rate regime between Uzbekistan and Jordan? Here and for all similar cases in our dataset, we focus on the *weakest link* between the two countries, i.e. we assume that market participants' perception of the stability of the bilateral exchange rate is dominated by the more flexible regime vis-à-vis the two countries' anchor currency. The bilateral exchange rate regime between Uzbekistan and Jordan thus takes a value of $MAX(3,6) = 6$.

Taking the *weakest link* for the countries that are pegging their exchange rates is plausible if we are willing to assume that the interventions of an individual country with respect to the U.S. dollar (euro) do not influence the actions of other peggers against the same currency. In this case there is no reason to believe that the exchange rate regime between Uzbekistan and Jordan should be less flexible than the exchange rate regime between Uzbekistan and the U.S. As another example, we can take Bolivia, which has a crawling peg against the U.S. dollar ($ERflex_{BOL,USA} = 5$), and El Salvador, which has no separate legal tender against the U.S. dollar ($ERflex_{SLV,USA} = 1$). As a consequence, the implicit de-jure exchange rate regime between El Salvador and Bolivia must be the same as the explicit de-jure exchange rate regime between the U.S. and Bolivia, computed as $ERflex_{BOL,SLV} = MAX(1,5) = 5$.[18] We conjecture that market participants are able (and have enough incentives) to replicate our algorithm and are thus aware of bilateral de-jure exchange rate regimes although there is no institution that explicitly publishes such information. A graphical representation of how we

[18]Expressing this idea in more formal terms starts from the fact that the nominal exchange rate between currencies $A$ and $B$, which both peg their currencies to some extent against the common anchor currency $C$, can be expressed as $E_{A,B} = E_{A,C} \cdot E_{C,B}$, with the first subscript letter denoting the base currency and the second letter denoting the counter currency. Taking logarithms and defining $e \equiv ln(E)$ yields $e_{A,B} = e_{A,C} + e_{C,B}$. The variance of the left-hand side is given by $Var(e_{A,B}) = Var(e_{A,C}) + Var(e_{C,B}) + 2Cov(e_{A,C}, e_{C,B})$. Apparently, $Var(e_{A,B}) = Var(e_{C,B})$ if $Var(e_{A,C}) = 0$. If none of the two variances is zero, it is quite plausible to assume that $Cov(e_{A,C}, e_{C,B}) < 0$, reflecting appreciations and depreciations of currency $C$ against *all* other currencies. But even in this case, $Var(e_{A,B})$ is likely to be dominated by the larger of the two variances vis-à-vis currency $C$.

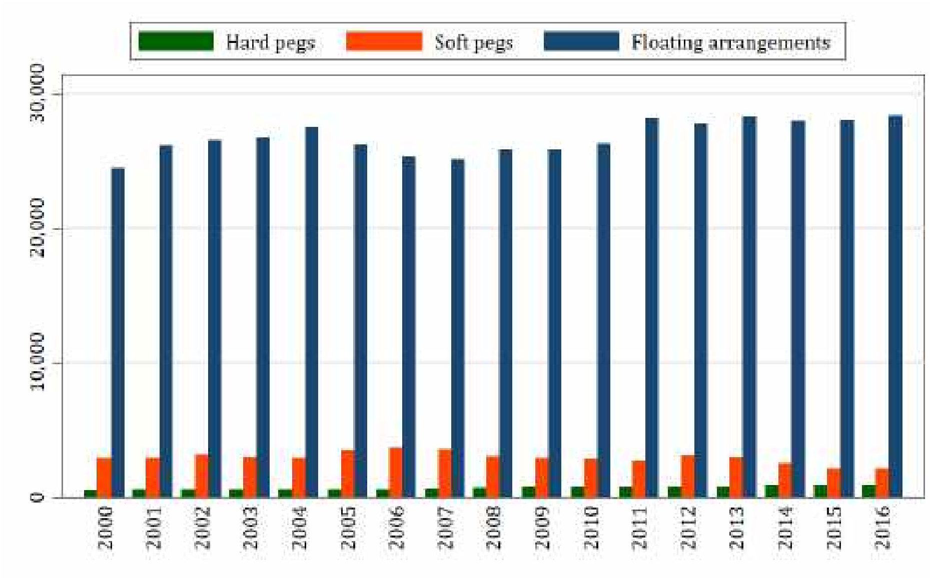



FIGURE 1.2: The number of bilateral de-jure exchange rate regimes (coarse categories) between 2000 and 2016. Source: IMF and own computations

constructed our set of bilateral de-jure exchange rate regimes can be found in Figure 1.7 (in Appendix 1.A.2).

When we apply this algorithm to our entire sample we get a symmetric 185x185 matrix for each year between 2000 and 2016, covering 185 countries, resulting in a total of 516 384 observations. The panel is not balanced since we dropped 10 percent of the observations for countries that were pegging their exchange rate to a composite index containing several currencies.

Figure 1.2 illustrates how the distribution of bilateral exchange rate regimes evolved over time. To draw this figure, we assigned the ten different regimes to three groups: Hard pegs ($ERflex_{ij} = 1, 2$), soft pegs ($ERflex_{ij} = 3, 4, 5, 6, 7, 8$) and floating arrangements ($ERflex_{ij} = 9, 10$). It can be seen from Figure 1.2 that hard pegs make up only a small share of bilateral exchange rate regimes. This is not surprising, given our approach to use the more flexible of two exchange rate regimes towards a respective anchor currency. Also, from a bilateral perspective only a relatively small share of countries is connected via direct or indirect soft pegs.

### 1.3.2 Empirical specification

Our goal is to estimate the effect of de-jure bilateral exchange rate flexibility on FDI. While our model described firms' choice between different modes of serving a foreign market – via exports or through a foreign affiliate – our empirical analysis will focus on *direct investment flows* as a dependent variable. Of course, foreign-affiliate sales would be preferable, but we argue that, in the absence of such (bilateral) data, FDI flows are an appropriate proxy for these sales. Moreover, our regression equation includes a large set of variables that reflect the *general* attractiveness of the foreign market, such that the inclusion of the exchange rate regime allows identifying the effect of exchange-rate stability on the mode of supply (affiliate sales vs. exports).

We use the Pseudo Poisson Maximum Likelihood (PPML) estimator introduced by Santos Silva and Tenreyro (2006) in order to avoid two important drawbacks of OLS estimation: first, the standard procedure of considering the logarithm of the dependent variable implies that observations with zero values are dropped. Second, as demonstrated by Santos Silva and Tenreyro (2006), OLS estimation of log-linearised models results in biased estimates if the disturbances are heteroskedastic. Our PPML model specification reads as follows:

$$FDI_{ijt} = exp(\alpha_0 + \beta ERflex_{ijt} + \delta' W_{ijt} + \phi' X_{jt} + \lambda' Y_{it} + \varphi' Z_{ij} + \alpha_i + \alpha_j + \xi_t) + \varepsilon_{ijt} \quad (1.14)$$

where $FDI_{ijt}$ denotes direct investment inflows from country $i$ (source) to country $j$ (host) at time $t$. $ERflex_{ijt}$ denotes the exchange rate flexibility index taking the values from 1 to 10, as described in Table 1.1. Based on the theoretical results from Section 1.2, we expect the coefficient $\beta$ to be negative and statistically significant. $W_{ijt}$ denotes a set of bilateral time-variant control variables, $X_{jt}$ ($Y_{it}$) denotes a set of time-variant control variables of the host (source) country, $Z_{ij}$ denotes a set of bilateral time-invariant control variables, $\alpha_i$ ($\alpha_j$) denotes source (host) country fixed effects and $\xi_t$ denotes year fixed effects. In one of our robustness checks in Section 1.5, we will later replace country-specific variables by *time-variant* country fixed effects.

While the specification in equation (1.14) uses the "linear" exchange rate flexibility index ($ERflex_{ijt}$), we also test for the existence of non-linear effects of exchange-rate stability by employing the set of *Regime* dummies defined in Table 1.1. In this case, the model specification for the PPML estimator is given by

$$FDI_{ijt} = exp(\alpha_0 + \sum_{k=1}^{6} \beta_k Regime_{k,ijt} + \delta' W_{ijt} + \phi' X_{jt} + \lambda' Y_{it} + \varphi' Z_{ij} + \alpha_i + \alpha_j + \xi_t) + \varepsilon_{ijt} \tag{1.15}$$

where $Regime_{k,ijt}$ is an exchange rate regime dummy, with $k$ ranging from 1 (no separate legal tender) to 6 (managed floating). The dummy characterizing bilateral free floats ($k = 7$) is excluded, such that $\beta_k$ reflects the differential impact of regime $k$ on FDI, relative to the case of a pure float.

Note that we do not include *country-pair fixed effects* since our main variable of interest – the bilateral de-jure exchange rate regime – exhibits little time variation in the period under consideration. This is illustrated by Figure 1.3, which reports the share of annual changes in de-jure exchange rate regimes. In the period we consider (2000 to 2016), the average share of countries that changed their bilateral exchange rate regime from one year to another is below 5 percent.

Apart from determining our empirical approach, the low time-series variation in bilateral de-jure exchange rate regimes is also important from a conceptual perspective: if most of the regimes were rather short-lived, it would be hard to argue that they really anchor investors' assessment of exchange rate-volatility. In fact, Klein and Shambaugh (2008) provide evidence that, during the period 1973-2004, a large number of exchange rate regimes had a very short duration. To meet this concern, we also report the duration of bilateral de-jure exchange rate regimes for our sample period 2000 - 2016 (see Figure 1.4). Our data show a pattern that is very different from what Klein and Shambaugh (2008) found, with most of the exchange rate regimes remaining unchanged for the whole period from 2000 to 2016 (17 years). This is particularly striking for hard pegs, where we see that the vast majority of arrangements lasted for the entire sample period. We believe that the difference between our findings and those of Klein and Shambaugh is driven by two factors: first, there was much less flipping back and forth in countries' exchange rate regimes after the start of the 2000s than in the more distant past (e.g. no country leaving the Eurozone / ERM II, a lower number of emerging-market currency crises after the tumultuous 1990s). Second, our dataset is based on *de-jure*, instead of *de-facto* regimes, with the former reflecting *policy announcements* and the latter *observed* exchange-rate volatility. A discrepancy between the

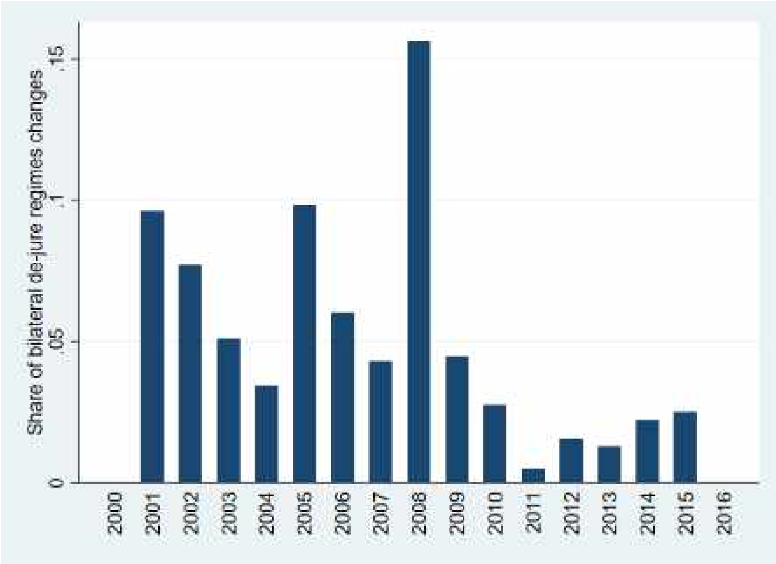



FIGURE 1.3: Shares of country-pairs that changed their bilateral de-jure exchange rate regimes in a given year (shares are ranging from 0 to 1). Bilateral regimes are classified following the coarse classification defined in the last column of Table 1.1. Source: IMF and own computations.

persistence of de-jure and de-facto arrangements arises if countries frequently deviate from the announced policies without adjusting their official exchange-rate policy – a phenomenon whose empirical relevance has been amply documented by Calvo and Reinhart (2002), Levy-Yeyati and Sturzenegger (2003) or Reinhart and Rogoff (2004). While we argue that de-jure exchange rate regimes are crucial for anchoring foreign investors' expectations, we will later explore the consequences of accounting for potential de-jure/de-facto discrepancies. As we will show in Section 1.5, the effect of de-jure stability is even stronger if the announcement is backed up by low de-facto exchange-rate fluctuations. Nevertheless, our results also demonstrate that there is a role for the de-jure regime in influencing FDI, regardless of the realized volatility of the exchange rate.

Along with the bilateral exchange-rate regime, we include several control variables that potentially affect bilateral FDI.[19] The time-variant control variables we use include the logs of the host and source countries' GDP ($LgdpH_{jt}$ and $LgdpS_{it}$); trade openness ($OpennessH_{jt}$ and $OpennessS_{it}$), defined as the sum of exports and imports over GDP, and "direct investment restrictions" on outflows from the source country and inflows into the host country ($RestrictionsH_{jt}$ and $RestrictionsS_{it}$) as published by Fernandez et al. (2016). A dummy variable reflecting countries' membership in regional trade agreements is denoted by $RTA_{ijt}$.

[19]The sources and summary statistics of these variables are listed in Tables 1.7 and 1.8 in Appendix 1.A.4.

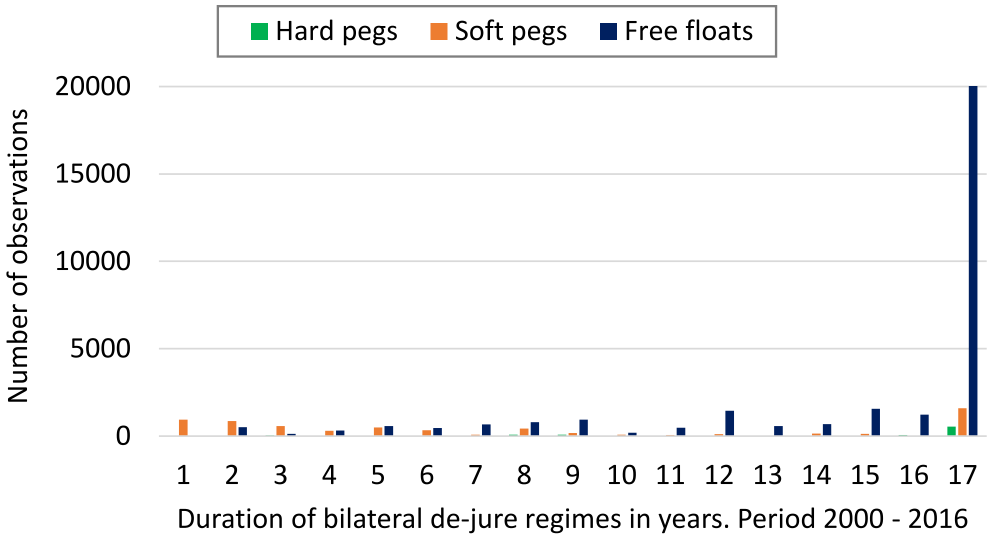



FIGURE 1.4: The number of bilateral exchange rate regimes experiencing a given duration (in years) between 2000 and 2016. Bilateral regimes are classified into three broad categories (hard pegs, soft pegs, floats). Source: IMF and own computations.

Bilateral time-invariant control variables include the (log) distance between the countries' capitals ($Ldistance_{ij}$) and dummies for a common border ($Border_{ij}$), a common language ($Comlang_{ij}$), a common colonial history ($Colony_{ij}$) and a common religion ($Religion_{ij}$). We expect the signs of all explanatory variables – with the exception of distance – to be positive.[20]

Data on bilateral FDI flows are available for the years 2001 through 2012 and taken from UNCTAD (see Table 1.7 in Appendix 1.A.4 for more details). In our benchmark specification, we use FDI inflows instead of (bilateral) FDI stocks – mainly to avoid the influence of valuation changes, which give rise to fluctuations in FDI stocks that do not reflect variations in real activity.[21] Finally, to avoid results that are driven by multinational firms' tax optimization rather than production and supply decisions, we exclude observations for all host countries that are classified as tax havens by either OECD (2000) or Dharmapala and Hines (2006).

[20]To capture the potential importance of relative wealth effects as drivers of FDI – as suggested by Klein and Rosengren (1994) for direct investment flows into the United States – we also experimented with a specification that included the *level* of the source and host countries' *real effective exchange rates*. However, in our sample these variables never had a significant effect on bilateral FDI flows.

[21]Wacker (2015) argues that, in theory, it should not matter whether one uses FDI flows or FDI stocks, because the former are only a homogeneous function of the latter. In fact, he shows that the correlation in the data between stocks and flows is very high, indicating that the choice between the two magnitudes is not really consequential. In Section 1.5 we will report the results of estimating our model using stock data, and confirm that our findings do not change by much if we use stocks instead of flows.

## 1.4 Bilateral de-jure exchange regimes and FDI: empirical results

In the following tables, we report the results of estimating equations (1.14) and (1.15), respectively. We start by using all observations and then split the sample, depending on whether the host country is classified as a *developed* or a *developing* country by UNCTAD.[22]

### 1.4.1 Effects of Exchange Rate Flexibility

Table 1.3 reports the results of estimating equation (1.14) with host country, source country and time fixed effects. Apparently, all coefficients of the standard gravity variables have the expected sign. For example, column 1 documents that a one per cent increase in the host country's GDP is associated with a 1.18 percent increase in FDI inflows. Moreover, a one percent increase in distance is associated with a decrease in FDI by around 0.53 percent, and this effect is significant at the 99 percent level.[23]

The coefficients of the common language and colonial history dummies are positive and statistically significant. For example, countries that share a common language receive on average $(exp(0.39) - 1) \cdot 100 = 48$ percent more FDI inflows from each other.[24] The coefficients of common border and religion have the expected sign, but turn out to be statistically insignificant. Finally, the coefficients of host and source country FDI restrictions are negative (although not always significant), while the effect of a regional trade agreement ($RTA$) is significantly positive.

Turning to our main regressor of interest, we see in column 1 that the exchange rate flexibility index has a negative, but statistically insignificant effect for the entire sample. However, once we split the sample into developed and developing *host* countries, we find that $ERflex$ has a significantly negative effect on FDI

[22] The country classification is taken from UNCTAD using https://unctadstat.unctad.org/EN/Classifications.html.

[23] Note that the influence of distance on FDI is somewhat weaker than on goods trade, where the estimated elasticity tends to be around minus one percent (Shepherd, 2013). One reason may be that distance plays an ambivalent role for FDI, with greater distance reducing the attractiveness of a country as a trading partner *in general*, but also raising transport costs and thus the attractiveness of foreign-affiliate sales vs. direct exports.

[24] We follow the approach of Santos Silva and Tenreyro (2006:651) to compute marginal effects in percentage terms by using the formula $(exp(b_i) - 1) \cdot 100$, where $b_i$ is the estimated coefficient of a dummy variable.

TABLE 1.3: **Exchange rate flexibility index** (*ERflex*) and bilateral FDI flows. PPML estimation of the gravity model (equation 1.14) with host country, source country and year fixed effects

| | (1) All countries | (2) Developed* | (3) Developing* |
|---|---|---|---|
| ERflex | -0.018 | -0.061*** | -0.045 |
| | (-0.935) | (-3.406) | (-1.631) |
| LgdpH | 1.183*** | 1.168*** | 1.151*** |
| | (8.678) | (4.221) | (4.958) |
| LgdpS | 1.098*** | 0.952*** | 1.080*** |
| | (7.649) | (4.529) | (6.608) |
| Ldistance | -0.528*** | -0.567*** | -0.524*** |
| | (-8.235) | (-7.016) | (-5.550) |
| OpennessH | 0.568*** | 1.071*** | 0.491*** |
| | (3.284) | (2.964) | (2.689) |
| OpennessS | 0.127 | 0.060 | -0.073 |
| | (0.816) | (0.173) | (-0.386) |
| RestrictionsH | -0.573*** | -1.178*** | -0.186 |
| | (-2.858) | (-3.966) | (-0.809) |
| RestrictionsS | -0.628*** | -0.623*** | -0.107 |
| | (-3.345) | (-2.731) | (-0.411) |
| RTA | 0.453** | -0.175 | 0.464*** |
| | (2.309) | (-1.142) | (3.409) |
| Border | 0.212 | -0.079 | 1.281*** |
| | (1.361) | (-0.529) | (5.923) |
| Comlang | 0.389*** | 0.269** | 0.830*** |
| | (3.002) | (2.069) | (3.882) |
| Colony | 0.551*** | 0.275* | 0.625** |
| | (3.714) | (1.924) | (2.449) |
| Religion | 0.272 | 0.185 | 0.478** |
| | (1.160) | (0.579) | (2.207) |
| N | 29334 | 12030 | 15089 |
| $R^2$ | 0.53 | 0.60 | 0.83 |

** FDI inflows to developed (column 2) or developing (column 3)* ***host*** *countries. All economies are included as potential* ***source*** *countries. Host, source and year fixed effects included but not reported.*

*t statistics based on standard errors clustered at the country-pair level are given in parentheses;* $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

in *developed* countries: a move towards a less flexible exchange rate regime by 1 degree is associated with an increase in FDI flows by about 6 percent. This result is also highly economically significant: country pairs with the least flexible exchange rate regimes receive bilateral FDI flows that are on average 60 percent higher compared to country pairs with freely floating regimes. The sign of the coefficient for *developing* countries (column 3) is also negative, but narrowly misses the threshold for a 90-percent significance level.

### 1.4.2 Effects of Regime Dummies

The specification in equation (1.14) characterized countries' exchange rate regimes by using the flexibility index $ERflex$, imposing a linear relationship between de-jure exchange rate stability and FDI. In this subsection, we abandon this restriction, using the *regime dummies* described in Table 1.1 and thus allowing for a non-linear effect of exchange rate stability on FDI. When estimating the specification in equation (1.15), we hypothesize that more stable regimes are associated with higher FDI inflows. The results of this estimation are reported in Table 1.4.

The numbers presented in column (1) of Table 1.4 show that country pairs with no separate legal tender ($Regime_1$) receive on average 42 percent more FDI inflows than country pairs that are not tied through (direct or indirect) exchange rate arrangements. By contrast, the coefficient of $Regime_2$ (currency board arrangements) is significantly negative, which comes as a surprise. For all other regimes, the effects are positive, though not always significant. Interestingly, the coefficients decrease almost monotonically, as we move from $Regime_3$ (conventional pegs) to $Regime_6$ (managed floating), confirming our hypothesis that reducing the ex-ante variance of exchange rate fluctuations enhances bilateral FDI flows. Columns (2) and (3), however, demonstrate that there are substantial differences between developed and developing host economies.

Figure 1.5 illustrates the coefficients displayed in Table 1.4, omitting those coefficients that are not significantly different from zero. While the decreasing size of the (positive) coefficients for *developing* host countries supports our hypothesis that announced exchange rate stability enhances FDI inflows, the negative coefficient of regime 4 for *developed* host countries is rather surprising. We conjecture that this result may be driven by the fact that many developing *source* countries peg their currencies against developed countries, and that direct investment flows from developing to developed countries – especially horizontal FDI as described

TABLE 1.4: **Exchange rate regime dummies** and bilateral FDI flows. PPML estimation of the gravity model (equation 1.15) with host country, source country and year fixed effects

| | (1) All countries | (2) Developed* | (3) Developing* |
|---|---|---|---|
| Regime 1 | 0.361** | 0.640*** | 1.271** |
| | (2.023) | (3.879) | (2.443) |
| Regime 2 | -1.262** | -0.099 | -0.253 |
| | (-2.279) | (-0.237) | (-0.594) |
| Regime 3 | 0.360* | -0.416 | 0.528** |
| | (1.677) | (-1.642) | (2.467) |
| Regime 4 | 0.451 | -0.727* | 0.378 |
| | (1.415) | (-1.798) | (1.546) |
| Regime 5 | 0.323** | 0.295 | 0.034 |
| | (1.964) | (1.460) | (0.075) |
| Regime 6 | 0.210* | 0.276 | 0.226* |
| | (1.947) | (1.356) | (1.897) |
| LgdpH | 1.180*** | 1.165*** | 1.162*** |
| | (8.752) | (4.125) | (4.868) |
| LgdpS | 1.133*** | 0.918*** | 1.128*** |
| | (7.684) | (4.427) | (6.317) |
| Ldistance | -0.506*** | -0.570*** | -0.505*** |
| | (-7.592) | (-7.024) | (-5.138) |
| OpennessH | 0.532*** | 1.079*** | 0.470** |
| | (3.241) | (2.973) | (2.550) |
| OpennessS | 0.065 | 0.040 | -0.043 |
| | (0.414) | (0.116) | (-0.216) |
| RestrictionsH | -0.566*** | -1.160*** | -0.181 |
| | (-2.829) | (-3.853) | (-0.799) |
| RestrictionsS | -0.601*** | -0.590** | -0.142 |
| | (-3.197) | (-2.546) | (-0.517) |
| RTA | 0.422** | -0.161 | 0.460*** |
| | (2.323) | (-1.047) | (3.390) |
| Border | 0.170 | -0.091 | 1.276*** |
| | (1.165) | (-0.609) | (5.970) |
| Comlang | 0.438*** | 0.254** | 0.854*** |
| | (3.590) | (1.986) | (3.988) |
| Colony | 0.477*** | 0.285** | 0.580** |
| | (3.392) | (1.977) | (2.224) |
| Religion | 0.386* | 0.202 | 0.545** |
| | (1.791) | (0.560) | (2.442) |
| N | 29334 | 12030 | 15089 |
| $R^2$ | 0.55 | 0.60 | 0.84 |

** FDI inflows to developed (column 2) or developing (column 3)* ***host*** *countries. All economies are included as potential* ***source*** *countries. Host, source and year fixed effects included but not reported.*

*t statistics based on standard errors clustered at the country-pair level are given in parentheses;* $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

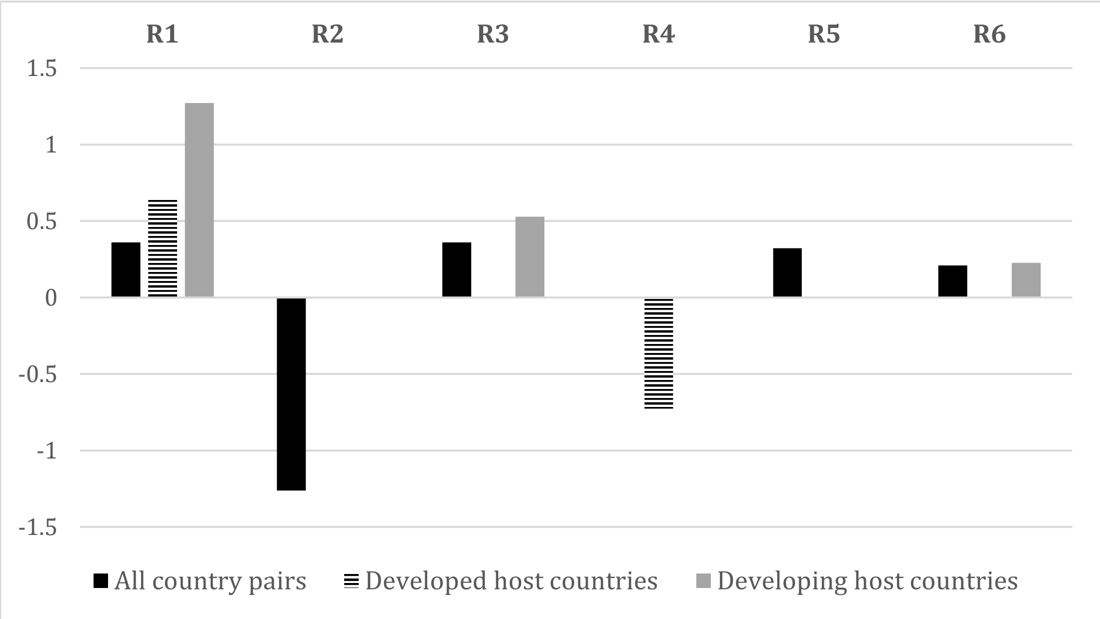



FIGURE 1.5: Effects of exchange rate regime dummies on bilateral FDI. The bars illustrate the coefficients displayed in Table 1.4, omitting those coefficients that do not significantly differ from zero

by our model – are close to zero. As a result, the negative coefficients of $Regime_3$ and $Regime_4$ may be driven by bilateral pegs, many of which are associated with zero FDI flows to developed host countries. To check whether our conjecture was correct, we re-estimated equation (1.15) for the three different host country groups, omitting observations for developing **source** countries. As demonstrated by Table 1.5, this restriction reduces our sample by 50 percent, but the resulting coefficients for developed host countries are much closer to what we would have expected. For both developed and developing host countries, the estimation with the smaller sample confirms our hypothesis that expected exchange rate stability raises FDI inflows – although the ranking of coefficients in terms of size no longer confirms the conjecture that the severity of a peg matters for FDI flows, once we split the sample.

The fact that, by and large, the influence of fixed exchange rates is stronger for developing than for developed host countries – especially when we omit developing source countries as in Table 1.5 – can be explained by referring to the higher likelihood of large exchange rate swings in developing economies. An expected reduction of exchange-rate volatility associated with an official peg is apparently more important and effective in such a context than in an environment where even flexible exchange rates are characterized by rather moderate fluctuations.

Table 1.5: Exchange rate regime dummies and bilateral FDI flows, excluding developing **source** countries. PPML estimation of the gravity model (equation 1.15) with host country, source country and year fixed effects

| | (1) All countries | (2) Developed* | (3) Developing* |
|---|---|---|---|
| Regime 1 | 0.597*** | 0.753*** | 1.426* |
| | (3.764) | (4.482) | (1.868) |
| Regime 2 | 0.295 | 0.829* | 0.584 |
| | (0.948) | (1.868) | (1.018) |
| Regime 3 | 0.175 | -0.069 | 0.749** |
| | (0.649) | (-0.242) | (2.063) |
| Regime 4 | 0.421** | 0.018 | 0.920*** |
| | (2.034) | (0.039) | (3.656) |
| Regime 5 | 0.469*** | 0.400* | 0.987** |
| | (2.936) | (1.852) | (2.231) |
| Regime 6 | 0.190* | 0.697*** | 0.171 |
| | (1.877) | (3.109) | (1.303) |
| LgdpH | 1.139*** | 1.148*** | 1.023*** |
| | (7.399) | (3.941) | (3.633) |
| LgdpS | 0.795*** | 0.653*** | 1.087*** |
| | (3.448) | (2.636) | (3.256) |
| Ldistance | -0.570*** | -0.599*** | -0.778*** |
| | (-7.811) | (-6.953) | (-6.002) |
| OpennessH | 0.541*** | 1.111*** | 0.453* |
| | (2.582) | (3.049) | (1.786) |
| OpennessS | -0.624 | -0.659 | 0.614 |
| | (-1.111) | (-1.059) | (0.747) |
| RestrictionsH | -0.735*** | -1.195*** | -0.340 |
| | (-3.500) | (-3.827) | (-1.473) |
| RestrictionsS | -0.619*** | -0.538** | -0.743* |
| | (-2.690) | (-2.038) | (-1.902) |
| RTA | -0.108 | -0.256* | 0.279 |
| | (-0.785) | (-1.647) | (1.504) |
| Border | -0.061 | -0.072 | 0.703*** |
| | (-0.424) | (-0.469) | (3.050) |
| Comlang | 0.307** | 0.229* | 0.700** |
| | (2.423) | (1.754) | (2.567) |
| Colony | 0.406*** | 0.201 | 0.786*** |
| | (2.963) | (1.354) | (2.934) |
| Religion | 0.527*** | 4.873** | 0.344* |
| | (3.065) | (2.431) | (1.650) |
| N | 16750 | 6410 | 8881 |
| $R^2$ | 0.58 | 0.59 | 0.62 |

** FDI inflows to developed (column 2) or developing (column 3)* ***host*** *countries. Only* ***developed*** *economies are included as potential* ***source*** *countries. Host, source and year fixed effects included but not reported.*
*t statistics based on standard errors clustered at the country-pair level are given in parentheses;* $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

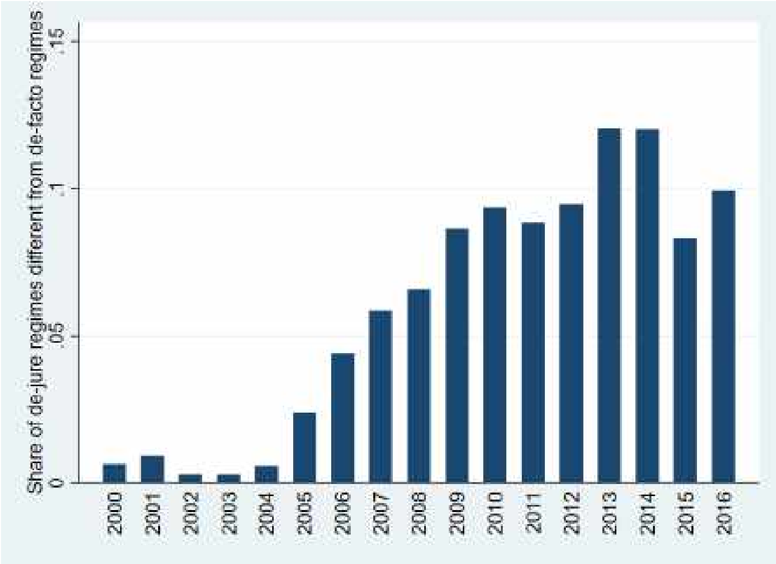



FIGURE 1.6: Share of bilateral **de-facto** exchange rate regimes that differed from the **de-jure** coarse classification in a given year by more than one category. When computing these deviations, we used the classification described in the last column of Table 1. Source: IMF and own computations.

## 1.5 Extensions and robustness tests

### 1.5.1 Accounting for deviations from the de-jure regime

Our key hypothesis that anticipated exchange-rate stability affects FDI flows hinges on the assumption that the announced exchange rate regime is credible. Otherwise, investors would not use the official regime to form their expectations about the future variability of the exchange rate. To check whether deviations from the de-jure regime matter, we compared de-jure and de-facto exchange rate arrangements in our dataset, using the IMF's de-facto assessments provided in the AREAER country reports. The discrepancy between de-jure and de-facto exchange rate regimes is illustrated in Figure 1.6, which shows the percentage of country-pairs for which the IMF's de-facto assessment of exchange-rate regimes substantially differed from the de-jure announcement, i.e. by more than one degree.[25] We see that, while the IMF did not do much reclassifications in the early 2000s, the years following 2006 saw reclassifications of about one-tenth of the sample.

Based on the information in the AREAER reports, we created a dummy variable $JFhost_{jt}$, which assumes a value of one if the **host country** has a (unilateral)

[25] When computing these deviations, we used the classification described in the last column of Table 1.

de-jure exchange rate regime that differs from its de-facto exchange rate regime by more than 1 degree. We then estimated the following specification:

$$\begin{aligned} FDI_{ijt} = exp(\alpha_0 + \sum_{K=1}^{6} \beta_K Regime_{K,ijt} + \gamma_1 JFhost_{jt} + \delta' W_{ijt} + \\ \phi' X_{jt} + \lambda' Y_{it} + \varphi' Z_{ij} + \alpha_i + \alpha_j + \xi_t) + \varepsilon_{ijt} \end{aligned} \tag{1.16}$$

The results of estimating this regression are shown in columns (1) to (3) in Table 1.9 (in Appendix 1.A.4). In columns (4) to (6) we report the results of estimating equation (1.15), *excluding* all observations for which $JFhost_{jt}$ was equal to one.

We find that the dummy $JFhost$ has a negative coefficient, but that it is statistically significant only for the subsample of developing countries. Developing host countries in which de-jure and de-facto arrangements differed substantially receive on average 44 percent less FDI inflows. This negative effect from a failure to credibly commit to a given exchange rate regime does not affect inward FDI for developed countries. The difference between the two country groups is plausible since developing countries are likely to have weaker institutions, which implies that they should benefit more from a credible ex-ante announcement than developed countries and suffer more strongly if markets' trust in their announcements declines. Finally, with respect to the other coefficients, the results of both specifications do not differ from the findings of our baseline specification, suggesting that our results are robust to explicitly accounting for limits to credibility.

### 1.5.2 Using bilateral *de-facto* exchange rate regimes

While the preceding robustness test accounted for the possibility of de-facto regimes deviating from official announcements, but entirely relied on IMF/AREAER information, we also checked whether our findings were robust to focusing on the "natural classification" developed by Reinhart and Rogoff (2004) and recently updated by Ilzetzki et al. (2017, henceforth IRR). We interpret the IRR classification as using the announced regime as a starting point, but correcting it whenever the official or parallel exchange rate was excessively volatile or stable. Moreover, the IRR classification offers a separate "freely falling" category, to which all country-year episodes with an inflation rate higher than 40 percent are assigned. The algorithm we used to compute *bilateral* de-facto (IRR-based) exchange rate regimes is similar to the procedure described in Section 1.3. However, we had to account for the separate "freely falling category" and – for ease of comparison – we reduced the 12 non-flexible regimes defined by IRR to *six* non-flexible regimes. Further details are provided in Appendix 1.A.3.

The results of using the (modified) IRR regime dummies in equation (1.15) are presented in Table 1.10. Interestingly, most of the de-facto fixed exchange regimes still exert a significantly positive effect on bilateral FDI flows, especially for developing countries. We thus interpret the results of this robustness test as further evidence that *announced* exchange rate regimes matter for FDI – especially if these announcements coincide with the exchange rate volatility that is actually observed.

### 1.5.3 A focus on currency unions

#### 1.5.3.1 Currency unions vs. dollarization

The *AREAER* classification system of the IMF introduced in Table 1.1 defines the hardest of all pegs as constellations where countries have *no separate legal tender* (NSLT). The NSLT category, in turn, consists of (a) countries where a foreign currency circulates as the sole legal tender (frequently also referred to as "dollarization") and (b) countries that belong to a monetary or currency union in which the same legal tender is shared by the members of the union. Given the large interest of the academic literature in the special case of currency unions, we adjust our dataset by splitting up the NSLT regime category ($Regime_1$) into currency union members ($CUdummy$) and "dollarized" countries ($OtherNSLT$).[26]

The results of this exercise are shown in Table 1.11 (in Appendix 1.A.4). We find that developed countries that are in a currency union receive on average 89 percent more FDI inflows from other currency union members compared to country pairs that have no explicit or implicit exchange rate arrangement. The effect is even stronger for developed host countries if they have no separate legal tender, without being members of a currency union.[27] Column (3) of Table 1.11

[26] Of course, the term "dollarization" does not imply that the currency in circulation has to be the U.S. dollar.

[27] Note that for most of these "dollarization arrangements" with developed host countries, it is actually the source country that adopts the currency of the host country, e.g. Ecuador (as a developing source country) adopting the currency of the United States (as a developed-host country). The number of such pairings is rather small, and the coefficient should therefore be taken with a grain of salt.

replicates column (3) of Table 1.4, since there is a lack of data on bilateral FDI flows to developing host countries that belong to the same currency union as the source countries. The developing host countries belonging to the $OtherNSLT$ country pairs receive on average 256 percent higher FDI inflows compared to free floating pairs. Taken together, these results suggest that it is the effect of expected exchange rate stability – rather than the specific institutional arrangement of a currency union – that attracts more FDI.

#### 1.5.3.2 Direct vs. indirect effects of currency unions

So far, our specification has been based on the idea that a currency union enhances bilateral FDI if *both* countries are members of that union. However, looking at the special case of the European Monetary Union (EMU), Schiavo (2007) found that EMU has resulted in larger FDI flows not only between EMU members, but also with the rest of the world. The intuition behind this result sounds compelling: membership in a currency union enhances a country's attractiveness for FDI not only from other member countries, but also from firms located outside the union who appreciate the access to a large single-currency market. To test this hypothesis, we created a new currency union dummy ($CUunilateral$) which equals one if a host country is a member of a currency union in year $t$, but which does not require that the source country also is a member of that union. The results are reported in columns (4) to (6) of Table 1.11.[28]

In contrast to Schiavo (2007), we find that the coefficient $CUunilateral$ is negative, but statistically insignificant, suggesting that currency union membership does not have an effect on FDI inflows beyond the implied exchange rate stability vis-à-vis other members of that union.

### 1.5.4 Time-varying multilateral resistance terms

While our inclusion of explicit control variables, combined with country and time fixed effects, goes a long way in reducing omitted variable bias, we may not capture all factors that affect bilateral FDI. If those factors are correlated with our main variable of interest – the bilateral de-jure exchange rate regime – the findings

[28]Note that, while we do not have data on bilateral FDI for developing host countries that are part of the same currency union as the host country, we do have data on bilateral FDI from countries outside the currency union to developing-country members of a currency union (e.g. the WAEMU).

presented so far may be biased. To test whether this is the case we replaced the vectors $X_{jt}$ and $Y_{it}$ in equation (1.15) by a set of country-time fixed effects, which also account for "multilateral resistance" (Anderson and van Wincoop, 2003).[29] The results displayed in Table 1.12 demonstrate that this modification does not alter our main findings, indicating that our results are not affected by omitted variable bias.

### 1.5.5 Lagged explanatory variables

Our theoretical model suggests that firms make their FDI decisions at time $t$, when they form an expectation on the variability of the exchange rate in period $t+1$. However, the model does not specify the duration of each period. Moreover, there is some uncertainty about the exact date at which FDI data are recorded by UNCTAD. Hence, it is possible that the effect of announced exchange regimes on FDI only materializes with a lag, and there might be a delay between the decision of engaging in FDI and the FDI being actually reported in the data. To account for this possibility, we lagged all explanatory variables by one year. As demonstrated by Table 1.13 in Appendix 1.A.4, the estimated coefficients are very similar to our baseline results. The only major difference we find is that while developing countries receive significantly higher FDI inflows if connected by soft pegs ($Regime_4$), the coefficients of the "least pegged" regimes ($Regime_5$ and $Regime_6$) now turn out to be statistically insignificant for the complete sample.

### 1.5.6 Further robustness tests

We have noted before that the benefit of a credible announcement in terms of anchoring expectations holds only as long as the exchange rate regime in place is credible and does not change ad hoc. We already controlled for the extent of credibility by using a dummy for countries whose de-facto exchange rate regimes differed from their de-jure announcements, and by using the IRR de-facto regime classification. We perform an additional robustness check by excluding observations for all countries that experienced a currency crisis *in any year* covered by our

[29] To implement this specification, we used the Stata command `ppml_panel_sg` introduced by Larch et al. (2017). Note that all robustness tests refer to the *entire* sample, including developing country source countries.

sample.[30] The results are reported in Table 1.14 (in Appendix 1.A.4). Apparently, the exclusion of countries with currency crises does not substantially change our previous results. However, the somewhat higher (positive) coefficients of $Regime_1$, $Regime_3$, $Regime_4$ and $Regime_6$ for developing countries can be interpreted as evidence that the effect of announced exchange-rate stability is even stronger if countries experiencing the breakdown of announced pegs are omitted.

We also tested whether our findings were robust to the consideration of FDI *stocks* instead of *flows*. The numbers displayed in Table 1.15 indicate that the results are similar to the specification using FDI flows.

Finally, we performed further robustness checks by dropping all countries with a population below one million, by dropping small island states and by using a different classification of tax havens. Our results turned out to be robust to all of these variations.[31]

## 1.6 Summary and conclusions

Using a newly developed dataset on *bilateral de-jure exchange rate regimes*, we investigated the claim that the expected stability of the nominal exchange rate is an important determinant of foreign direct investment. Our theoretical model suggested that higher exchange rate stability raises the attractiveness of serving foreign markets through foreign affiliates, thus increasing FDI. Our novel dataset allowed testing this hypothesis.

The empirical evidence generally supports our theoretical predictions: We find that country pairs with no separate legal tender receive significantly more FDI inflows from each other. This holds for both currency unions and other "dollarized" regimes. The effect of the remaining exchange rate regimes differs between country groups. In particular, *developed host countries* with a fixed exchange rate attract more FDI inflows only if they have no separate legal tender, while conventional peg arrangements seem even detrimental to FDI inflows in these countries. As we have shown, however, this result is driven by low FDI flows from developing source

[30] The data on currency crises are taken from the updated Systemic Banking Crises Database compiled by Laeven and Valencia (2012), which is available at https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Systemic-Banking-Crises-Database-An-Update-26015. Note that we condition our exclusion of certain countries on *observed* currency crises. However, we conjecture that these also were the countries to which markets assigned a high crisis probability *ex ante*.

[31] The results for these estimations are available upon request.

countries that peg their currencies to developed economies' currencies. Once we omit this group of (potential) source countries, the results are much more in line with our theoretical hypothesis. For *developing host countries*, the effect of a fixed exchange rate is either positive or not significantly different from zero, with the size of estimated coefficients confirming the notion that a growing extent of flexibility reduces FDI inflows to these economies. We interpret this as evidence that the influence of announced exchange rate stability on investors' decisions is particularly strong in an environment where other monetary policy rules fail to anchor expectations.

# Chapter 1: Appendix

## 1.A Appendix

### 1.A.1 Nominal exchange rate stability and vertical FDI

In this Appendix, we extend the simple model introduced in Section 1.2 to explore whether anticipated nominal exchange rate stability affects firms' decisions to engage in *vertical* FDI. Again, we consider a firm that enjoys monopoly power for the good it produces. Unlike in the model version of Section 1.2, all output is sold on the domestic market, where the firm faces a constant elasticity of demand. If the firm produces domestically ($DOM$), it incurs marginal costs of one (in terms of domestic currency units). As an alternative, the firm can engage in vertical FDI ($VFDI$) and set up a subsidiary abroad. This subsidiary produces at a cost $\mu$ (in foreign currency units) which is likely to be smaller than one. However, foreign production is associated with a fixed cost $C$ (in domestic currency units). Expected profits for the two production modes can be written as

$$\mathbf{E}_t(\Pi_{t+1}^{DOM}) = \left(P_t^{DOM} - 1\right)\left(P_t^{DOM}\right)^{-\theta} \tag{1.17}$$

$$\mathbf{E}_t(\Pi_{t+1}^{VFDI}) = \left[P_t^{VFDI} - \mathbf{E}_t\left(E_{t+1}\mu\right)\right]\left(P_t^{VFDI}\right)^{-\theta} - C \tag{1.18}$$

Computing optimal prices and inserting them into the profit definitions above, one can easily show that $\mathbf{E}_t(\Pi_{t+1}^{DOM}) = \theta^{-\theta}(\theta-1)^{(\theta-1)} \equiv \Theta$, while $\mathbf{E}_t(\Pi_{t+1}^{VFDI}) = \Theta\left[\mathbf{E}_t(E_{t+1})\mu\right]^{(1-\theta)} - C$. Given our assumption that $\mathbf{E}_t(E_{t+1}) = 1$, the nominal exchange rate disappears from this expression, and we are left with the statement that the firm prefers producing abroad if the following inequality is satisfied:

$$\Theta\left[\left(\frac{1}{\mu}\right)^{(\theta-1)}-1\right]>C \tag{1.19}$$

The trade-off between the lower marginal costs and the additional fixed costs of producing abroad is unaffected by the variance of the nominal exchange rate, and the anticipated stability of the nominal exchange rate thus does not influence the firm's FDI decision.

### 1.A.2 Computing bilateral de-jure exchange rate regimes: a graphical representation

Figure 1.7 summarizes the structure of the algorithm underlying our set of bilateral exchange rate regimes. Note that for the time periods covered by our sample (2001 - 2012), there are only two anchor currencies, the US dollar and the Euro. The blue nodes denote the direct connections between two countries (for example U.S. against Jordan and Uzbekistan). The red diamonds denote the indirect connections that are computed using our weakest link approach (for example Uzbekistan against Jordan). The countries belonging to the red **circles** are members of the Eastern Caribbean Currency Union (ECCU, circle D), West African Economic and Monetary Union (WAEMU, circle O) and Central African Economic and Monetary Community (CAEMC, circle P). The advantage of the bilateral dataset is that we can capture the members of the same currency union as well as their relationship against the rest of the world. For example, members of the ECCU (circle D) are assigned to regime 1 (no separate legal tender) in bilateral pairs against each other, but each member of the ECCU is assigned to regime 2 in the bilateral pair against the U.S. Following the "weakest link principle", the indirect arrangement of a ECCU member vis-à-vis an economy that formally sustains a crawling peg to the US dollar also is a crawling peg. Finally, all countries that have the US dollar as an anchor currency are freely floating against all countries for whom the anchor currency is the Euro.

FIGURE 1.7: Computing bilateral de-jure exchange rate regimes

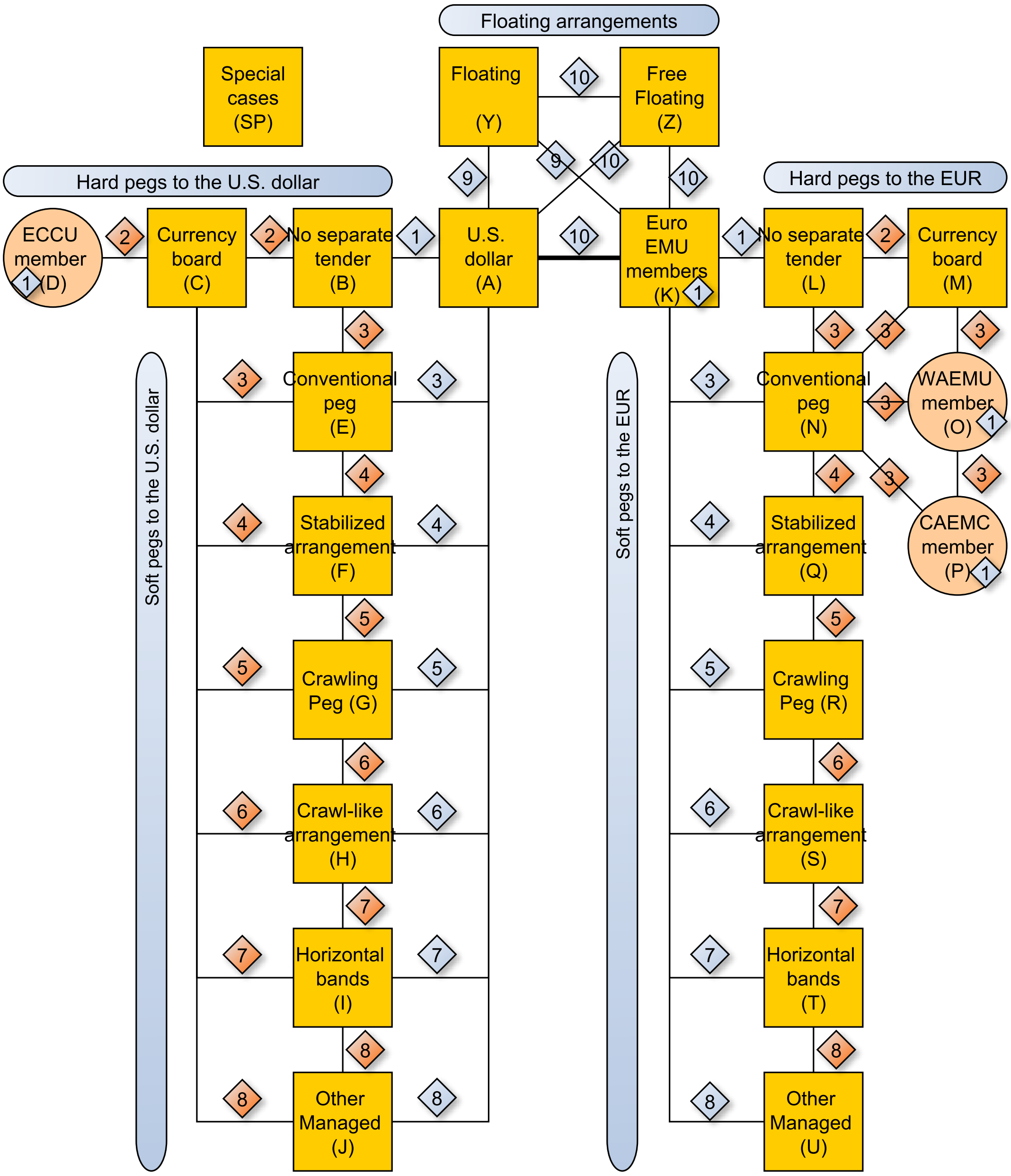


FIGURE 1.8: Shares of country-pairs that changed their bilateral **de-facto** exchange rate regimes (IMF-based) in a given year (shares are ranging from 0 to 1). Bilateral regimes are classified following the coarse classification defined in the last column of Table 1.1. Source: IMF and own computations.

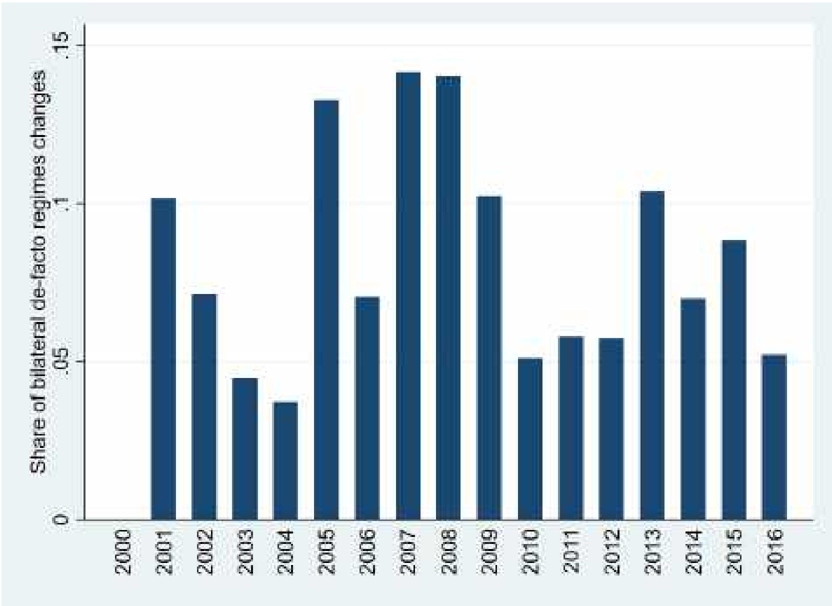
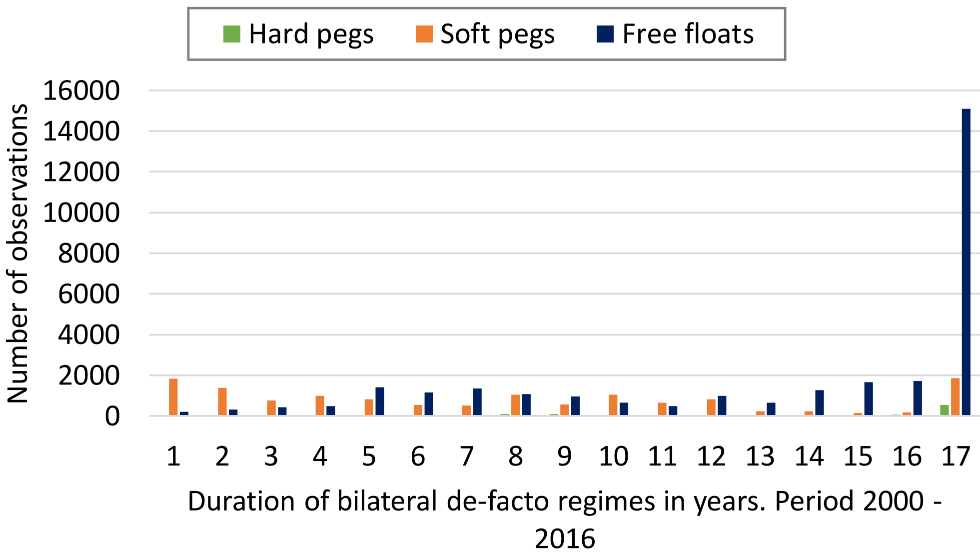



FIGURE 1.9: The number of bilateral **de-facto** exchange rate regimes (IMF-based) experiencing a given duration (in years) between 2000 and 2016. Bilateral de-facto regimes are classified into three broad categories (hard pegs, soft pegs, floats). Source: IMF and own computations.



### 1.A.3 Computing *bilateral de-facto* exchange rate regimes (IRR-based)

TABLE 1.6: IRR **de-facto** exchange rate regimes mapped into exchange rate flexibility index and regime dummies (source: Ilzetzki et al. (2017))

| De-facto exchange rate regimes | Exchange rate flexibility (index) | Exchange rate regime |
|---|---|---|
| *Hard pegs* | | |
| No separate legal tender or currency union | 1 | $\text{Regime}_1^{df}$ |
| Pre announced peg or currency board arrangement | 2 | $\text{Regime}_2^{df}$ |
| *Soft pegs* | | |
| Pre announced horizontal band that is narrower than or equal to +/-2% * | 3 | - |
| De facto peg | 4 | $\text{Regime}_3^{df}$ |
| Pre announced crawling peg; de facto moving band narrower than or equal to +/-1% | 5 | $\text{Regime}_4^{df}$ |
| Pre announced crawling band / de facto horizontal band that is narrower than or equal to +/-2% | 6 | $\text{Regime}_4^{df}$ |
| De facto crawling peg | 7 | $\text{Regime}_4^{df}$ |
| De facto crawling band that is narrower than or equal to +/-2% | 8 | $\text{Regime}_5^{df}$ |
| Pre announced crawling band that is wider than or equal to +/-2% | 9 | $\text{Regime}_5^{df}$ |
| De facto crawling band that is narrower than or equal to +/-5% | 10 | $\text{Regime}_5^{df}$ |
| Moving band that is narrower than or equal to +/-2% | 11 | $\text{Regime}_6^{df}$ |
| *Floating arrangements* | | |
| De facto moving band +/-5%/ Managed floating | 12 | $\text{Regime}_6^{df}$ |
| Freely floating | 13 | $\text{Regime}_7^{df}$ |
| *Residuals* | | |
| Freely falling ** | - | $\text{Regime}_{FF}^{df}$ |
| Dual market in which parallel market data is missing ** | - | - |

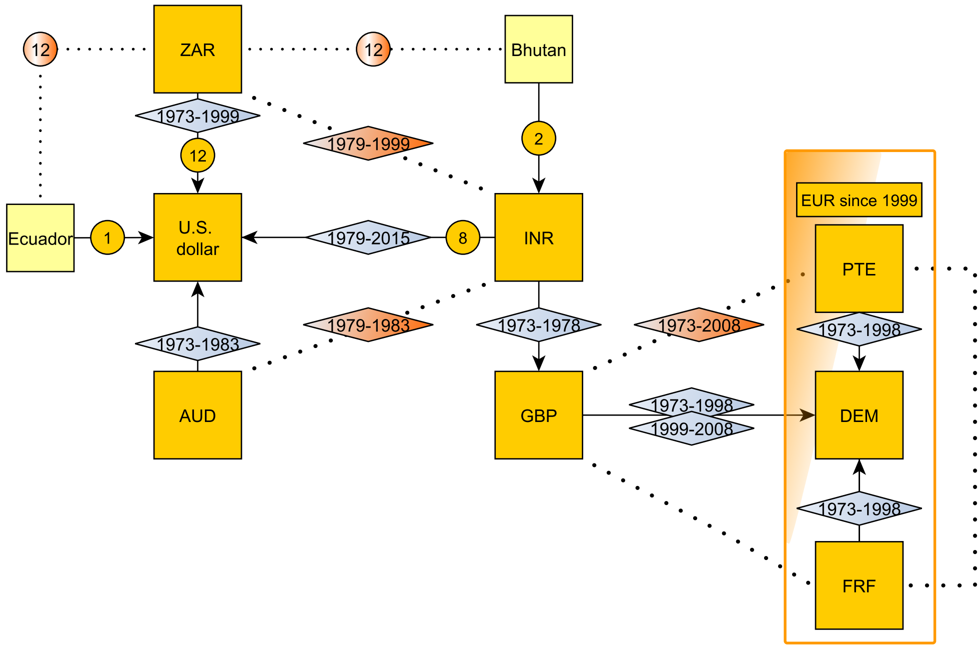
* We do not include the category "Pre announced horizontal band that is narrower than or equal to +/-2%" in our specification as we had no observations for this regime in our sample.

** Residuals 'Freely falling' and 'Dual market in which parallel makret data is missing' were dropped in the index.

We transform the most-recent unilateral exchange rate regime data provided by Ilzetzki et al. (2017) by applying the basic logic of our algorithm. The de-facto exchange rate regimes range from 1 (no separate legal tender or currency union) to 13 (freely floating). The mapping of the exchange rate regimes into our dummy specification (similar to the de-jure exchange rate regimes) is reported in Table 1.6. Using data starting from 1973, Ilzetzki et al. (2017) provide nine potential anchor currencies that were in place in this period (AUD, DEM, EUR, FRF, GBP, INR, PTE, USD, ZAR). Note that our dependent variable (bilateral FDI data) is available only for the years 2001 through 2012, therefore most of the anchor currencies are not relevant for our investigation.

The structure of our bilateral algorithm for the various anchors is presented in Figure 1.10, where the rhombus-shaped nodes represent the years during which the individual anchor currencies were connected to each other. The blue nodes represent the connections of the direct peggers and the red nodes represent the connections of the indirect peggers. Further technical details on the construction of bilateral de-facto exchange rate regimes are available upon request.

FIGURE 1.10: Computing *bilateral de-facto* exchange rate regimes based on the unilateral IRR **de-facto** regime classification




## 1.A.4 Data sources, summary statistics, and robustness checks

TABLE 1.7: Data sources

| Variable | Description | Source |
|---|---|---|
| | *Main variables* | |
| De-jure regime (dummies) | Bilateral de-jure exchange rate regime (IMF-based). | Chair of International Economics Website. Link: http://www.international.economics.uni-mainz.de/. |
| De-facto regime (dummies) | Bilateral de-facto exchange rate regimes (IMF-based). | |
| JF host | De-jure ERR differs from the de-facto ERR by more than 1 degree. | |
| IRR de-facto regime (dummies) | Bilateral de-facto exchange rate regime (IRR-based) variable constructed using data by Ilzetzki et al. (2017). | |
| FDI flows | FDI stock data from UNCTAD. | United Nations, UNCTAD: Bilateral FDI Statistics. |
| FDI stock | FDI flow data from UNCTAD. | Link: http://unctad.org/ |
| | *Other control variables* | |
| LgdpH | Logarithm of the host country's GDP (current US$). | World Bank (World Development Indicators) |
| LgdpS | Logarithm of the source country's GDP (current US$). | |
| OpennessH | Host country's openness. | WorldBank (World Development Indicators) |
| OpennessS | Source country's openness. | |
| RestrictionsH | Average direct investment restrictions of the host country. | Fernández et al. (2016) |
| RestrictionsS | Average direct investment restrictions of the source country. | |
| RTA | Dummy, existence of a regional trade agreement. | Egger and Larch (2008), Link: https://www.ewf.uni-bayreuth.de |
| Ldistance | Log of distance between the two capitals. | |
| Border | Dummy for common border. | CEPII. Link: |
| Comlang | Dummy for common language. | http://www.cepii.fr/CEPII/en/cepii/cepii.asp |
| Colony | Dummy for common colonial history. | |
| Religion | Dummy for common religion. | CIA, the World Factbook library |

Note: country classification is taken from UNCTAD: http://unctadstat.unctad.org/EN/Classifications.html

Table 1.8: Summary statistics

| | **From** | **To** | **Obs** | **Mean** | **Std. Dev.** | **Min** | **Max** | **Unit** |
|---|---|---|---|---|---|---|---|---|
| *Main variables* | | | | | | | | |
| ER flexibility index (De-jure / IMF) | 2000 | 2016 | 516,384 | 8.81 | 2.14 | 1 | 10 | Categorical |
| ER flexibility index (De-facto / IMF) | 2000 | 2016 | 521,612 | 8.48 | 2.31 | 1 | 10 | Categorical |
| JF host | 2000 | 2016 | 513,580 | 0.109 | .312 | 0 | 1 | Dummy |
| ER flexibility index (De-facto / IRR) | 2000 | 2016 | 543,470 | 10.51 | 3.64 | 1 | 15* | Categorical |
| FDI flows | 2001 | 2012 | 55,819 | 277.95 | 2179.48 | 0 | 117617.9 | Millions of US dollars |
| FDI stocks | 2001 | 2012 | 68,258 | 1918.68 | 14123.05 | 0 | 592273.2 | Millions of US dollars |
| *Other control variables* | | | | | | | | |
| LgdpH | 2000 | 2016 | 673,554 | 23.74 | 2.43 | 16.40 | 30.56 | Log of current US$ |
| LgdpS | 2000 | 2016 | 673,554 | 23.74 | 2.43 | 16.40 | 30.56 | Log of current US$ |
| OpennessH | 2000 | 2016 | 634,172 | 0.901 | 0.52 | 0.002 | 4.43 | Index |
| OpennessS | 2000 | 2016 | 634,172 | 0.901 | 0.52 | 0.002 | 4.43 | Index |
| RestrictionsH | 2000 | 2016 | 341,040 | 0.385 | 0.398 | 0 | 1 | Index |
| RestrictionsS | 2000 | 2016 | 341,040 | 0.385 | 0.398 | 0 | 1 | Index |
| RTA | 2000 | 2016 | 683,400 | 0.158 | 0.364 | 0 | 1 | Dummy |
| *Time invariant variables* | | | | | | | | |
| Ldistance | - | - | 517,650 | 8.71 | 0.777 | 2.35 | 9.89 | Log of kilometres |
| Border | - | - | 517,650 | 0.018 | 0.133 | 0 | 1 | Dummy |
| Comlang | - | - | 517,650 | 0.145 | 0.352 | 0 | 1 | Dummy |
| Colony | - | - | 517,650 | 0.011 | 0.107 | 0 | 1 | Dummy |
| Religion | - | - | 517,650 | 0.473 | 0.499 | 0 | 1 | Dummy |
| HavenOecdH | - | - | 578,680 | 0.13 | 0.337 | 0 | 1 | Dummy / tax haven |

* Residuals 'Freely falling' (de facto regime 14) and 'Dual market in which parallel market data is missing' (de facto regime 15) were dropped in the index.

TABLE 1.9: Exchange rate regime dummies and bilateral FDI flows: accounting for **deviations from the de-jure exchange-rate regime** (*JF host*)

| | (1) All | (2) Developed* | (3) Developing* | (4) All | (5) Developed* | (6) Developing* |
|---|---|---|---|---|---|---|
| | *JF host* as a dummy variable | | | Observations excluded if *JF host* = 1 | | |
| *JF host* | -0.221 | -0.037 | -0.366** | | | |
| | (-1.582) | (-0.121) | (-2.193) | | | |
| Regime 1 | 0.366** | 0.640*** | 1.263** | 0.401** | 0.608*** | 1.344** |
| | (2.052) | (3.878) | (2.449) | (2.374) | (3.584) | (2.509) |
| Regime 2 | -1.267** | -0.094 | -0.279 | -0.945** | -0.123 | -0.179 |
| | (-2.281) | (-0.225) | (-0.656) | (-2.265) | (-0.296) | (-0.434) |
| Regime 3 | 0.338* | -0.419* | 0.461** | 0.471* | -0.439* | 0.683*** |
| | (1.649) | (-1.657) | (2.127) | (1.656) | (-1.747) | (2.866) |
| Regime 4 | 0.384 | -0.714* | 0.239 | 0.702** | -0.710* | 0.710*** |
| | (1.133) | (-1.759) | (0.913) | (2.091) | (-1.746) | (3.105) |
| Regime 5 | 0.333* | 0.274 | -0.137 | 0.324* | 0.231 | -0.293 |
| | (1.852) | (1.345) | (-0.289) | (1.724) | (1.117) | (-0.624) |
| Regime 6 | 0.222** | 0.301 | 0.261** | 0.191 | 0.295 | 0.274** |
| | (2.004) | (1.444) | (2.184) | (1.580) | (1.427) | (1.960) |
| LgdpH | 1.257*** | 1.168*** | 1.341*** | 1.313*** | 1.172*** | 1.554*** |
| | (8.806) | (4.059) | (5.550) | (8.992) | (4.044) | (6.379) |
| LgdpS | 1.114*** | 0.912*** | 1.077*** | 1.057*** | 0.947*** | 1.088*** |
| | (7.536) | (4.450) | (6.149) | (7.329) | (4.577) | (6.345) |
| Ldistance | -0.499*** | -0.569*** | -0.504*** | -0.535*** | -0.564*** | -0.546*** |
| | (-7.512) | (-6.991) | (-5.118) | (-8.161) | (-6.889) | (-5.595) |
| OpennessH | 0.531*** | 1.085*** | 0.482*** | 0.610*** | 1.059*** | 0.646*** |
| | (3.219) | (2.808) | (2.675) | (3.736) | (2.725) | (3.476) |
| OpennessS | 0.065 | 0.039 | -0.020 | -0.573** | 0.062 | -0.750*** |
| | (0.425) | (0.110) | (-0.105) | (-1.987) | (0.175) | (-3.791) |
| RestrictionsH | -0.581*** | -1.163*** | -0.211 | -0.693*** | -1.157*** | -0.329 |
| | (-2.878) | (-3.836) | (-0.886) | (-3.171) | (-3.820) | (-1.099) |
| RestrictionsS | -0.603*** | -0.592** | -0.155 | -0.483*** | -0.556** | -0.215 |
| | (-3.299) | (-2.550) | (-0.572) | (-2.738) | (-2.424) | (-0.807) |
| RTA | 0.434** | -0.157 | 0.477*** | 0.191 | -0.137 | 0.286* |
| | (2.357) | (-1.020) | (3.528) | (1.149) | (-0.867) | (1.949) |
| Border | 0.177 | -0.090 | 1.279*** | 0.077 | -0.103 | 1.107*** |
| | (1.211) | (-0.601) | (5.932) | (0.545) | (-0.690) | (5.489) |
| Comlang | 0.433*** | 0.253** | 0.867*** | 0.440*** | 0.294** | 0.768*** |
| | (3.556) | (1.975) | (4.055) | (3.703) | (2.234) | (3.545) |
| Colony | 0.475*** | 0.287** | 0.562** | 0.412*** | 0.285** | 0.530* |
| | (3.360) | (1.984) | (2.145) | (2.981) | (1.961) | (1.902) |
| Religion | 0.387* | 0.210 | 0.544** | 0.543** | 0.208 | 0.577** |
| | (1.795) | (0.580) | (2.430) | (2.469) | (0.574) | (2.458) |
| N | 29059 | 11973 | 14936 | 26735 | 11914 | 12962 |
| $R^2$ | 0.55 | 0.60 | 0.83 | 0.55 | 0.60 | 0.73 |

** FDI inflows to developed (columns 2, 5) or developing (columns 3, 6)* ***host*** *countries. All economies are included as potential* ***source*** *countries. Host, source and year fixed effects included but not reported.*
*t statistics based on standard errors clustered at the country-pair level are given in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*

Table 1.10: IRR **de-facto** exchange rate regime **dummies** and bilateral FDI flows.

| | (1) All | (2) Developed* | (3) Developing* |
|---|---|---|---|
| De-facto Regime 1 | 0.324* | 0.743*** | 1.232** |
| | (1.900) | (4.739) | (2.189) |
| De-facto Regime 2 | -0.702** | -0.102 | 0.139 |
| | (-2.562) | (-0.515) | (0.409) |
| De-facto Regime 3 | 0.851*** | 0.142 | 1.160*** |
| | (3.541) | (0.322) | (4.503) |
| De-facto Regime 4 | 0.736*** | 0.307 | 1.204*** |
| | (3.402) | (1.370) | (4.137) |
| De-facto Regime 5 | -0.114 | 0.273 | 0.097 |
| | (-0.689) | (1.194) | (0.361) |
| De-facto Regime 6 | -0.072 | 0.134 | 0.033 |
| | (-0.537) | (0.979) | (0.171) |
| Regime "freely falling" | -0.358 | 0.352 | -0.531 |
| | (-1.337) | (0.571) | (-1.542) |
| LgdpH | 1.076*** | 1.115*** | 1.150*** |
| | (7.735) | (3.868) | (5.207) |
| LgdpS | 1.081*** | 0.829*** | 0.985*** |
| | (7.442) | (3.949) | (5.725) |
| Ldistance | -0.509*** | -0.564*** | -0.606*** |
| | (-8.137) | (-6.966) | (-6.955) |
| OpennessH | 0.615*** | 1.083*** | 0.604*** |
| | (3.895) | (2.851) | (3.445) |
| OpennessS | 0.109 | -0.007 | -0.136 |
| | (0.672) | (-0.021) | (-0.710) |
| RestrictionsH | -0.524** | -1.163*** | -0.123 |
| | (-2.516) | (-3.699) | (-0.516) |
| RestrictionsS | -0.587*** | -0.618** | -0.208 |
| | (-3.085) | (-2.560) | (-0.821) |
| RTA | 0.405*** | -0.237 | 0.339** |
| | (2.727) | (-1.592) | (2.495) |
| Border | 0.187 | -0.069 | 0.970*** |
| | (1.357) | (-0.458) | (5.732) |
| Comlang | 0.373*** | 0.235* | 0.585*** |
| | (3.125) | (1.825) | (2.940) |
| Colony | 0.506*** | 0.279* | 0.770*** |
| | (3.596) | (1.935) | (3.287) |
| Religion | 0.256* | 0.216 | 0.393*** |
| | (1.812) | (0.696) | (2.659) |
| N | 28235 | 11719 | 14855 |
| $R^2$ | 0.57 | 0.60 | 0.87 |

** FDI inflows to developed (column 2) or developing (column 3)* ***host*** *countries. All economies are included as potential* ***source*** *countries. Host, source and year fixed effects included but not reported.*
*t statistics based on standard errors clustered at the country-pair level are given in parentheses;* $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

TABLE 1.11: Exchange rate regime dummies and bilateral FDI flows: **focus on currency unions**

| | (1) All | (2) Developed* | (3) Developing* | (4) All | (5) Developed* | (6) Developing* |
|---|---|---|---|---|---|---|
| | CU members and other "dollarized" | | | Unilateral membership in the CU | | |
| CU dummy | 0.369** | 0.633*** | | 0.369** | 0.633*** | |
| | (2.003) | (3.780) | | (2.003) | (3.780) | |
| CU unilateral | | | | 0.072 | -1.758 | -0.130 |
| | | | | (0.069) | (-1.373) | (-0.088) |
| OtherNSLT | 0.070 | 1.765*** | 1.271** | 0.070 | 1.765*** | 1.271** |
| | (0.177) | (3.911) | (2.443) | (0.177) | (3.911) | (2.443) |
| Regime 2 | -1.262** | -0.100 | -0.253 | -1.262** | -0.100 | -0.253 |
| | (-2.279) | (-0.242) | (-0.594) | (-2.279) | (-0.242) | (-0.594) |
| Regime 3 | 0.359* | -0.417* | 0.528** | 0.359* | -0.417* | 0.528** |
| | (1.672) | (-1.650) | (2.467) | (1.672) | (-1.650) | (2.467) |
| Regime 4 | 0.449 | -0.726* | 0.378 | 0.449 | -0.726* | 0.378 |
| | (1.412) | (-1.797) | (1.546) | (1.412) | (-1.797) | (1.546) |
| Regime 5 | 0.325** | 0.292 | 0.034 | 0.325** | 0.292 | 0.034 |
| | (1.968) | (1.442) | (0.075) | (1.968) | (1.442) | (0.075) |
| Regime 6 | 0.210* | 0.275 | 0.226* | 0.210* | 0.275 | 0.226* |
| | (1.948) | (1.353) | (1.897) | (1.948) | (1.353) | (1.897) |
| LgdpH | 1.180*** | 1.165*** | 1.162*** | 1.180*** | 1.165*** | 1.162*** |
| | (8.753) | (4.123) | (4.868) | (8.753) | (4.123) | (4.868) |
| LgdpS | 1.131*** | 0.920*** | 1.128*** | 1.131*** | 0.920*** | 1.128*** |
| | (7.646) | (4.429) | (6.317) | (7.646) | (4.429) | (6.317) |
| Ldistance | -0.506*** | -0.568*** | -0.505*** | -0.506*** | -0.568*** | -0.505*** |
| | (-7.591) | (-6.955) | (-5.138) | (-7.591) | (-6.955) | (-5.138) |
| OpennessH | 0.533*** | 1.079*** | 0.470** | 0.533*** | 1.079*** | 0.470** |
| | (3.242) | (2.972) | (2.550) | (3.242) | (2.972) | (2.550) |
| OpennessS | 0.065 | 0.041 | -0.043 | 0.065 | 0.041 | -0.043 |
| | (0.409) | (0.118) | (-0.216) | (0.409) | (0.118) | (-0.216) |
| RestrictionsH | -0.566*** | -1.160*** | -0.181 | -0.566*** | -1.160*** | -0.181 |
| | (-2.829) | (-3.854) | (-0.799) | (-2.829) | (-3.854) | (-0.799) |
| RestrictionsS | -0.600*** | -0.591** | -0.142 | -0.600*** | -0.591** | -0.142 |
| | (-3.187) | (-2.548) | (-0.517) | (-3.187) | (-2.548) | (-0.517) |
| RTA | 0.423** | -0.158 | 0.460*** | 0.423** | -0.158 | 0.460*** |
| | (2.325) | (-1.023) | (3.390) | (2.325) | (-1.023) | (3.390) |
| Border | 0.169 | -0.089 | 1.276*** | 0.169 | -0.089 | 1.276*** |
| | (1.162) | (-0.598) | (5.970) | (1.162) | (-0.598) | (5.970) |
| Comlang | 0.436*** | 0.256** | 0.854*** | 0.436*** | 0.256** | 0.854*** |
| | (3.534) | (1.992) | (3.988) | (3.534) | (1.992) | (3.988) |
| Colony | 0.478*** | 0.286** | 0.580** | 0.478*** | 0.286** | 0.580** |
| | (3.393) | (1.980) | (2.224) | (3.393) | (1.980) | (2.224) |
| Religion | 0.386* | 0.202 | 0.545** | 0.386* | 0.202 | 0.545** |
| | (1.791) | (0.562) | (2.442) | (1.791) | (0.562) | (2.442) |
| N | 29334 | 12030 | 15089 | 29334 | 12030 | 15089 |
| $R^2$ | 0.55 | 0.60 | 0.84 | 0.55 | 0.60 | 0.84 |

** FDI inflows to developed (columns 2, 5) or developing (columns 3, 6)* ***host*** *countries. All economies are included as potential* ***source*** *countries. Host, source and year fixed effects included but not reported.*
*t statistics based on standard errors clustered at the country-pair level are given in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*

TABLE 1.12: Exchange rate regime dummies and bilateral FDI flows. PPML estimation of the gravity model (equation 1.15) with **time-variant** host country and source country fixed effects

| | (1) All countries | (2) Developing* | (3) Developed* |
|---|---|---|---|
| Regime 1 | -0.034 | 0.309*** | 0.887*** |
| | (-0.308) | (3.041) | (2.790) |
| Regime 2 | -1.227*** | -0.341* | -0.412 |
| | (-5.857) | (-1.891) | (-1.473) |
| Regime 3 | -0.009 | -0.724** | 0.514*** |
| | (-0.048) | (-2.078) | (4.000) |
| Regime 4 | 1.285*** | -0.428 | 1.253*** |
| | (4.760) | (-0.785) | (6.734) |
| Regime 5 | 0.101 | 0.193 | -0.174 |
| | (0.594) | (1.028) | (-0.449) |
| Regime 6 | 0.279*** | 0.083 | 0.477*** |
| | (2.723) | (0.476) | (5.197) |
| RTA | 0.982*** | 0.635*** | 0.723*** |
| | (11.865) | (7.116) | (9.521) |
| Border | 0.691*** | 0.476*** | 1.881*** |
| | (9.112) | (5.271) | (23.014) |
| Comlang | 0.172** | -0.079 | 0.916*** |
| | (2.478) | (-0.943) | (10.513) |
| Colony | 0.426*** | 0.293*** | 0.479*** |
| | (6.108) | (3.714) | (4.594) |
| Religion | 0.708*** | 0.277 | 0.778*** |
| | (8.181) | (1.356) | (10.577) |
| N | 42660 | 17000 | 19241 |
| $R^2$ | 0.61 | 0.71 | 0.89 |

** FDI inflows to developed (column 2) or developing (column 3)* ***host*** *countries. All economies are included as potential* ***source*** *countries.* ***Host-year*** *and* ***source-year*** *fixed effects included but not reported. t statistics based on standard errors clustered at the country-pair level are given in parentheses;* $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

Table 1.13: Exchange rate regime dummies and bilateral FDI flows: **lagged explanatory variables**

| | (1)<br>All countries | (2)<br>Developed* | (3)<br>Developing* |
|---|---|---|---|
| Regime 1 | 0.364** | 0.634*** | 1.272** |
| | (2.045) | (3.791) | (2.349) |
| Regime 2 | -1.294** | -0.134 | -0.301 |
| | (-2.384) | (-0.326) | (-0.720) |
| Regime 3 | 0.436** | -0.424* | 0.520** |
| | (2.371) | (-1.734) | (2.429) |
| Regime 4 | 0.491 | 0.246 | 0.435** |
| | (1.627) | (0.616) | (2.129) |
| Regime 5 | 0.205 | 0.164 | -0.028 |
| | (1.198) | (0.758) | (-0.059) |
| Regime 6 | 0.139 | 0.167 | 0.174 |
| | (1.224) | (0.886) | (1.371) |
| LgdpH | 1.266*** | 1.048*** | 1.490*** |
| | (9.361) | (3.781) | (6.021) |
| LgdpS | 1.185*** | 1.093*** | 1.073*** |
| | (7.797) | (4.742) | (5.573) |
| Ldistance | -0.508*** | -0.563*** | -0.515*** |
| | (-7.874) | (-6.962) | (-5.116) |
| OpennessH | 0.678*** | 1.116*** | 0.770*** |
| | (4.302) | (3.366) | (4.373) |
| OpennessS | 0.276 | 0.675** | -0.095 |
| | (1.375) | (2.112) | (-0.425) |
| RestrictionsH | -0.565*** | -1.149*** | -0.101 |
| | (-3.191) | (-4.047) | (-0.510) |
| RestrictionsS | -0.545*** | -0.487** | -0.349 |
| | (-3.021) | (-2.092) | (-1.524) |
| RTA | 0.413** | -0.134 | 0.401*** |
| | (2.427) | (-0.875) | (2.932) |
| Border | 0.164 | -0.096 | 1.287*** |
| | (1.111) | (-0.642) | (5.726) |
| Comlang | 0.432*** | 0.252* | 0.841*** |
| | (3.550) | (1.943) | (3.967) |
| Colony | 0.465*** | 0.285** | 0.578** |
| | (3.319) | (1.977) | (2.240) |
| Religion | 0.386* | 0.198 | 0.533** |
| | (1.818) | (0.599) | (2.394) |
| N | 29128 | 11966 | 14951 |
| r2 | 0.55 | 0.60 | 0.83 |

** FDI inflows to developed (column 2) or developing (column 3)* ***host*** *countries. All economies are included as potential* ***source*** *countries. Host, source and year fixed effects included but not reported.*
*t statistics based on standard errors clustered at the country-pair level are given in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*

TABLE 1.14: Exchange rate regime dummies and bilateral FDI flows: excluding all observations for countries (host or source) that experienced a **currency crisis**

| | (1) All | (2) Developed* | (3) Developing* |
|---|---|---|---|
| Regime 1 | 0.400** | 0.649*** | 1.341*** |
| | (2.204) | (3.912) | (2.622) |
| Regime 2 | -1.263** | -0.087 | -0.167 |
| | (-2.253) | (-0.209) | (-0.379) |
| Regime 3 | 0.440* | -0.421 | 0.645*** |
| | (1.945) | (-1.592) | (2.843) |
| Regime 4 | 0.516 | -0.650 | 0.489** |
| | (1.545) | (-1.555) | (1.990) |
| Regime 5 | 0.376** | 0.303 | 0.056 |
| | (2.256) | (1.486) | (0.121) |
| Regime 6 | 0.264** | 0.277 | 0.304** |
| | (2.295) | (1.320) | (2.266) |
| LgdpH | 1.166*** | 1.157*** | 1.100*** |
| | (8.308) | (4.073) | (4.504) |
| LgdpS | 1.150*** | 0.929*** | 1.136*** |
| | (7.431) | (4.377) | (5.965) |
| Ldistance | -0.483*** | -0.571*** | -0.446*** |
| | (-6.961) | (-6.969) | (-4.117) |
| OpennessH | 0.541*** | 1.084*** | 0.459** |
| | (3.262) | (2.987) | (2.507) |
| OpennessS | 0.088 | 0.048 | 0.004 |
| | (0.546) | (0.136) | (0.020) |
| RestrictionsH | -0.771*** | -1.207*** | -0.403 |
| | (-3.469) | (-3.914) | (-1.291) |
| RestrictionsS | -0.647*** | -0.621*** | -0.202 |
| | (-3.214) | (-2.606) | (-0.605) |
| RTA | 0.448** | -0.167 | 0.464*** |
| | (2.330) | (-1.078) | (3.016) |
| Border | 0.184 | -0.087 | 1.384*** |
| | (1.237) | (-0.584) | (5.855) |
| Comlang | 0.411*** | 0.247* | 0.832*** |
| | (3.257) | (1.926) | (3.609) |
| Colony | 0.465*** | 0.274* | 0.576** |
| | (3.220) | (1.891) | (2.030) |
| Religion | 0.401* | 0.205 | 0.555** |
| | (1.813) | (0.569) | (2.476) |
| N | 23990 | 10708 | 11772 |
| $R^2$ | 0.55 | 0.60 | 0.85 |

** FDI inflows to developed (column 2) or developing (column 3) **host** countries. All economies are included as potential **source** countries. Host, source and year fixed effects included but not reported.*
*t statistics based on standard errors clustered at the country-pair level are given in parentheses;* $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$.

Table 1.15: Exchange rate regime dummies and bilateral **FDI stocks**

| | (1) All | (2) Developed* | (3) Developing* | (4) All | (5) Developed* | (6) Developing* |
|---|---|---|---|---|---|---|
| | *De-jure regimes classification* | | | *De-facto regimes classification* | | |
| Regime 1 | 0.247 | 0.544*** | 1.341*** | 0.138 | 0.646*** | 1.724*** |
| | (1.430) | (3.553) | (2.858) | (0.799) | (4.148) | (3.169) |
| Regime 2 | -1.665*** | -0.058 | -0.991** | -0.989*** | -0.240 | -0.157 |
| | (-3.886) | (-0.122) | (-2.270) | (-3.684) | (-1.303) | (-0.352) |
| Regime 3 | 0.532** | -0.666*** | 0.817*** | 1.097*** | -0.473 | 1.498*** |
| | (2.226) | (-2.903) | (3.977) | (4.404) | (-1.171) | (4.713) |
| Regime 4 | 0.885*** | -0.585* | 0.927*** | 0.631*** | 0.382** | 1.407*** |
| | (3.173) | (-1.772) | (3.085) | (2.874) | (2.140) | (4.136) |
| Regime 5 | 0.289 | -0.168 | 0.262 | -0.275 | 0.010 | 0.584* |
| | (1.237) | (-0.675) | (0.503) | (-1.624) | (0.046) | (1.859) |
| Regime 6 | 0.081 | 0.246 | 0.252 | -0.141 | 0.111 | 0.401 |
| | (0.563) | (1.141) | (1.253) | (-1.241) | (1.156) | (1.427) |
| "Freely falling" | | | | -0.002 | -0.251 | -0.054 |
| | | | | (-0.012) | (-0.594) | (-0.242) |
| LgdpH | 0.965*** | 1.160*** | -0.182 | 0.879*** | 1.123*** | -0.283 |
| | (7.083) | (7.806) | (-0.457) | (5.642) | (7.157) | (-0.724) |
| LgdpS | 0.785*** | 0.941*** | 0.420** | 0.731*** | 0.915*** | 0.065 |
| | (6.053) | (6.689) | (2.489) | (4.119) | (6.306) | (0.299) |
| Ldistance | -0.491*** | -0.636*** | -0.439*** | -0.502*** | -0.627*** | -0.556*** |
| | (-6.852) | (-7.459) | (-4.550) | (-7.799) | (-7.498) | (-5.407) |
| OpennessH | 0.225** | 0.787** | -0.501** | 0.206 | 0.821** | -0.531*** |
| | (2.237) | (2.143) | (-2.444) | (1.615) | (2.102) | (-2.632) |
| OpennessS | -0.050 | 0.474** | -0.255 | -0.025 | 0.514** | -0.450** |
| | (-0.243) | (2.241) | (-1.557) | (-0.106) | (2.350) | (-2.439) |
| RestrictionsH | -0.174** | -0.209** | -0.339* | -0.138* | -0.212** | -0.341** |
| | (-2.400) | (-2.092) | (-1.879) | (-1.809) | (-2.008) | (-1.982) |
| RestrictionsS | -0.252** | -0.268*** | -0.062 | -0.215** | -0.277*** | -0.050 |
| | (-2.510) | (-2.710) | (-0.304) | (-2.086) | (-2.673) | (-0.268) |
| RTA | 0.498*** | -0.111 | 0.662*** | 0.511*** | -0.170 | 0.553*** |
| | (3.421) | (-0.746) | (5.697) | (3.881) | (-1.170) | (4.692) |
| Border | 0.332** | 0.064 | 1.568*** | 0.343*** | 0.091 | 1.213*** |
| | (2.551) | (0.495) | (7.509) | (2.768) | (0.705) | (6.455) |
| Comlang | 0.532*** | 0.327*** | 0.876*** | 0.502*** | 0.311*** | 0.798*** |
| | (4.187) | (2.755) | (5.551) | (4.106) | (2.644) | (4.924) |
| Colony | 0.590*** | 0.483*** | 0.482** | 0.604*** | 0.458*** | 0.483** |
| | (4.796) | (3.708) | (2.328) | (4.919) | (3.585) | (2.335) |
| Religion | 0.159 | -0.166 | 0.408** | 0.147 | -0.057 | 0.311* |
| | (0.926) | (-0.368) | (2.068) | (0.991) | (-0.132) | (1.821) |
| N | 37130 | 15595 | 18832 | 36198 | 15214 | 18800 |
| $R^2$ | 0.78 | 0.88 | 0.88 | 0.79 | 0.88 | 0.89 |

** FDI inflows to developed (columns 2, 5) or developing (columns 3, 6)* ***host*** *countries. All economies are included as potential* ***source*** *countries. Host, source and year fixed effects included but not reported.*
*t statistics based on standard errors clustered at the country-pair level are given in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*

# Chapter 2

# The Effect of Exchange Rate Regimes on Business Cycle Synchronization: A Robust Analysis

by Jia Hou* and Jakub Knaze†

## 2.1 Introduction

Exchange rate regimes have been shown to significantly affect international trade, foreign direct investment, economic growth and other macroeconomic variables.[1] Although many studies have also investigated the effect of *currency unions* on business cycles synchronization, the empirical evidence on the potential effect of remaining exchange rate regimes remains scarce. In this paper we argue that the seemingly exaggerated focus on currency unions arises due to the difficulty

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[1]See for example Klein and Shambaugh (2006) for the effect of exchange rate regimes on international trade, Harms and Knaze (2018 ) for the effect on FDI or Ghosh et al. (2014) for the effect on inflation. Further, exchange rate regimes have been found to significantly affect GDP growth (Levy-Yeyati and Sturzenegger, 2003), terms of trade (Broda, 2004) or other policy variables (e.g. Obstfeld et al., 2005, on monetary policy).

with proper identification of *bilateral* exchange rate regimes other than currency unions. The traditional unilateral exchange rate regimes classifications are suitable to analyse unilateral outcome variables, but they are not suitable for bilateral outcome variables such as business cycles synchronization.

In this paper we use the new dataset on *bilateral de-facto* exchange rate regimes constructed by Harms and Knaze (2018), which allows us to analyse the effect of exchange rate regimes on business cycle synchronization over the past 44 years. Thus, we investigate the effect *various* exchange rate regimes - rather than just currency unions - have on business cycle synchronization. The construction of these exchange rate regimes is based on an algorithm that processes data from the "natural classification" developed by Reinhart and Rogoff (2004) and recently updated by Ilzetzki et al. (2017), and that combines information on each country's exchange rate regime vis-à-vis all potential anchor currencies (Harms and Knaze, 2018). Eventually, the dataset consists of a *bilateral exchange rate flexibility index*, which ranges from one (no separate legal tender / currency union) to thirteen (freely floating), and a set of dummy variables that distinguish between seven bilateral exchange rate regimes.

Various theoretical models indicate several channels through which exchange rate regimes might matter for business cycle synchronization. First class of models is based on the classical contribution formalised in the Mundell-Flemming model (Fleming, 1962; Mundell, 1963). This model implies that exchange rate regimes strengthen or neutralise the effects of monetary and fiscal policies aimed at income and employment stabilisation. Given the flexible exchange rate regime, only monetary but not fiscal policies have an effect on production, and vice versa for the fixed exchange rate regime. Consequently, how do exchange rate regimes affect business cycle synchronization depends on the type of underlying shocks. There are also potential indirect channels through other variables by which exchange rate regimes affect business cycle synchronization. For example, more fixed regimes are expected to foster a higher degree of financial integration (McKinnon, 2004) or more trade between countries (Klein and Shambaugh, 2006). In this line of models, the effect of exchange rate regimes on business cycle synchronization depends on the interaction with other policy variables.

A new type of model is proposed by Itskhoki and Mukhi (2019) who argue that the shift of exchange rate regime from fixed to flexible does not cause higher volatility in macroeconomic variables through financial shocks, apart from exchange rate volatilities. That is, exchange rate regimes are not expected to affect business cycle synchronization. This is the case if the financial intermediaries can adjust their risk taking behaviour under each exchange rate regime correspondingly and thus mitigate the impact of financial shocks. While the two lines of models predict different effects of exchange rate regimes on business cycle synchronization, both of them rely on exogenous shocks to generate synchronization of business cycles. This assumption is relaxed in the behavioural macroeconomic model following De Grauwe and Ji (2017), where exchange rate regimes can affect business cycle synchronization endogenously. Assuming that individuals are rational, the waves of pessimism or optimism in two countries are more correlated under fixed exchange rate regime than flexible regime, which leads to higher synchronization of business cycles. Given different predictions of the models, it is ultimately an empirical question to determine whether exchange rate regimes affect business cycle synchronization. Especially, in reality we observe various types of exchange rate regimes beyond the two extremes of fixed and floating regimes investigated in the theoretical literature.

The main contribution of this paper is to provide empirical evidence on the effect of seven different types of exchange rate regimes on business cycle synchronization. We follow Inklaar et al. (2008) and conduct the Extreme Bound Analysis (EBA) as proposed by Leamer (1983) and modified by Sala-I-Martin (1997) as our main empirical strategy. The method allows us to determine basic set of exogenous variables that capture all observed features that might affect both exchange rate regimes and covariance between explanatory variables. The basic idea of EBA is to run a set of multiple regressions at once. Among this set of regressions, all possible combinations of potential determinants for a given outcome variable are tested to find EBA-robust determinants of the dependent variable. We collect data on 38 different variables as potential determinants of business cycle synchronization as mentioned by previous literature. We run several thousand regressions with all possible combinations of all 38 variables to obtain the "robust" determinants of business cycle synchronization.

In further analysis, we employ OLS by including all EBA-robust variables. To ensure that our empirical evidence is not sensitive to biases caused by measurement errors or empirical specifications, we run several robustness tests. For example, our investigation uses 5 distinctive correlation periods, with the exchange rate regime measured both at the beginning and middle of each respective period to make sure that the results are not driven by changes in the exchange rate regimes *within* periods. Importantly, our results remain robust to the use of both *de-facto* and *de-jure* regime classifications. Also, country and country-time fixed effects are used to control for any unobserved heterogeneity. Given that the exchange rate regimes change only slowly, Klein and Shambaugh (2010) argue that using country or country-pair fixed effects seems to address adequately concerns with endogeneity. Importantly, we address the potential reverse causality problem by including only country pairs that are linked indirectly through a common anchor currency. These tests should account for the fact that countries might decide on adoption of the exchange rate regime based on high degree of trade intensity, financial integration or observed business cycle co-movement.

Our empirical investigation provides evidence that less flexible regimes are associated with more synchronised business cycles, but the magnitude of the coefficients varies depending on the individual regime type. More specifically, country pairs with no separate legal tenders are associated with a correlation coefficient of business cycle synchronization higher by around 0.12 points, compared to country pairs with freely floating regimes. Thus, no separate legal tenders are indeed significantly, positively related to business cycle correlation when considered in isolation. This effect is stronger for participants of a currency union, as compared to the case when a foreign currency circulates as the sole legal tender.

We also find strong positive effects for other regimes with low exchange rate flexibility, such as currency board arrangements and de-facto pegs. When moving to the more flexible regimes, we find that the effect for country pairs with soft pegs is more heterogeneous. Comparing to the most flexible (freely floating) regimes, crawling pegs and crawling bands turn out to be insignificant. However, moving bands are found to be positive and significant, although they are more flexible than crawling bands. Therefore, our results imply that not only currency unions, but all hard pegs and even some softly pegged exchange rate regimes are associated with higher business cycle synchronisation. We interpret this as evidence to the impact of exchange rate regimes on real macroeconomic variables. The non-linearity of the impact shows a need to further refine current theoretical models to also take intermediate exchange rate regimes into account.

The rest of the paper is structured as follows: Section 2.2 briefly reviews the previous empirical findings and summarizes relevant theories on the role of exchange rate regimes for business cycle synchronization. Section 2.3 describes the data and outlines our empirical methodology. Section 2.4 reports the benchmark results on the effect of bilateral exchange rate regimes on business cycle synchronization. Section 2.5 investigates the robustness of the results and section 2.6 concludes.

## 2.2 Literature review

Our study is nested in the literature of determinants of business cycle synchronization and it is closest to the study of Inklaar et al. (2008), which investigates an exhaustive set of possible determinants of business cycle synchronization among 21 OECD countries for the period 1970-2003. The relevant determinants of business cycle synchronization such as trade intensity, trade specialisation or similarity in financial infrastructure were identified in earlier studies by Baxter and Kouparitsas (2005), Imbs (2004) and Kalemli-Ozcan et al. (2001).

### 2.2.1 Empirical evidence

#### 2.2.1.1 Relevant determinants of business cycle synchronization

While individual studies focus on many different determinants of business cycle synchronization, there is a range of commonly recognised factors that are found to affect the comovement. Among them, bilateral trade and trade structure have been identified as a key determinant in most empirical studies. As documented by Anderson et al. (1999) and Calderon et al. (2007), country pairs with more intense trade relationships have more synchronised business cycles. As the latter study shows, the impact of trade *intensity* on business cycle synchronization is smaller for developing countries than for developed countries. To further disentangle the effect of trade on business cycle comovement, studies of Kalemli-Ozcan et al. (2001), Burstein et al. (2008) and Arkolakis and Ramanarayanan (2009) address the role of trade *specialisation*. The strength of the effect also depends on the type of international trade linkages used in production (Di Giovanni and Levchenko, 2010).

Other determinants of business cycle synchronization that were frequently examined by the literature include the degree of financial integration (e.g. Kalemli-Ozcan et al., 2013) and transmission of monetary policy shocks (see e.g. Ehrmann and Fratzscher, 2009; Rey, 2016). Whereas the studies mentioned investigate the effect of individual factors, Imbs (2004) provide one of the earliest studies to consider possible determinants of business cycle synchronization simultaneously in the context of a system of simultaneous equations. The subsequent studies of Baxter and Kouparitsas (2005) and Inklaar et al. (2008) use the approach of Leamer (1983) to find “robust” variables explaining the comovement. These studies consider in particular trade intensity, specialisation, financial, fiscal and monetary policy integration as common determinants of business cycle synchronization. Given the importance of those variables on business cycles, we expect both a direct and an indirect link between exchange regimes and business cycle synchronization.

#### 2.2.1.2 The role of exchange rate regimes as a determinant of business cycle synchronization

There is a large number of studies investigating the effect of currency unions – in particular of the European Monetary Union (EMU) – on business cycle synchronization. The number of studies is large enough such that Campos et al. (2018) performed a meta-analysis. The authors analyse 63 studies on business cycle correlations between European countries. Synchronization was found to increase from about 0.4 to 0.6 following introduction of the Euro. To our knowledge, nobody has extended this analysis to the role of other exchange rate regimes yet.

Even if the role of exchange rate regimes was not investigated as determinant of synchronization, regimes were found to affect many other variables (such as international trade). If these variables make business cycles more synchronised, we could observe an indirect channel of exchange rate regimes on business cycles. There are many studies on the consequences of an exchange rate regimes choice. Fixing an exchange rate was found to promote international trade as shown by Klein and Shambaugh (2006) or Dorn and Egger (2015). Broda (2004) shows how the real shocks (measured by changes in terms-of-trade) affect the changes in real GDP. He finds that the real shocks are significantly smoother in floats than in pegs. Further studies show the relevance of exchange rate regimes on other common determinants: Taylor (2001) and Obstfeld et al. (2005) on monetary policy; Chang and Velasco (2000) on interaction between regimes, banking system and financial stability. Other studies also consider the effect exchange rate regimes have on economic growth, inflation and fiscal policy (e.g. Levy-Yeyati and Sturzenegger, 2003).

### 2.2.2 Related theoretical frameworks

There is no theoretical model that incorporates exchange rate regimes *directly* as a driver of business cycle synchronization. Nevertheless, already the Mundell-Fleming model shows how monetary and fiscal policies affect the real economy under fixed versus floating exchange rate regimes (Fleming, 1962; Mundell, 1963). One implication of the Mundell-Fleming framework is that, given free capital movement, the monetary policy of an economy that fixes its exchange rate regime should be more convergent with monetary policy in the anchor country. As monetary integration has been empirically found by earlier studies to increase business cycle synchronization, we can also expect the synchronisation to be higher under fixed exchange rate regime. Similarly, we should expect a higher synchronization of business cycles under flexible exchange rate regime if the shock comes from fiscal policies. The Mundell-Fleming framework thus gives us one possible channel for the exchange rate regimes to affect business cycle synchronization. Nevertheless, other defining features of exchange rate regimes such as behaviour of foreign exchange reserves or official announcements can also play a role.

Another strand of the theoretical literature related to our topic focuses on the other determinants of international business cycles. For example, Canova and Dellas (1993) provides a general equilibrium model that analyses the contribution of trade interdependence to international business cycles. Further theoretical studies on relevant determinants of comovement include Kehoe and Perri (2002) on frictions in international finance, Cravino and Levchenko (2017) on the role of multinational firms or De Grauwe and Ji (2017) on the role of internationally correlated behavioural changes. We find the macroeconomic model developed by De Grauwe and Ji (2017) to be the most relevant for our investigation. Their model studies the transmission of shocks across countries under two cases, monetary union and monetary independence. This framework indicates that more fixed exchange rate regimes are associated with more synchronised business cycles. Although the authors analyse only these two extreme cases, they provide an useful hypothesis to empirically investigate different types of exchange rate regimes using a finer classification.

The theory also suggests that exchange rate regimes have a potential to weaken or strengthen the effects of other economic variables. We expect that the strength of this effect crucially depends on the degree of financial openness. For example, Mundell (1973) assumes perfect capital mobility. This can be interpreted in light of a well-known "impossible trinity" argument, which states that an economy cannot adopt *monetary independence*, *fixed exchange rate regime* and *free capital mobility* at the same time. One implication is that if we have free movement of capital, the monetary policy of an economy in fixed exchange rate regime should be more convergent with policy of an anchor country. For example, Obstfeld et al. (2005) argue that monetary policy for countries with fixed exchange rate regimes is more constrained if there are no *capital controls* in place. Rey (2016) argues that floating regimes are not the only necessary condition that guarantees monetary autonomy under large *capital flows*. The strength of the potential exchange rate regime effect thus depends crucially on the level of countries' financial openness. One can on average expect the effect of regimes to be larger if capital can move freely across countries.

## 2.3 Data and Methodology

### 2.3.1 Data on dependent variable

Our dependent variable of business cycle synchronization is a correlation coefficient of the business cycle component of GDP growth data. We use either yearly or quarterly GDP growth data for the period 1973-2016. The yearly data is retrieved from the World Bank and the quarterly data is taken from the OECD and International Financial Statistics of the IMF. We use the Baxter-King filter to identify the business cycle components. We use the default filtering option which passes through the components with fluctuations between 2 and 8 years for yearly data. The thresholds for quarterly data are 6 and 32 quarters, respectively. We use both yearly and quarterly data since both have their own advantages: with yearly data we have a large country coverage. Quarterly data are more often used in practice for detrending (Christiano and Fitzgerald, 2003), but such data are available mainly for the limited group of OECD countries.

We compute the correlation of the business cycle components over 5 distinctive time intervals: 1973-1983, 1982-1992, 1991-2000, 1999-2008 and 2007-2016. We include a two years overlap between two neighbouring intervals as a natural split in the data for two reasons. First, the fourth interval starting in the year 1999 is intentionally chosen such that it reflects a substantial change in the regimes structure brought in by the introduction of the Euro. The fourth interval until the year 2008 was also not affected by the global financial crisis and subsequent worldwide declines in real GDP growth rates in the year 2009. Second, we need a sufficiently large time span to obtain a reliable measure of correlation coefficient for each country-pair. Intervals with the duration of at least 10 years seem to be sufficiently large to achieve this goal.

Table 2.1 presents the summary statistics of our dependent variables for each interval. The sample of *yearly* data covers countries across the whole world with

TABLE 2.1: Summary statistics for the business cycle synchronization variable

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Interval* | 1973-1983 | 1982-1992 | 1991-2000 | 1999-2008 | 2007-2016 |
| **Yearly Data** | | | | | |
| Mean | .072 | .034 | .054 | .284 | .287 |
| Standard Deviation | .373 | .357 | .372 | .380 | .449 |
| Observations | 12,432 | 18,632 | 26,732 | 31,506 | 31,152 |
| **Quarterly Data** | | | | | |
| Mean | .357 | .261 | .208 | .678 | .648 |
| Standard Deviation | .295 | .341 | .429 | .186 | .242 |
| Observations | 600 | 600 | 992 | 2,550 | 2,756 |

*Note: Business cycle synchronization is measured by the correlation of the business cycle components of the real GDP growth rates.*

observations number ranging from 12,432 in the first periods to over 31,000 in the last two periods as new countries became independent and data for more countries became available. The mean correlation coefficient for the business cycle synchronization was close to zero in the first three intervals but it increased to almost 0.3 in the last two intervals. The sample of *quarterly* data contains substantially less country-pairs observations since the quarterly data are reported mainly for developed countries. The mean correlation coefficient for the quarterly data ranges from around 0.2 to 0.7. It is not surprising that the quarterly data shows higher business cycle synchronization since the developed countries included in the quarterly sample are likely to be more closely integrated compared to the worldwide average.

Inklaar et al. (2008) argue that there is a possible problem with using the original correlation data, because the error terms in a regression model are unlikely to be normally distributed. Therefore, we follow the authors by transforming our measure of business cycle synchronization by constructing the Fisher's Z-transformation as $C'_t = \frac{1}{2}ln(\frac{1+C_t}{1-C_t})$, with $C_t$ being an original correlation coefficient computed over each time interval $t$. Figure 2.1 displays the original and transformed correlations of the business cycle synchronization coefficients. We can see from the left panels in blue that both yearly and quarterly data are far from being normally distributed. In particular, the distribution for *quarterly* data correlations is strongly skewed due to the large degree of integration in those countries covered by the quarterly data. The transformed coefficients ensure that the distribution for both yearly and quarterly data is normally distributed.

FIGURE 2.1: Distribution of *untransformed* and *transformed* coefficients of business cycle synchronization


*Note: The transformed correlation is based on the Fisher's z-transformation function:* $C' = \frac{1}{2}ln(\frac{1+C}{1-C})$. *The distribution is drawn from observations for the five intervals 1973-1983, 1982-1992, 1991-2000, 1999-2008 and 2007-2016.*

### 2.3.2 Data on bilateral exchange rate regimes and other variables

Our key independent variable is the bilateral de-facto exchange rate regime. Data we use is taken from the new dataset provided by Harms and Knaze (2018)[2]. The main feature of the dataset is that the data is at country-pair – bilateral – level for the cross-sectional dimension, which is transformed from unilateral exchange rate regimes data, with the unilateral exchange rate regimes data retrieved from Ilzetzki et al. (2017). The classification of the bilateral *de-facto* exchange rate regimes is shown in Table 2.10 in Appendix 2.A.1, with exchange rate regimes ranging from least flexible (no separate legal tender including currency union) to freely floating. We follow Harms and Knaze (2018) by defining exchange rate regime as integers ranging from 1 (least flexible) to 13 (freely floating). Unless otherwise specified, we pool them to a coarser set of 7 dummy variables denoted $Regime_k$ with $k$ ranging from 1 (least flexible) to 7 (freely floating).[3]

[2]The dataset with further description is available at: `https://www.international.economics.uni-mainz.de/data-on-bilateral-exchange-rate-regimes/`

[3]In some part of the analysis, we also test the specification by including the $Regime_{FF}$ dummy that takes a value of one if at least one country from a given country pair had a freely falling exchange rate regime at a given period.

Another feature of the data relevant for our analysis is that we can differentiate whether the bilateral regime between a country pair is direct or indirect. For example, Ecuador has a no separate legal tender against US dollar, thus U.S. and Ecuador are directly linked. Another direct US pegger (Hong Kong) is therefore indirectly pegged to Ecuador. Note that this can act as an important instrument to address the endogeneity concern of exchange rate regimes. It is plausible to assume that the decision of the Ecuador to peg to the U.S. dollar is independent of the decision of Hong Kong to peg to the U.S. dollar. We can then expect that an indirect peg of Honk Kong against Ecuador is less likely to be endogenous. We will use this information in robustness tests in Section 2.5.1.[4]

Data on bilateral exchange rate regimes is constructed at yearly intervals. Figure 2.2 shows the number of year-to-year changes in exchange rate regimes. It provides information on the variance of our key independent variable. We can see that there have been more changes in bilateral exchange rate regimes before 1990 and the time around 1999, when the EMU was formed. The upper part of Figure 2.2 also plots the 5 intervals over which we compute the business cycle synchronization. We use data of exchange rate regimes at the beginning (BOP) or in the middle (MOP) of each time period. For example, for the first interval 1973-1983, we test the results using the exchange rate regimes in the year 1973 (BOP) and year 1978 (MOP). Our analysis requires that exchange rate regime coefficients are properly measured and the consideration of both BOP and MOP ensures that the results are not driven by *within-period* variation. Given the low variability in exchange rate regimes over time, consistent results between the BOP and MOP measures should be enough to ensure that the exchange rate regime in a given interval is properly measured.[5]

Note that Harms and Knaze (2018) provide *de-facto* exchange rate regimes data based on the dataset of Ilzetzki et al. (2017) as well as *de-jure* data based on the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). Unlike Harms and Knaze (2018), our paper focuses on the *de-facto* data as we are mainly interested in the role of actually implemented exchange rate regimes. The *de-facto* regimes data also has a longer time span starting in 1973, thus having much larger sample size than the *de-jure* data that starts in 2000. However, we use *de-jure* data in one of our robustness checks.

[4]Figure 2.8 in Appendix 2.A.1 displays the distribution of de-facto regimes split by direct and indirect links.

[5]Another approach would be to use an average value of the exchange rate regime measure for each period. However, taking averages would leave us with non-integer values. For example, if a country had a crawling peg (Regime 4) and later on adopted a crawling band (Regime 5).

FIGURE 2.2: A number of year-to-year changes in the exchange rate regimes

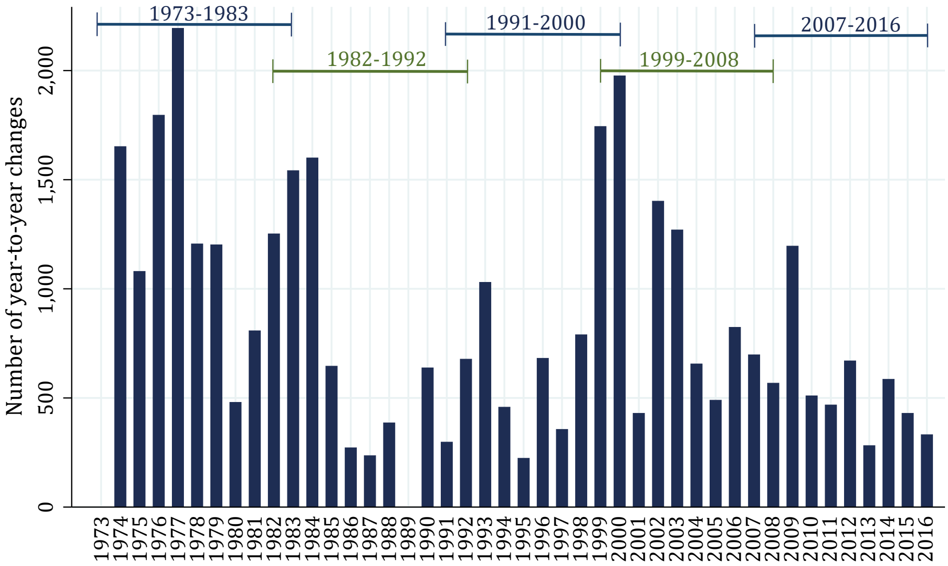



FIGURE 2.3: Density of the *quarterly* business cycle correlations split by the exchange rate regime dummies

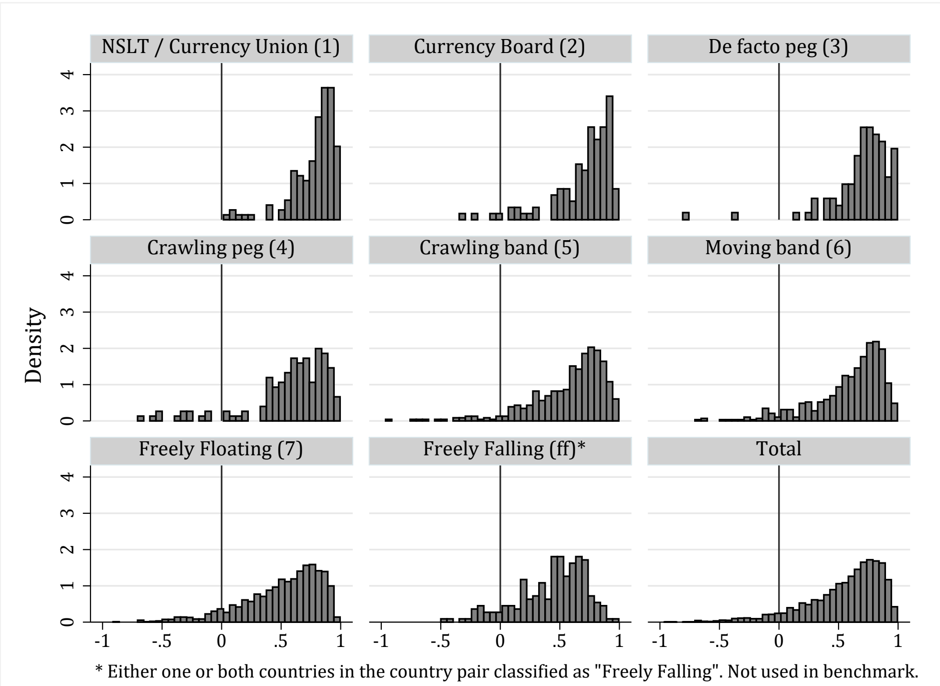


Figure 2.3 motivates our empirical investigation: here we plot density of the business cycle correlation coefficients for quarterly data across different exchange rate regimes. Compared to the overall density (box in the lower right corner), we can observe that countries with less flexible regimes (the three boxes in the first row of Figure 2.3) seem to have more synchronized business cycles than the other regimes. We shall of course be aware of the omitted variable bias between those two variables as countries with less flexible exchange rate regimes are likely to have other common characteristics.[6]

Regarding other potential determinants of business cycle synchronization, we collect an extensive set of all variables mentioned in the previous literature, following mainly Inklaar et al. (2008) and Baxter and Kouparitsas (2005). In particular, we focus on nine groups of determinants: (1) monetary integration; (2) trade intensity; (3) specialization; (4) similarity in governments' net lending / net borrowing; (5) financial infrastructure ; (6) financial integration; (7) inflation; (8) other variables such as difference in saving rate and physical capital. The complete data description including data sources and indicators is reported in Table 2.10 in Appendix 2.A.1.

### 2.3.3 Empirical specification

Our empirical strategy consists of two steps. The first step is to perform Extreme Bound Analysis (EBA) to identify robust determinants from a set of potential determinants of business cycle synchronization. EBA is a methodology based on Leamer (1985) which tests how a dependent variable, in our case business cycle synchronization, is associated with a variety of possible determinants of the synchronization. The EBA strategy is useful to deal with the problem of model uncertainty, especially if the literature is lacking solid theoretical or empirical guidance on the key determinants of business cycle synchronisation (Inklaar et al., 2008). Thus, EBA allows us to examine how sensitive parameters estimates are to different model specifications (Sturm and Haan, 2005).

[6] Please see Figure 2.9 in Appendix 2.A.1 for business cycle synchronization measured by yearly data.

For each variable of interest, our EBA examination consists of running $n$ separate regression equations specified as:

$$Y'_{n,ijt} \equiv \underbrace{\frac{1}{2} ln\left(\frac{1+Y_{n,ijt}}{1-Y_{n,ijt}}\right)}_{\text{Fisher's } z\text{-transformation}} = \alpha_n + \underbrace{\beta_n I_{n,ijt}}_{\text{Interest}} + \underbrace{\boldsymbol{\delta}_n \boldsymbol{D_{n,ijt}}}_{\text{Potential}} + \boldsymbol{\gamma}_n \boldsymbol{Z_{n,ijt}} + \epsilon_{n,ijt}, \quad (2.1)$$

where $Y'_{ijt}$ are the transformed yearly (quarterly) business cycle correlations between countries $i$ and $j$ over interval $t$. Note that the $t$ notation indicates the intervals, which have 5 potential values. For each given $t$, the dependent variable is a correlation coefficient computed over 10 or 11 years. For simplicity, we omit the notation of $ijt$ in the following description of the equation. $I$ denotes the variable of interest that is being assessed by the EBA and it is therefore always included. Note that $I \in \boldsymbol{X}$, where $\boldsymbol{X}$ is a vector of 38 *potentially* robust bilateral variables between countries. Among variables of interest, our main focus is given on the exchange rate regime variable. $\boldsymbol{D}$ consists of unique combinations of up to 3 variables from the set of $\boldsymbol{X}$ (excluding $I$), which differs in each of the $n$ separate regression models. Lastly, $\boldsymbol{Z}$ denotes variables always included in each regression model $n$. Our vector $\boldsymbol{Z}$ uses a full set of country $i$ and $j$ fixed effects to control for any unobservable country characteristics. We use a more flexible version of the EBA introduced by Sala-I-Martin (1997), where we look at the entire distribution of regression coefficients. In particular, a variable is considered to be EBA robust if at least 95 percent of its beta coefficients have the same sign.[7] In addition, at least 90 percent of all beta coefficients must be statistically significant at the 5 percent significance level.

Having determined the EBA robust variables of business cycle synchronization, we then use the robust variables in a reduced form equation specified as:

$$Y'_{ijt} = \alpha_0 + \boldsymbol{\beta X_{ijt,robust}} + \alpha_i + \alpha_j + \varepsilon_{ij} \quad (2.2)$$

where $X_{robust}$ denotes a vector of bilateral variables that are found to be EBA robust determinants of business cycle synchronization. $\alpha_i$ ($\alpha_j$) denotes source (host) country fixed effects.[8] Standard errors are clustered at country-pair level.

[7]Using the normally distributed cumulative distribution function being at right or left side of zero in at least 95 percent of all cases (CDF (0) test statistics $> 0.95$).

[8]In one of our robustness checks, we will later replace country-specific variables by *time-variant* country fixed effects in line with Harms and Knaze (2018). Note, however, that we do not include country-pair fixed effects since our main variable of interest — the bilateral de-facto exchange rate regime — exhibits little time variation.

The main challenge of the estimation strategy is the potential endogeneity of business cycles and exchange rate regimes. As indicated among others by Frankel and Rose (1998) following the theory of optimal currency area (OCA) by Mundell (1961), more synchronized business cycles increase the likelihood of two countries adopting the same currency. This is a common issue in most studies on currency unions. We account for the endogeneity issue in multiple ways discussed in extensions in section 2.5. Our first approach borrows the intuition from Barro and Tenreyro (2007) who argue that *directly* linked exchange rate regimes are more likely to be endogenous and exclude all such observations from the sample. This can be done using our dataset since we have data on both *directly* and *indirectly* linked exchange rate regimes. The intuition runs as follows: suppose that both country A and country B peg their currency to an anchor currency of country C. If both countries A and B decide *independently* to keep a close parity with country C's currency, the exchange rate regime between countries A and B would be exogenous to the bilateral trade, co-movement of business cycles or other economic variables between these two countries. Therefore, exchange rate regime that is only *indirectly* linked between countries A and B is assumed to be exogenous.

We also exclude country-pair observations containing countries whose currencies are being frequently adopted as an anchor such as the U.S. or Germany, since the decision on the exchange rate regime involving those countries is more likely to be endogenous, as suggested by Barro and Tenreyro (2007). Further, Baxter and Kouparitsas (2005) also used gravity variables such as distance and dummies for common colonial history, common border, language and religion as a group of potential determinants in the EBA estimation. However, the gravity variables are likely to affect other variables such as trade specialization that influence business cycle synchronisation as well (Inklaar et al., 2008). Specification including gravity terms thus also faces an endogeneity problem. Nevertheless, we also show in section 2.5 that the results are also robust to the inclusion of the gravity variables in the specification.

## 2.4 Empirical Results

### 2.4.1 The extreme bound analysis (EBA)

The following section reports the results from estimating equation 2.1 using the EBA methodology and reports the robust variables. We focus on reporting the

Table 2.2: EBA results with selected coefficients for the exchange rate regimes

| | Yearly data | | | Quarterly data | | |
|---|---|---|---|---|---|---|
| | Share of significant betas | | EBA robust? | Share of significant betas | | EBA robust? |
| Bilateral de-facto ERR: BOP* (index) | 100.0 | %<0 | ✓ | 100.0 | %<0 | ✓ |
| Bilateral de-facto ERR: MOP* (index) | 100.0 | %<0 | ✓ | 100.0 | %<0 | ✓ |
| Regime 1, BOP* (NSLT / Currency union) | 100.0 | %>0 | ✓ | 100.0 | %>0 | ✓ |
| Regime 2, BOP* (Currency board) | 79.7 | %>0 | ✗ | 96.6 | %>0 | ✓ |
| Regime 3, BOP* (De facto peg) | 97.3 | %>0 | ✓ | 100.0 | %>0 | ✓ |
| Regime 4, BOP* (Crawling peg) | 92.0 | %>0 | ✓ | 78.2 | %>0 | ✗ |
| Regime 5, BOP* (Crawling band) | 46.4 | %>0 | ✗ | 43.2 | %<0 | ✗ |
| Regime 6, BOP* (Moving band) | 100.0 | %>0 | ✓ | 100.0 | %>0 | ✓ |

*Note: * BOP denotes beginning of period. MOP denotes middle of period. The share of significant betas refers to the share of coefficients of corresponding exchange rate dummies being significant among the 1781 regressions.*

EBA results for the exchange rate regimes.[9] In a first step, we construct a flexibility measure using an index ranging from 1 (least flexible regime) to 13 (freely floating) as specified in Table 2.10 in Appendix 2.A.1. As Harms and Knaze (2018) have shown, it is likely that the regimes effect is non-linear. To take this into account, in a second step we map the measure of 13 regimes into a set of 7 coarser dummy variables. Our variable of interest $I$ becomes a set of six coarser regime dummies, ranging from 1 (no separate legal tender) to 6 (managed floating) as reported in the last column of Table 2.10 in Appendix 2.A.1. The dummy characterizing bilateral free floats (Regime 7) is excluded, such that the 6 dummies reflect the differential impact of each regime on business cycle synchronization, relative to the case of free floats.[10]

The first two rows in Table 2.2 report results for the flexibility index. A combination of the exchange rate regimes flexibility index as a variable of interest $I$ with up to three potentially robust variables leads to a total of 1,781 regressions. We find that the regimes coefficient is negative and statistically significant in all 100 percent of cases for both yearly and quarterly GDP data, thus passing the EBA robustness test. The results are identical for both beginning of period (BOP; row 1) and middle of period (MOP; row 2). We conclude that less flexible regimes (having lower value on the index) are on average associated with more synchronised business cycles. The remaining 6 rows of Table 2.2 show the EBA results

[9]The EBA results for other potential determinants of business cycle synchronization can be found in Table 2.10 in Appendix 2.A.1.

[10]Unless otherwise indicated, our analysis for the rest of the empirical part will focus on the effect of individual regime dummies.

when the exchange rate regime dummies are used for each regime type. The large share of positive and significant beta coefficients means that those regimes are found to have significantly more synchronised business cycles than free floats. We find that only regime 1, regime 3 and regime 6 passed the robustness test for both yearly and quarterly data. In addition, we find currency boards (regime 2) to be EBA robust using quarterly data only. For yearly data we find that currency boards have still all betas with positive signs but they are statistically significant only in 1,419 individual regressions (79.7 percent of all regressions we ran).

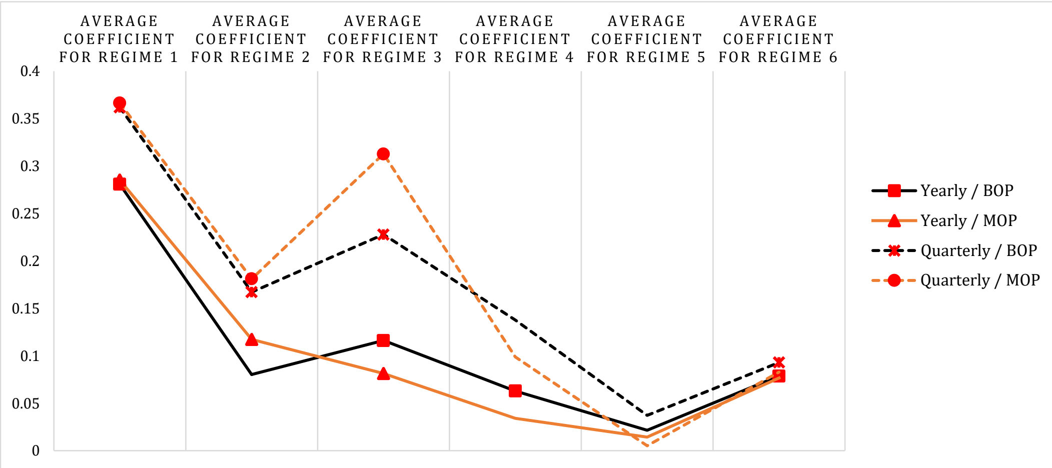
Figure 2.4 plots the average size of each beta coefficient of different exchange rate regimes from all 1,781 regressions. We weigh each beta using the adjusted $R^2$ of each estimation. We perform this step to mitigate the possibility that the size of the average coefficient is driven by a handful of estimations with low explanatory power.[11] We report the yearly and quarterly data using solid and dotted lines, respectively. The red markers denote estimations which passed the EBA robustness test.

We can see that the coefficients for the quarterly data are always higher than for yearly data, but the two display a similar pattern for individual exchange rate regimes. In particular, regime 1 (no separate legal tender) is associated with the strongest positive effect on business cycle synchronization, with both quarterly and yearly data being EBA robust. We also find regime 3 (hard pegs) to be EBA robust, but the average size of the effect is much higher for quarterly than for yearly data. Regime 6 (managed floating) is also strongly EBA robust but the average size of its coefficient is only about a quarter of the effect of regime 1. Finally, the differences in the use of a regime classification at the beginning (BOP) and middle of period (MOP) are negligible. This is not surprising given the overall low variability in bilateral exchange rate regimes over time.

One concern in our estimation is that our results might be driven by countries with currency crises. However, these countries are likely to be already classified as a residual "freely falling" regimes category: The dataset contains a dummy variable $Regime_{FF}$ for freely falling regimes. This takes a value of one for each country pair where *at least one* country was categorized as having a freely falling exchange rate regime by Ilzetzki et al. (2017). The "freely falling" category consists of regimes with very high inflation over 40 percent per annum that by definition do not have any de-facto anchor. We repeat our EBA test using the alternative dummies

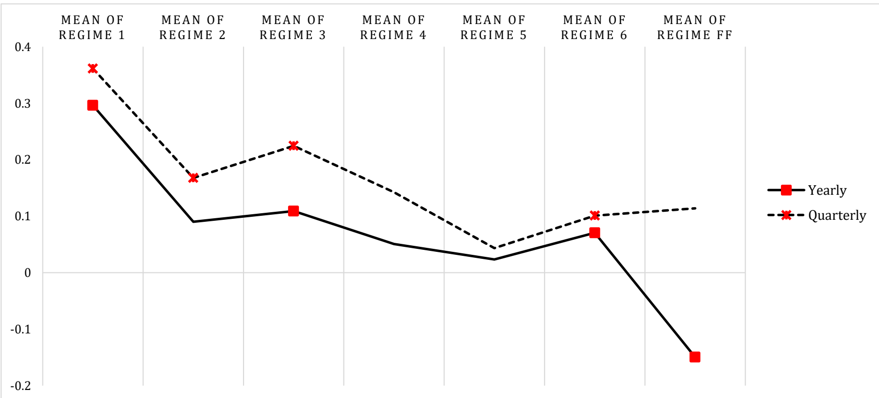
[11] Nevertheless, we find that this is not the case. The unadjusted average of coefficients shows very similar pattern with slightly more outliers. The results are available upon request.

FIGURE 2.4: Average effect of the $R^2$-weighted exchange rate regime dummy coefficients from 1,781 regressions




*Note: Red markers denote the EBA robust coefficients. BOP – Beginning of period; MOP – Middle of period. The coefficients show the differential impact of each individual regime on business cycle synchronization - measured as a correlation - relative to the case of free floats.*

FIGURE 2.5: Average effect of the $R^2$-weighted exchange rate regime dummy coefficients from 1,781 regressions: with "Freely Falling Regime (FF)" included




*Note: Red markers denote EBA robust coefficients.*

specification with the $Regime_{FF}$ dummy included. The estimation results are reported in Figure 2.5.

The results remain similar, with regime 1, regime 3 and regime 6 being most significant. In addition, we find that our dummy variable $Regime_{FF}$ dummy has an EBA robust *negative* coefficient: country pairs where at least one country's regime is classified as freely falling have substantially less synchronised business cycles compared to the country pairs with free floating regimes. This is in line with our intuition: if countries with freely falling exchange rate regime suffer severe financial and economic crisis, then the business cycles get significantly out of synchronization compared to countries that are currently not in crisis. The coefficient for freely falling regimes using quarterly data is not EBA robust, which is not surprising as none but two countries with quarterly GDP data were ever classified as having a freely falling exchange rate regime.[12]

Note that results reported in Figure 2.5 are estimated with the freely falling regime at the beginning of each correlation interval. However, each of our intervals has a length of at least 10 years. This might be problematic for the interpretation of empirical results if the freely falling regime prevails only for the very short time span. For example, we might misidentify all cases where freely falling regime occurred later than in the first year of the sample. We find that the average duration for countries ever classified as having the "freely falling" regime between years 1973 and 2016 is 7.3 years. This is indeed shorter than the average duration of other exchange rate regimes. Some countries like Turkey, Uruguay, Argentina or Brazil were in this category for more than 20 years, but most other countries were in this category for significantly shorter time spans. Thus, the "freely falling" regimes coefficients might be biased.

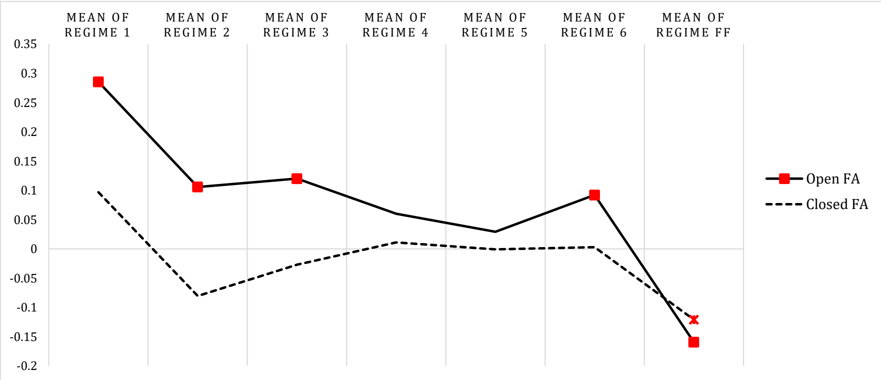
However, this should not affect our results if the exchange rate regime dummies of primary interest (Regimes 1 to 6) remain stable. This is indeed the case as can be seen in Figure 2.5. This is also the case when we perform further robustness tests by excluding countries that were classified as freely floating during *any* given correlation interval or (even more restrictively) in any year between the 1973 and 2016.[13] Moving on, we treat the "freely falling" regime as a special category used for robustness checks, also because this classification does not fit well into our bilateral structure when only one country within a country pair was classified as a freely falling regime.

Rey (2016) argues that flexible exchange rates are not sufficient to guarantee monetary autonomy for countries with large capital flows. Therefore, we are also concerned about the extent to which regimes interact with countries' levels of financial openness. To account for the importance of capital flows, we do a sample split using a measure of financial openness as in Chinn and Ito (2006). We compute an average of the unilateral measure of financial account openness of each county pair at the beginning of each period. Yearly data for the dependent variable is

[12]Specifically, for quarterly data we have only 126 country-pair observations with $Regime_{FF}$ dummy being equal to one at the beginning of each period from a full sample of approximately 5000 observations for quarterly data. These observations come from a freely falling regimes being in place in Iceland and Brazil. There are no observations falling into the freely falling category for quarterly data when exchange rate regimes at the middle of period is taken.

[13]See Section 2.5 for extensions and robustness tests.

FIGURE 2.6: Average effect of the $R^2$-weighted exchange rate regime dummy coefficients from 1,781 regressions: Sample split by the degree of *financial openness*




*Note: Red markers denote EBA robust coefficients.*

used.[14] The results reported in Figure 2.6 show that regimes matter only for country pairs with an open financial account: all regimes except regime 4 and regime 5 are EBA robust. Also, note that the regime 2 (currency boards) that previously failed the EBA robustness test when using the yearly data is now EBA robust as well. We find no robust regimes for countries with a closed financial account.

We proceed with the EBA on all other potential determinants of synchronization. The complete EBA results for all 38 doubtful variables are reported in Table 2.10 in Appendix 2.A.1. The robust determinants identified by EBA are very similar to the determinants found by Inklaar et al. (2008). In addition to those determinants found by Inklaar et al. (2008), the correlation of CPI based inflation rates and average trade openness are found to be robust determinants of synchronization. We take all EBA robust variables and use them in estimating our reduced model as outlined in equation 2.2.

### 2.4.2 Benchmark estimation of the reduced model

Estimation of the reduced model specified in equation 2.2 is shown in Table 2.3. Following the EBA exercise, a vector $\boldsymbol{X_{ijt,robust}}$ consists of all EBA robust variables including exchange rate regime dummies. These variables include measures

[14] The reason is that quarterly data consists of mostly developed countries that all have a relatively high degree of financial openness.

Table 2.3: Effect of exchange rate regimes on business cycle synchronization: *Benchmark results*

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Beginning of period | | Middle of period | |
| | Yearly | Quarterly | Yearly | Quarterly |
| Bilateral Trade (PCA, standardized) | 0.027*** | 0.018*** | 0.027*** | 0.020*** |
| | (6.398) | (5.417) | (6.386) | (6.398) |
| Specialization (standardized) | 0.037*** | 0.037*** | 0.035*** | 0.028*** |
| | (11.375) | (5.833) | (10.836) | (4.283) |
| Fiscal integration (standardized) | 0.060*** | 0.064*** | 0.066*** | 0.083*** |
| | (21.368) | (9.171) | (24.275) | (11.450) |
| Inflation correlation (standardized) | 0.044*** | 0.036*** | 0.022*** | 0.002 |
| | (12.337) | (4.266) | (6.657) | (0.176) |
| Openness (standardized) | 0.348*** | 0.300*** | 0.366*** | 0.427*** |
| | (33.648) | (14.540) | (35.406) | (17.678) |
| Regime 1 (NSLT / Currency union) | 0.114*** | 0.266*** | 0.115*** | 0.194*** |
| | (7.229) | (8.068) | (7.970) | (6.155) |
| Regime 2 (Currency board) | 0.022 | 0.100** | 0.040** | 0.077** |
| | (1.134) | (2.334) | (2.320) | (2.089) |
| Regime 3 (De facto peg) | 0.056*** | 0.182*** | 0.045*** | 0.311*** |
| | (2.888) | (4.451) | (2.929) | (8.542) |
| Regime 4 (Crawling peg) | 0.005 | 0.001 | 0.004 | 0.139*** |
| | (0.405) | (0.021) | (0.359) | (2.998) |
| Regime 5 (Crawling band) | -0.009 | -0.014 | -0.025** | -0.028 |
| | (-1.013) | (-0.615) | (-2.511) | (-0.885) |
| Regime 6 (Moving band) | 0.032*** | 0.029* | 0.051*** | 0.060*** |
| | (3.728) | (1.718) | (5.585) | (2.721) |
| N | 29634 | 5000 | 32073 | 5198 |
| $R^2$ | 0.47 | 0.41 | 0.44 | 0.40 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country i and country j fixed effects included but not reported. Business cycle synchronization is a dependent variable.*

for *trade intensity* (principal component)[15], *trade specialization* (share of intra-industry trade), *fiscal integration*, *inflation correlation* and *average trade openness*. Note that we report the standardized coefficients of non-dummy explanatory variables to make the individual coefficients comparable.[16]

Table 2.3 shows that all standardized coefficients have the expected sign and are statistically significant. The sample size for yearly data (column 1) is much larger than for quarterly data (column 2), but the size of the standardized coefficients is very similar. The size of the standardized coefficients is also in line with the

[15]Our EBA estimation included both different measures of trade intensity as well as the pricipal component of four different measures to estimate parameters of principal-component model following Inklaar et al. (2008). Since all variables were found to be EBA robust (see Figure 2.10 in Appendix 2.A.1, we use the principal component of the variables in the benchmark results.

[16]We standardize each variable $x_{ijt}$ by subtracting its mean and dividing by its standard deviation such that $x_{ijt}^{std} = \frac{[x_{ijt} - mean(x_{ijt})]}{sd(x_{ijt})}$. Note that dummies for exchange rate regimes are not standardized.

previous literature. For example, the coefficient for fiscal integration is identical to the findings of Inklaar et al. (2008). The coefficient of *trade intensity* (bilateral trade) is slightly lower (0.02-0.03) compared to Inklaar et al. (2008), which seems to be driven by the fact that we are also including a measure of *aggregate* trade (openness).

Turning to our coefficients of main interest, it can be see in column (1) that coefficients for no separate legal tenders (Regime 1) and de-facto pegs (Regime 3) are positive and strongly statistically significant. As for the other soft pegs, only moving bands (Regime 6) are statistically significant. We find that no separate legal tender (Regime 1) has by far the strongest effect on business cycle synchronization compared to the free floating pairs. The size of the effect for regime 3 is only about half as large compared to regime 1. The size of the effect for regime 6 is only about one fourth of regime 1.

When turning to quarterly data (column 2), the results turn out to be consistent with the yearly data. However, the size of the coefficients is always larger when using quarterly data. We discuss reasons for this discrepancy in extensions in section 2.5.2. Finally, taking the regimes at the middle of the period (see columns 3 and 4) yields very similar results, which is not surprising to us given the low variability in exchange rate regimes over time. Note that currency boards (Regime 2) are significant only for columns (2)-(4) but not for yearly data in column (1). We show in section 2.5.4 that the currency boards coefficient is significant only for financially open countries.[17]

We find that the results for exchange rate regimes – especially for hard pegs – are also economically significant. We see this by re-estimating our benchmark results with the untransformed dependent variable instead of using the Fisher's Z-transformation. This specification is easier for interpretation, since the correlation coefficients after the transformation do not range from -1 to 1. For example, we find that the estimated coefficient of regime 1 (NSLT / Currency union) ranges from 0.07 to 0.12, implying that regime 1 increases business cycle correlation by 0.07-0.12, compared to the free floating regimes. We report the complete results when using the *untransformed* dependent variable in Table 2.11 in Appendix 2.A.2.[18]

[17]For completeness, please see Table 2.12 in Appendix 2.A.2 for the results when observations of "Free Falling" regime is included.

[18]We note a difficulty in comparing the strength of the effects *between* individual determinants: the dummy coefficients for exchange rate regimes are non-standardized, whereas the other variables have standardized coefficients. Despite the standardization, bilateral variables constructed

TABLE 2.4: Effect of exchange rate regimes on business cycle synchronization: Split of Regime 1 into *currency unions (EMU)* and *no separate legal tenders*

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Beginning of period | | Middle of period | |
| | Yearly | Quarterly | Yearly | Quarterly |
| Currency union (EMU) | 0.313*** | 0.266*** | 0.260*** | 0.194*** |
| | (10.307) | (8.068) | (10.128) | (6.155) |
| Other no separate legal tender | 0.034** | | 0.040*** | |
| | (2.122) | | (2.625) | |
| Regime 2 (Currency board) | 0.022 | 0.100** | 0.040** | 0.077** |
| | (1.104) | (2.334) | (2.349) | (2.089) |
| Regime 3 (De facto peg) | 0.056*** | 0.182*** | 0.046*** | 0.311*** |
| | (2.876) | (4.451) | (2.938) | (8.542) |
| Regime 4 (Crawling peg) | 0.004 | 0.001 | 0.003 | 0.139*** |
| | (0.363) | (0.021) | (0.270) | (2.998) |
| Regime 5 (Crawling band) | -0.008 | -0.014 | -0.025** | -0.028 |
| | (-0.917) | (-0.615) | (-2.515) | (-0.885) |
| Regime 6 (Moving band) | 0.034*** | 0.029* | 0.052*** | 0.060*** |
| | (3.875) | (1.718) | (5.648) | (2.721) |
| N | 29634 | 5000 | 32073 | 5198 |
| $R^2$ | 0.47 | 0.41 | 0.44 | 0.40 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country i and country j fixed effects included but not reported. Other explanatory variables from vector $X_{ijt,robust}$ included but not reported.*

### 2.4.3 Focus on the special case of currency unions

The bilateral dataset defines the "no separate legal tender" (NSLT, Regime 1) category as a) countries where a foreign currency circulates as the sole legal tender (frequently also referred to as "dollarization") and b) countries that belong to a monetary or currency union in which the same legal tender is shared by members of the union (Harms and Knaze, 2018). To facilitate the comparison with numerous studies on the effect of currency unions, we split the NSLT category into country pairs within the EMU and pairs that are NSLT but outside of the EMU. The reason is that EMU can be considered as the only currency union that conducts monetary policy based on criteria for the union as a whole. Other currency unions are only implicitly pegging against other currencies. For example, West African Economic and Monetary Union (WAEMU) or Central African Economic and Monetary Community (CAEMC) are pegged against the Euro (before French Franc) and Eastern Carribean Currency Union is pegged against the US dollar.

as bilateral correlations such as trade specialisation are difficult to compare with aggregate measures such as trade openness. Therefore, our paper focuses on the *relative* importance between *individual* exchange rate regimes for business cycles synchronization.

Table 2.4 reports the results when the EMU dummy is separated. We can see that both coefficients remain positive and statistically significant, but the coefficient of currency union (0.313, row 1 in column 1) is higher than for other "dollarized" (NSLT) countries without Eurozone (0.034, row 2 in column 1). This implies that the Eurozone membership is associated with an increase in business cycle synchronization by almost ten times as much compared to the other NSLT countries. Therefore, the role of a common central bank with a monetary policy conducted across all member states seems to be of a particular importance. Further, we can see from column 2 (quarterly data) that the EMU category is almost identical to the coefficient for regime 1 in Table 2.3, since all countries with available quarterly data are members of the EMU. This partially explains the difference observed between yearly and quarterly coefficients in the previous table.

## 2.5 Extensions and Robustness Tests

### 2.5.1 Exclusion of observations with possibly endogenous exchange rate regimes and the "freely falling" cases

The concern that an exchange rate regime might not be exogenous to different outcome variables has been frequently raised in the literature. For example, Klein and Shambaugh (2006) note that the variables of interest such as inflation or economic growth are both *determined* by the peg and *determine* the likelihood to peg. However, the authors argue that the choice to peg is largely related to variables that only change slowly, such that the use of country or country-pair fixed effects seems to address adequately concerns with endogeneity. We also believe that our dependent variable is less prone to the endogeneity problem than variables such as inflation, because it is constructed as a correlation over five independent periods with relatively long time horizon. Nevertheless, to rule out this possibility, we use three rather strict criteria for excluding potentially endogenous exchange rate regimes observations.

The first approach borrows the intuition from Barro and Tenreyro (2007) that exchange rate regime that is only *indirectly* linked between countries is assumed to be exogenous. This feature can be easily applied to the bilateral exchange rate regimes dataset. We have data on country pairs that have both *directly* as well as *indirectly* linked exchange rate regimes (See Figure 2.7 in Appendix 2.A.2.)

*Directly* linked exchange rate regimes consist of connections when a given country adopts the currency of a main anchor country in a "client-anchor" relationship (f.e. Hong-Kong - U.S.), a currency union relationship (f.e. Germany-France) or a "client-currency union" relationship (f.e. Denmark-Eurozone). *Indirect* link dummies consist of country pairs that are connected indirectly through common anchor currency as "anchor-anchor" (f.e. Honk-Kong - Jordan) and pairs that are both pegged to a currency union as "anchor-currency union" (f.e. Denmark and Bulgaria). We use the argument of Barro and Tenreyro (2007) that the *directly* linked regimes are more likely to be endogenous and exclude all such observations from the sample.

The results are reported in columns 1 and 2 of Table 2.5. We see that the effect of regime 1 is almost identical for both country and country-pair fixed effects. Thus, even if all "client-anchor", "client-currency union" observations are excluded the results remain robust. As for regimes 3 and 6, those regimes remain significant only for country-time fixed effects, which could be driven by the fact that we strongly reduce the number of available observations.[19] An unexpected result shows up for regime 5, when country fixed effects are controlled for. The negatively significant result indicates that country pairs in crawling band have lower synchronization than the freely floating regimes. However, the coefficient turns out to be positive and significant once the country-time fixed effects are used. Combined with the fact that regime 5 was not EBA significant, we tend not to make any inference on the effect of this regime on business cycle synchronization.

In line with the same intuition, the second approach is to exclude observations for countries that are frequently identified as main anchor currencies. The countries identified as major anchor currencies as in by Barro and Tenreyro (2007) are Australia, France, Germany, Japan, the United Kingdom and the United States. We exclude all observations where at least one country from the country-pair belongs to this list. Excluding these countries should eliminate the observations that are most likely to suffer from endogeneity. Columns 3 and 4 of Table 2.5 show results when excluding observations involving these 6 countries. The positive effect of regimes 1, 3 and 6 is robust in both specifications. In addition, regimes 4 and 5 shows a significantly positive effect on synchronization when we control for country-time fixed effects. Finally, the third approach is to exclude all observations for regime 1 (No separate legal tenders / currency unions) as they are possibly more likely to be subject to the endogeneity issue due to requirements on variables

[19]Note that from cca. 27.000 observations available, the large majority are the freely floating regimes.

TABLE 2.5: Exclusion of observations that are prone to endogeneity problem

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Excluded | Excluded | Excluded | Excluded | Excluded | Excluded |
| | Direct Links | Direct Links | 6 Anchors | 6 Anchors | Regime 1 | Regime 1 |
| Regime 1 (NSLT / Currency union) | 0.174*** | 0.156*** | 0.108*** | 0.055*** | | |
| | (6.507) | (5.525) | (6.296) | (3.123) | | |
| Regime 2 (Currency board) | -0.015 | -0.029 | 0.015 | -0.012 | 0.026 | -0.004 |
| | (-0.603) | (-1.195) | (0.710) | (-0.620) | (1.311) | (-0.189) |
| Regime 3 (De facto peg) | 0.032 | 0.046** | 0.047** | 0.045** | 0.060*** | 0.064*** |
| | (1.390) | (2.176) | (2.182) | (2.297) | (3.089) | (3.514) |
| Regime 4 (Crawling peg) | -0.014 | 0.013 | 0.010 | 0.026** | 0.010 | 0.033*** |
| | (-1.095) | (1.104) | (0.783) | (2.126) | (0.821) | (2.825) |
| Regime 5 (Crawling band) | -0.028*** | 0.037*** | -0.001 | 0.046*** | -0.004 | 0.050*** |
| | (-3.077) | (4.138) | (-0.132) | (5.281) | (-0.471) | (5.944) |
| Regime 6 (Moving band) | 0.015 | 0.030*** | 0.034*** | 0.044*** | 0.036*** | 0.039*** |
| | (1.612) | (3.261) | (3.671) | (4.742) | (4.140) | (4.422) |
| Country Fixed Effects | Yes | No | Yes | No | Yes | No |
| Country-Time Fixed Effects | No | Yes | No | Yes | No | Yes |
| Observations (N) | 27476 | 27476 | 25556 | 25556 | 28572 | 28572 |
| $R^2$ | 0.45 | 0.61 | 0.47 | 0.61 | 0.46 | 0.62 |

*t statistics in parentheses;* $^{*}$ $p < 0.1$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$. *Standard errors clustered at country-pair level. Other explanatory variables from vector* $X_{ijt,robust}$ *included but not reported. Note: Yearly data is used for this table. Business cycle synchronization is the dependent variable.*

such as inflation and government deficit to be more synchronised in order to join currency unions. The results are shown in the last two columns of Table 2.5. We can see that the results with regime 1 excluded are very similar to our benchmark results.

An additional issue we consider is the occurrence of short-lived exchange rate regimes in any given interval. This is especially the case for the "freely falling" residual category. This could be especially problematic if the regime went from peg to freely falling at any point in time other than the beginning of period (BOP) or the middle of period (MOP). To check for this possibility, Table 2.6 reports the results when excluding "freely falling" observations even if they were not classified as such at the BOP or MOP: Column 1 excludes observations that had a freely falling regime at any year during a given interval, even if this was in the last year. Column 2 is even more strict such that it excludes all observations for countries classified as freely falling at any point in history starting from the year 1973.

These exclusions greatly reduce the number of observations available. Nevertheless, the robustness of the results for regimes 1, 3 and 6 remains. Similarly to the previous table, the non-EBA robust regime 5 turns out to be negative, with the coefficient being barely economically significant. Further, there remains a possibility that an exchange rate regime was not classified as "freely falling" but a country experienced serious banking, currency and debt crises. We control for this possibility by excluding countries that experienced a crisis during our correlation period

Table 2.6: Excluding observations classified as *freely falling* or in *crisis*

| | (1) Excluded Freely falling (in period) | (2) Excluded Freely falling (all periods) | (3) Excluded Banking crises (in period) | (4) Excluded Currency crises (in period) | (5) Excluded Debt crises (in period) |
|---|---|---|---|---|---|
| Regime 1 (NSLT / Currency union) | 0.128*** | 0.123*** | 0.110*** | 0.104*** | 0.120*** |
| | (7.647) | (6.896) | (5.959) | (6.470) | (7.180) |
| Regime 2 (Currency board) | 0.020 | 0.035 | 0.025 | 0.021 | 0.029 |
| | (0.871) | (1.267) | (1.128) | (1.036) | (1.422) |
| Regime 3 (De facto peg) | 0.062** | 0.086*** | 0.058** | 0.075*** | 0.050** |
| | (2.576) | (3.249) | (2.571) | (3.346) | (2.492) |
| Regime 4 (Crawling peg) | 0.018 | 0.022 | 0.031** | 0.013 | 0.014 |
| | (1.316) | (1.204) | (2.256) | (1.030) | (1.130) |
| Regime 5 (Crawling band) | -0.025** | -0.034** | 0.002 | -0.004 | -0.013 |
| | (-2.221) | (-2.255) | (0.217) | (-0.367) | (-1.411) |
| Regime 6 (Moving band) | 0.046*** | 0.066*** | -0.018* | 0.012 | 0.038*** |
| | (4.421) | (4.903) | (-1.759) | (1.342) | (4.189) |
| Observations (N) | 19620 | 12824 | 20348 | 24524 | 27548 |
| $R^2$ | 0.51 | 0.44 | 0.47 | 0.50 | 0.48 |

*t statistics in parentheses;* * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. *Standard errors clustered at country-pair level. Country i and country j fixed effects included but not reported. Other explanatory variables from vector* $X_{ijt,robust}$ *included but not reported.* *Note: Yearly data is used for this table.*

as specified in Laeven and Valencia (2012). The results are reported in columns 3 to 5 of Table 2.6. We find that even this exclusion does not significantly alter our results.

### 2.5.2 Accounting for differences between yearly and quarterly data

Our benchmark results suggest that the exchange rate regimes coefficients for *quarterly* data are on average always larger than for *yearly* data. There are two possible channels for such systematic differences: First option is that exchange rate regimes might affect business cycles at shorter time horizon more. Second possibility is that the coefficients are driven by a specific set of country pairs that are included only in the smaller sample of countries with quarterly data. By limiting the sample of annual data to the same set of quarterly countries, we find the latter channel is driving our results: We show in Table 2.13 in Appendix 2.A.2 that the coefficients of the yearly business cycle correlation are almost identical to the quarterly coefficients when the same sample of country pairs is used. We recall that the quarterly data are available mostly for developed countries. These results are then in line with the previous literature that finds that the effect of business cycle synchronization is smaller for developing countries than for developed countries (Calderon et al., 2007). Indeed, a sample split shown in Table 2.14

TABLE 2.7: Controlling for the time-varying heterogeneity using *country-time* fixed effects

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Beginning of period | | Middle of period | |
| | Yearly | Quarterly | Yearly | Quarterly |
| Regime 1 (NSLT / Currency union) | 0.056*** | 0.158*** | 0.074*** | 0.203*** |
| | (3.587) | (5.261) | (5.171) | (7.537) |
| Regime 2 (Currency board) | -0.009 | 0.050 | 0.020 | 0.090*** |
| | (-0.500) | (1.541) | (1.225) | (3.236) |
| Regime 3 (De facto peg) | 0.060*** | 0.233*** | 0.085*** | 0.378*** |
| | (3.318) | (5.758) | (5.760) | (10.657) |
| Regime 4 (Crawling peg) | 0.027** | 0.152*** | 0.031*** | 0.143*** |
| | (2.340) | (3.620) | (2.975) | (3.903) |
| Regime 5 (Crawling band) | 0.046*** | 0.040* | 0.074*** | 0.080** |
| | (5.467) | (1.878) | (7.744) | (2.554) |
| Regime 6 (Moving band) | 0.035*** | 0.040** | 0.038*** | 0.116*** |
| | (4.021) | (2.516) | (4.390) | (5.750) |
| N | 29634 | 5000 | 32073 | 5198 |
| $R^2$ | 0.62 | 0.67 | 0.61 | 0.69 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country **i-time** and country **j-time** fixed effects included but not reported. Other explanatory variables from vector $X_{ijt,robust}$ included but not reported. Business cycle synchronization is the dependent variable.*

in Appendix 2.A.2 shows that the coefficients are stronger for country pairs that are both high-income countries (columns 1 and 2).[20]

### 2.5.3 Additional controls for time trend and gravity variables

Our benchmark estimation includes country $i$ and $j$ fixed effects. The use of standard *country-year* fixed effects is not possible as our dependent variable is constructed as a correlation over multiple years. We believe that the time-varying unobserved heterogeneity is not an issue to us since we consider 5 distinctive intervals over long time spans. Nevertheless, to test this possibility we also include country-time fixed effects to account for unobservable country-time varying heterogeneity. Table 2.7 reports the results. We can see that the coefficients are higher for most regimes than in our benchmark results, except for regime 2. Also, regime 4 and regime 5 are found to significantly affect synchronization, which has

[20]Note that the World Bank's Atlas classification in the year 2000 is used as a classification method. The sample of high-income countries is roughly similar to the "developed" category published by UNCTAD. Our sample split greatly limits the number of available observations, and the coefficient should therefore be taken with a grain of salt.

not been the case before. We note that the size of the coefficients for each regime generally falls as the regimes become more flexible.

Our results also remain robust when country $i$, country $j$ and time $t$ fixed effects are used (i.e. no country-time dummies but separate time dummies) and when bilateral gravity variables are added to the specification. Table 2.15 in Appendix 2.A.2 reports regression results when country $i$, country $j$ and time $t$ fixed effects are controlled. Importantly, our results remain robust when we include bilateral gravity variables. Table 2.16 in Appendix 2.A.2 shows that all gravity variables except common border are found to be significant determinants of business cycle synchronisation. The size of the exchange rate regimes coefficients turns out to be somewhat smaller, but the coefficients remain positive and signifficant.

### 2.5.4 Accounting for the role of financial openness and institutional quality

Our next robustness check consists of splitting the sample by a degree of financial openness based on Chinn and Ito (2006) and by institutional quality as measured by the World Governance Indicators from the World Bank. The intuition to consider financial openness is that the relationship between regimes and monetary autonomy exists only when there is a free movement of capital. The relationship between regimes and synchronization might be stronger when the financial account is open. Moreover, a more open financial account should allow the exchange rate regime to play a larger role in the real economy. An intuition to consider the institutional quality is that countries with high quality governance are expected to perform better at maintaining exchange rate pegs and abandon them less often, as suggested by Alesina and Wagner (2006). Even if a country is committed to a credible exchange rate regime, poor institutional quality is expected to impose more challenges to implement and maintain its policy targets.

The first two columns of Table 2.8 confirm the EBA results presented in Figure 2.6, which show that exchange rate regime is a significant determinant of synchronization only if financial account is relatively open.[21] In contrast to the EBA, our reduced model also shows positive and significant effect of regime 1 for countries with closed financial account, even though the coefficient is lower than for countries with an open financial account. The last two columns of Table 2.8 show

[21] We perform the sample split by defining a threshold of 0.5 in the range 0 to 1, where countries with an index of 0.5 or higher are understood as having an open financial account.

TABLE 2.8: *Sample split* by levels of financial openness and institutional quality

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Openness | | Governance quality | |
| | High | Low | High | Low |
| Regime 1 (NSLT / Currency union) | 0.128*** | 0.114*** | 0.133*** | 0.090*** |
| | (7.368) | (3.660) | (7.306) | (3.335) |
| Regime 2 (Currency board) | 0.052** | -0.047 | 0.027 | -0.000 |
| | (2.350) | (-1.160) | (1.329) | (-0.009) |
| Regime 3 (De facto peg) | 0.077*** | 0.004 | 0.080*** | 0.023 |
| | (3.280) | (0.118) | (3.401) | (0.649) |
| Regime 4 (Crawling peg) | 0.005 | 0.011 | 0.019 | -0.017 |
| | (0.322) | (0.574) | (1.046) | (-0.889) |
| Regime 5 (Crawling band) | 0.002 | -0.039** | -0.018 | -0.025 |
| | (0.216) | (-2.499) | (-1.496) | (-1.613) |
| Regime 6 (Moving band) | 0.045*** | 0.009 | 0.031*** | 0.012 |
| | (4.386) | (0.552) | (2.709) | (0.767) |
| N | 20936 | 8374 | 17490 | 12144 |
| $R^2$ | 0.50 | 0.39 | 0.50 | 0.42 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country i and country j fixed effects included but not reported. Other explanatory variables from vector $X_{ijt,robust}$ included but not reported. Note: Institutional quality is represented by the world governance index (WGI). Yearly data is used for this table. Exchange rate regime at the beginning of each period is used. Business cycle synchronization is the dependent variable.*

that the effect of the regimes on synchronization is higher and more significant for countries with higher institution quality.

### 2.5.5 Robustness across samples, periods and regime classifications

Finally, we re-estimate the effect of exchange rate regimes on business cycle synchronization by excluding observations whenever at least one country in a country pair belonged to either: (1) oil-exporting countries with a membership in the Organization of the Petroleum Exporting Countries (OPEC); (2) countries with a population of less than 1 million; (3) tax havens as classified by the OECD and (4) Latin America countries. We exclude these groups due to their country-specific characteristics that might potentially bias our results. For example, countries in Latin America are excluded as those have been subject to multiple economic or financial crises in recent history. It can be seen from Table 2.9 that our results remain very robust to our benchmark and do not appear to be driven by any particular country group. Lastly, we confirm that our results are not driven by

TABLE 2.9: Exclusion of the selected *country groups* from the sample

| | (1) Excluded OPEC | (2) Excluded Small Countries | (3) Excluded Tax Heavens | (4) Excluded Latin America |
|---|---|---|---|---|
| Regime 1 (NSLT / Currency union) | 0.126*** | 0.108*** | 0.117*** | 0.113*** |
| | (6.901) | (6.032) | (6.798) | (6.669) |
| Regime 2 (Currency board) | 0.001 | 0.006 | 0.016 | 0.015 |
| | (0.055) | (0.214) | (0.657) | (0.740) |
| Regime 3 (De facto peg) | 0.075*** | 0.083*** | 0.062*** | 0.060*** |
| | (3.190) | (3.278) | (2.636) | (3.095) |
| Regime 4 (Crawling peg) | 0.025* | 0.003 | 0.011 | 0.011 |
| | (1.680) | (0.218) | (0.798) | (0.832) |
| Regime 5 (Crawling band) | -0.017* | -0.002 | 0.005 | 0.017* |
| | (-1.708) | (-0.174) | (0.572) | (1.753) |
| Regime 6 (Moving band) | 0.038*** | 0.015 | 0.021** | 0.031*** |
| | (3.790) | (1.558) | (2.239) | (3.064) |
| N | 22038 | 22744 | 24442 | 23301 |
| $R^2$ | 0.50 | 0.49 | 0.48 | 0.48 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country i and country j fixed effects included but not reported. Other explanatory variables from vector $X_{ijt,robust}$ included but not reported. Note: Yearly data is used for this table.*

any specific time period[22] or by the *de-jure* versus *de-facto* dichotomy in regimes classification.[23]

## 2.6 Conclusion

The use of a new dataset on *bilateral* exchange rate regimes allows us to move beyond the special case of currency unions and test the effect of various exchange rate regimes on business cycle synchronization. We find that currency unions increase the co-movement of business cycles, which is consistent with the previous literature. The point estimate from our analysis measuring business cycle correlation indicates that – compared to pairs with free floating regimes – countries with no separate legal tenders have more synchronised business cycles by around 0.12 points. This effect is particularly strong for countries within a currency union, as compared to countries with foreign currency as their sole legal tender.

The effect of other exchange rate regimes has not been previously tested empirically. We find that country pairs with other less flexible regimes have more synchronised business cycles. The effect remains positive and significant for both currency boards as well as de-facto pegs. The effect is much stronger for countries

[22] See Table 2.17 in Appendix 2.A.2 for split according to periods.
[23] See Table 2.18 in Appendix 2.A.2 for a comparison of coefficients.

with high financial openness. In particular, currency boards are found to lead to more synchronised business cycles only for financially opened countries. The effect of soft pegs is more heterogeneous - with the coefficient not always linearly decreasing with the increasing exchange rate flexibility - such that we must be careful in differentiating between the effects of individual soft pegs. Overall, we find *no* exchange rate regimes with *less* synchronised business cycles than free floats, at least as long as countries do not experience a severe financial crisis.

# Chapter 2: Appendix

## 2.A Appendix

### 2.A.1 Description of the Data

Table 2.10: De-facto exchange rate regimes mapping

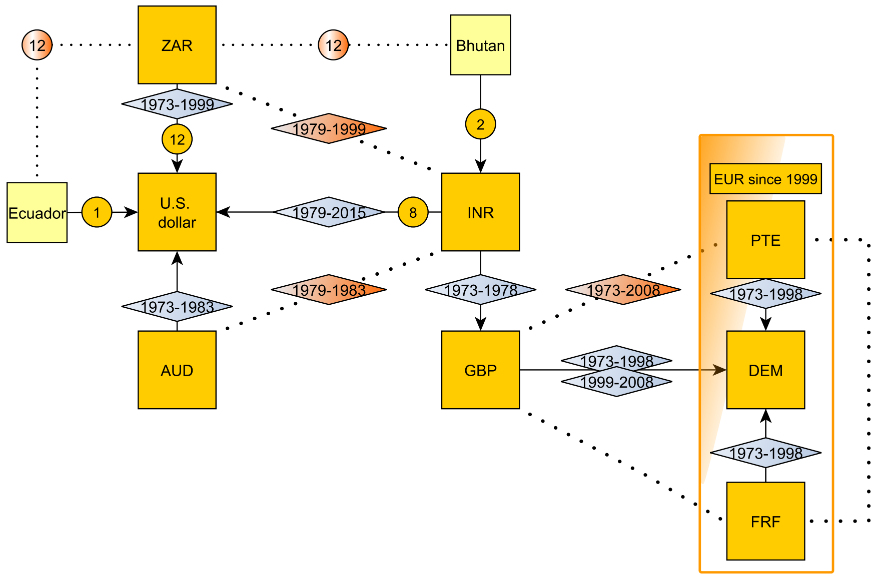
| De-facto exchange rate regimes | Exchange rate flexibility (index) | Exchange rate regime |
|---|---|---|
| *Hard pegs* | | |
| No separate legal tender or currency union | 1 | $Regime_1$ |
| Pre announced peg or currency board arrangement | 2 | $Regime_2$ |
| *Soft pegs* | | |
| Pre announced horizontal band that is narrower than or equal to +/-2% * | 3 | - |
| De facto peg | 4 | $Regime_3$ |
| Pre announced crawling peg; de facto moving band narrower than or equal to +/-1% | 5 | $Regime_4$ |
| Pre announced crawling band / de facto horizontal band that is narrower than or equal to +/-2% | 6 | $Regime_4$ |
| De facto crawling peg | 7 | $Regime_4$ |
| De facto crawling band that is narrower than or equal to +/-2% | 8 | $Regime_5$ |
| Pre announced crawling band that is wider than or equal to +/-2% | 9 | $Regime_5$ |
| De facto crawling band that is narrower than or equal to +/-5% | 10 | $Regime_5$ |
| Moving band that is narrower than or equal to +/-2% | 11 | $Regime_6$ |
| *Floating arrangements* | | |
| De facto moving band +/-5%/ Managed floating | 12 | $Regime_6$ |
| Freely floating | 13 | $Regime_7$ |
| *Residuals* | | |
| Freely falling ** | - | $Regime_{FF}$ |
| Dual market in which parallel market data is missing ** | - | - |

* We do not include the category "Pre announced horizontal band that is narrower than or equal to +/-2%" in our specification as we had no observations for this regime in our sample.

** Residuals 'Freely falling' and 'Dual market in which parallel makret data is missing' were dropped in the index.

Note: Table is based on Table A1 from (Harms and Knaze 2018).

FIGURE 2.7: Example of the bilateral structure of the data




*<u>Note</u>: Information on countries' anchor currencies is used to identify country-pairs' exchange rate regimes. For example, taking South African Rand (ZAR) pegged to U.S. dollar and Bulgarian Lev pegged to the Euro, South Africa rand is classified as floating to Bulgarian Lev since U.S. dollar is agains the Euro. Continuing with the example above, South African Rand is connected to the U.S. with a direct link (yellow dot in Figure 2.7). Since Ecuador is having no separate legal tender to the U.S. dollar, it has a direct link to the U.S. and at the same time an indirect link against South Africa (red dot in Figure 2.7).*

FIGURE 2.8: Density distribution of exchange rate regimes with direct and indirect connections

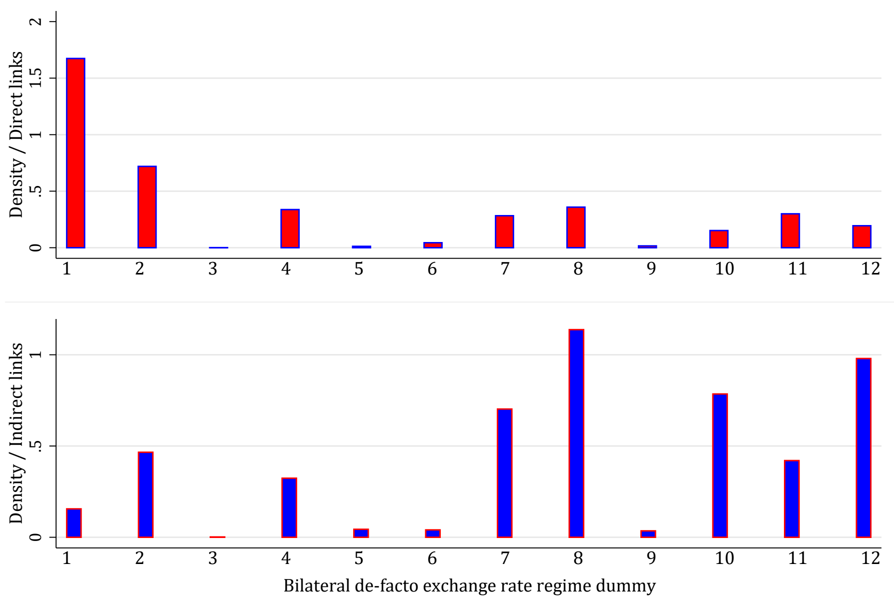


FIGURE 2.9: Density of the *yearly* business cycle correlations split by bilateral exchange rate regime dummies

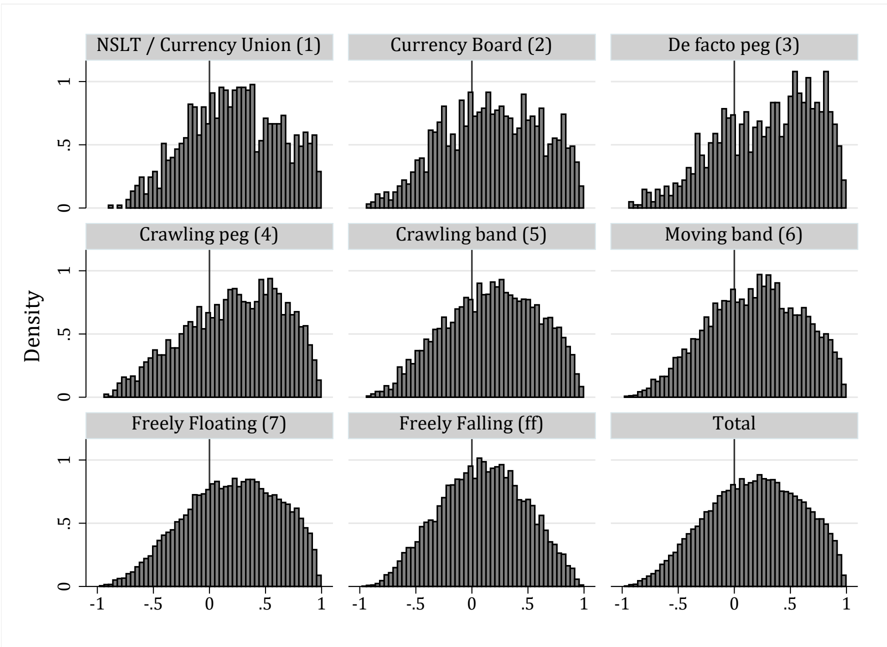


FIGURE 2.10: Variables used in the EBA to choose the EBA robust variables

| Variable | Source | EBA robust? |
|---|---|---|
| **1. Monetary integration** | | |
| Bilateral de-facto exchange rate regime (index), BOP* | Harms and Knaze (2018), link: https://www.international.economics.uni-mainz.de/data-on-bilateral-exchange-rate-regimes/ | yes |
| Bilateral de-facto exchange rate regime (index), MOP* | | yes |
| Bilateral de-jure exchange rate regime (index), BOP* | | yes |
| Bilateral de-jure exchange rate regime (index), MOP* | | yearly only |
| Nominal Interest rate correlations: Deposit Rate | IMF: International Financial Statistics. Link: http://data.imf.org/IFS | yes |
| Nominal Interest rate corr.: Government Bond Yield | | yes |
| Nominal Interest rate corr.: Treasury Bill Rate | | yes |
| Nominal Interest Rate corr.: Central Bank Policy Rate | | yes |
| Real Interest rate corr.: Deposit Rate | | yes |
| Real Interest rate corr.: Government Bond Yield | | yes |
| Real Interest rate corr.: Treasury Bill Rate | | yes |
| Real Interest Rate corr.: Central Bank Policy Rate | | yes |
| Bilateral pairs within the EMU (dummy) | | yes |
| Exchange rate variability (mean of monthly changes) | | yes |
| Exchange rate variability (squared) | | yes |
| **2. Trade intensity** | | |
| Ratio of bilateral trade to the sum of total trade | World Bank, WITS: https://wits.worldbank.org/ | yes |
| Ratio of bilateral trade to the sum of GDP | | yes |
| Maximum of trade intensity | | yes |
| Principal component analysis of the previous variables | | yes |
| **3. Specialization** | | |
| Export similarity between two countries (abs): extent of trade in similar goods in the same industry | World Bank, WITS: https://wits.worldbank.org/ | quarterly |
| Export similarity between two countries (square) | | yes |
| Share of intra-industrial trade | | yes |
| **4. Similarity of fiscal policies** | | |
| Yearly correlations in general government net lending / borrowing (percent of GDP) | IMF: WEO. Link: https://www.imf.org/external/pubs/ft/weo/2018/01/weodata/index.aspx | yes |
| **5. Financial infrastructure** | | |
| Difference in FI (abs, private credit by money banks to % of GDP/stock mkt capitalization to % of GDP) | World Bank: World Development Indicators. Link: https://datacatalog.worldbank.org/dataset/world-development-indicators | quarterly |
| Difference in FI (abs, private credit by deposit banks to % of GDP/stock mkt capitalization to % of GDP) | | quarterly |
| Difference in FI (sqr, private credit by money banks to % of GDP/stock mkt capitalization to % of GDP) | | no |
| Difference in FI (sqr, private credit by deposit banks to % of GDP/stock mkt capitalization to % of GDP) | | no |
| **6. Financial integration** | | |
| Difference in the net foreign assets positions (NFA/GDP) | Lane and Milesi-Ferretti, 2007 | no |
| Overall capital inflows restrictions correlations | IMF: AREAER. Link: https://www.elibrary-areaer.imf.org | no |
| Overall capital restrictions index correlations | Fernández, Klein, Rebucci, Schindler and Uribe (2016) | no |
| **7. Inflation** | | |
| Correlation of CPI based inflation rates | IMF: International Financial Statistics. Link: http://data.imf.org/IFS | yes |
| Standard deviation of inflation rates differences between two countries | | quartely |
| **8. Others** | | |
| Absolute difference in capital stock per person between country pairs in constant 2011 USD | Penn World Table version 9.0. Link: https://www.rug.nl/ggdc/productivity/pwt/ | quarterly |
| Trade openness | World Bank: World Development Indicators | yes |
| Difference in oil import share (absolute diff or squared) | | quarterly |
| Difference in oil import share (squared diff of square) | | quarterly |
| Difference in saving rate (absolute diff or squared) | OECD. Link: https://data.oecd.org/natincome/saving-rate.htm | no |
| Difference in saving rate (squared diff) | | no |

** Note: BOP denotes "Beginning of the period" and stands for the first year of the respective period. MOP denotes "Middle of the period" and stands for the median year of the respective period.*

## 2.A.2 Additional Estimation Results

Table 2.11: Effect of exchange rate regimes on business cycle synchronization as an *untransformed* dependent variable without the Fisher's-Z transformation

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Beginning of period | | Middle of period | |
| | Yearly | Quarterly | Yearly | Quarterly |
| Bilateral Trade (PCA, standardized) | 0.013*** | 0.004** | 0.013*** | 0.006*** |
| | (6.984) | (2.325) | (6.745) | (3.476) |
| Specialization (standardized) | 0.020*** | 0.024*** | 0.020*** | 0.019*** |
| | (9.465) | (5.915) | (9.221) | (4.382) |
| Fiscal integration (standardized) | 0.040*** | 0.046*** | 0.045*** | 0.060*** |
| | (19.391) | (9.729) | (22.758) | (12.353) |
| Inflation correlation (standardized) | 0.028*** | 0.022*** | 0.013*** | 0.002 |
| | (10.631) | (3.847) | (5.298) | (0.311) |
| Openness (standardized) | 0.238*** | 0.184*** | 0.253*** | 0.266*** |
| | (31.614) | (14.522) | (33.418) | (17.062) |
| Regime 1 (NSLT / Currency union) | 0.069*** | 0.116*** | 0.072*** | 0.081*** |
| | (7.007) | (7.655) | (8.035) | (4.862) |
| Regime 2 (Currency board) | 0.019 | 0.056** | 0.029*** | 0.042** |
| | (1.626) | (2.569) | (2.865) | (2.078) |
| Regime 3 (De facto peg) | 0.041*** | 0.119*** | 0.028*** | 0.183*** |
| | (3.094) | (5.796) | (2.591) | (9.484) |
| Regime 4 (Crawling peg) | 0.006 | -0.027 | 0.004 | 0.091*** |
| | (0.701) | (-0.943) | (0.464) | (3.194) |
| Regime 5 (Crawling band) | 0.002 | -0.004 | -0.017** | -0.024 |
| | (0.383) | (-0.262) | (-2.365) | (-1.200) |
| Regime 6 (Moving band) | 0.024*** | 0.027*** | 0.036*** | 0.037*** |
| | (3.892) | (2.585) | (5.651) | (2.583) |
| N | 29634 | 5000 | 32073 | 5198 |
| $R^2$ | 0.46 | 0.39 | 0.42 | 0.37 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country i and country j fixed effects included but not reported. The transformation does not have any effect on the significance of individual coefficients.*

TABLE 2.12: The effect of exchange rate regimes on business cycle synchronization: with "Freely falling" regimes

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Beginning of period | | Middle of period | |
| | Yearly | Quarterly | Yearly | Quarterly |
| Bilateral Trade (PCA, standardized) | 0.028*** | 0.017*** | 0.028*** | 0.020*** |
| | (6.485) | (5.295) | (6.539) | (6.398) |
| Specialization (standardized) | 0.035*** | 0.035*** | 0.032*** | 0.028*** |
| | (10.965) | (5.744) | (10.202) | (4.283) |
| Fiscal integration (standardized) | 0.063*** | 0.070*** | 0.065*** | 0.083*** |
| | (23.822) | (10.299) | (24.370) | (11.450) |
| Inflation correlation (standardized) | 0.034*** | 0.039*** | 0.024*** | 0.002 |
| | (10.564) | (4.752) | (7.452) | (0.176) |
| Openness (standardized) | 0.345*** | 0.305*** | 0.371*** | 0.427*** |
| | (34.994) | (14.806) | (37.004) | (17.678) |
| Regime 1 (NSLT / Currency union) | 0.118*** | 0.271*** | 0.111*** | 0.194*** |
| | (7.510) | (8.237) | (7.715) | (6.155) |
| Regime 2 (Currency board) | 0.042** | 0.107** | 0.050*** | 0.077** |
| | (2.143) | (2.502) | (2.940) | (2.089) |
| Regime 3 (De facto peg) | 0.055*** | 0.188*** | 0.053*** | 0.311*** |
| | (2.814) | (4.609) | (3.433) | (8.542) |
| Regime 4 (Crawling peg) | 0.005 | 0.010 | -0.000 | 0.139*** |
| | (0.438) | (0.195) | (-0.029) | (2.998) |
| Regime 5 (Crawling band) | -0.000 | 0.005 | -0.026*** | -0.028 |
| | (-0.010) | (0.209) | (-2.643) | (-0.885) |
| Regime 6 (Moving band) | 0.025*** | 0.044*** | 0.048*** | 0.060*** |
| | (2.885) | (2.652) | (5.286) | (2.721) |
| Regime ff (Freely falling) | -0.085*** | 0.026 | -0.207*** | 0.000 |
| | (-6.733) | (0.543) | (-13.292) | (.) |
| N | 32722 | 5126 | 33703 | 5198 |
| $R^2$ | 0.45 | 0.41 | 0.43 | 0.40 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country i and country j fixed effects included but not reported.*

TABLE 2.13: Effect of exchange rate regimes on business cycle synchronization: Limiting the sample of *yearly* data only for observations when the *quarterly* data are not missing

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Beginning of period | | Middle of period | |
| | Yearly | Quarterly | Yearly | Quarterly |
| Bilateral Trade (PCA, standardized) | 0.018*** | 0.018*** | 0.021*** | 0.020*** |
| | (5.732) | (5.417) | (6.527) | (6.398) |
| Specialization (standardized) | 0.042*** | 0.037*** | 0.036*** | 0.028*** |
| | (6.250) | (5.833) | (5.207) | (4.283) |
| Fiscal integration (standardized) | 0.066*** | 0.064*** | 0.085*** | 0.083*** |
| | (9.383) | (9.171) | (11.594) | (11.450) |
| Inflation correlation (standardized) | 0.043*** | 0.036*** | 0.004 | 0.002 |
| | (5.056) | (4.266) | (0.477) | (0.176) |
| Openness (standardized) | 0.430*** | 0.300*** | 0.552*** | 0.427*** |
| | (19.101) | (14.540) | (21.510) | (17.678) |
| Regime 1 (NSLT / Currency union) | 0.248*** | 0.266*** | 0.180*** | 0.194*** |
| | (7.206) | (8.068) | (5.617) | (6.155) |
| Regime 2 (Currency board) | 0.054 | 0.100** | 0.070* | 0.077** |
| | (1.287) | (2.334) | (1.950) | (2.089) |
| Regime 3 (De facto peg) | 0.151*** | 0.182*** | 0.298*** | 0.311*** |
| | (3.866) | (4.451) | (8.085) | (8.542) |
| Regime 4 (Crawling peg) | 0.011 | 0.001 | 0.097** | 0.139*** |
| | (0.234) | (0.021) | (2.341) | (2.998) |
| Regime 5 (Crawling band) | -0.002 | -0.014 | 0.008 | -0.028 |
| | (-0.095) | (-0.615) | (0.270) | (-0.885) |
| Regime 6 (Moving band) | 0.021 | 0.029* | 0.042* | 0.060*** |
| | (1.198) | (1.718) | (1.864) | (2.721) |
| Constant | 0.620*** | 0.633*** | 0.589*** | 0.601*** |
| | (52.128) | (56.224) | (49.644) | (53.082) |
| N | 5000 | 5000 | 5198 | 5198 |
| $R^2$ | 0.46 | 0.41 | 0.44 | 0.40 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country **i** and country **j** fixed effects included but not reported.*

TABLE 2.14: Splitting the sample if both countries in a pair are classified as high income countries (columns 1 and 2) and if at least one country in a pair is not a high income country (columns 3 and 4)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | High income countries both in pair | | At least one in pair not high income | |
| | Yearly | Quarterly | Yearly | Quarterly |
| Bilateral Trade (PCA, standardized) | 0.015*** | 0.013*** | 0.028*** | 0.037*** |
| | (3.790) | (3.136) | (4.525) | (6.389) |
| Specialization (standardized) | 0.028*** | 0.043*** | 0.029*** | 0.019** |
| | (2.971) | (3.975) | (8.292) | (2.350) |
| Fiscal integration (standardized) | 0.052*** | 0.041*** | 0.058*** | 0.106*** |
| | (6.021) | (3.921) | (19.520) | (10.196) |
| Inflation correlation (standardized) | -0.005 | 0.021 | 0.045*** | 0.059*** |
| | (-0.460) | (1.507) | (11.976) | (5.179) |
| Openness (standardized) | 0.465*** | 0.430*** | 0.332*** | 0.061* |
| | (17.693) | (13.502) | (28.949) | (1.887) |
| Regime 1 (NSLT / Currency union) | 0.274*** | 0.262*** | 0.036** | |
| | (7.140) | (5.644) | (2.296) | |
| Regime 2 (Currency board) | 0.329*** | 0.516*** | -0.008 | -0.057 |
| | (4.985) | (6.242) | (-0.417) | (-1.427) |
| Regime 3 (De facto peg) | 0.359*** | 0.294*** | 0.010 | 0.108 |
| | (8.645) | (5.818) | (0.480) | (1.428) |
| Regime 4 (Crawling peg) | 0.001 | 0.069 | -0.010 | -0.146 |
| | (0.018) | (1.160) | (-0.808) | (-1.451) |
| Regime 5 (Crawling band) | 0.010 | 0.056 | -0.010 | -0.001 |
| | (0.350) | (1.357) | (-1.087) | (-0.053) |
| Regime 6 (Moving band) | 0.066*** | 0.065 | 0.026*** | 0.056*** |
| | (2.610) | (1.604) | (2.734) | (2.876) |
| Constant | 0.418*** | 0.556*** | 0.365*** | 0.727*** |
| | (20.975) | (21.641) | (88.031) | (57.828) |
| N | 3064 | 2160 | 26570 | 2840 |
| $R^2$ | 0.44 | 0.42 | 0.47 | 0.47 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country **i** and country **j** fixed effects included but not reported.*

TABLE 2.15: Effect of exchange rate regimes on business cycle synchronization: Benchmark with country and period fixed effects

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Beginning of period | | Middle of period | |
| | Yearly | Quarterly | Yearly | Quarterly |
| Regime 1 (NSLT / Currency union) | 0.050*** | 0.058* | 0.066*** | 0.113*** |
| | (3.067) | (1.704) | (4.456) | (3.756) |
| Regime 2 (Currency board) | 0.008 | 0.030 | 0.027 | 0.068** |
| | (0.397) | (0.839) | (1.616) | (2.188) |
| Regime 3 (De facto peg) | 0.070*** | 0.198*** | 0.090*** | 0.396*** |
| | (3.696) | (5.140) | (5.971) | (11.826) |
| Regime 4 (Crawling peg) | 0.011 | 0.054 | 0.025** | 0.122*** |
| | (0.973) | (1.305) | (2.347) | (3.402) |
| Regime 5 (Crawling band) | 0.032*** | 0.046** | 0.044*** | 0.092*** |
| | (3.880) | (2.288) | (4.645) | (3.102) |
| Regime 6 (Moving band) | 0.034*** | 0.021 | 0.042*** | 0.079*** |
| | (4.112) | (1.311) | (4.756) | (3.934) |
| N | 29634 | 5000 | 32073 | 5198 |
| $R^2$ | 0.52 | 0.56 | 0.49 | 0.57 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country **i**, country **j** and period **t** fixed effects included but not reported. Other explanatory variables from vector $X_{ijt,robust}$ included but not reported.*

TABLE 2.16: Effect of exchange rate regimes on business cycle synchronization: Gravity variables and country-time fixed effects included

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Beginning of period | | Middle of period | |
| | Yearly | Quarterly | Yearly | Quarterly |
| Bilateral Trade (PCA, standardized) | 0.024*** | 0.018*** | 0.023*** | 0.019*** |
| | (5.349) | (4.679) | (5.336) | (4.821) |
| Specialization (standardized) | 0.035*** | 0.021*** | 0.033*** | 0.011* |
| | (11.121) | (3.312) | (10.724) | (1.711) |
| Fiscal integration (standardized) | 0.034*** | 0.049*** | 0.037*** | 0.057*** |
| | (12.674) | (5.686) | (14.381) | (6.646) |
| Inflation correlation (standardized) | 0.042*** | 0.063*** | 0.026*** | 0.050*** |
| | (10.666) | (6.993) | (7.520) | (5.751) |
| Openness (standardized) | 0.083 | -2.061*** | 0.129 | -2.081*** |
| | (0.732) | (-3.555) | (1.129) | (-3.722) |
| Regime 1 (NSLT / Currency union) | 0.027* | 0.102*** | 0.045*** | 0.139*** |
| | (1.673) | (3.171) | (3.083) | (4.726) |
| Regime 2 (Currency board) | -0.031* | -0.010 | -0.001 | 0.030 |
| | (-1.675) | (-0.289) | (-0.031) | (1.019) |
| Regime 3 (De facto peg) | 0.048** | 0.187*** | 0.070*** | 0.339*** |
| | (2.571) | (4.554) | (4.493) | (8.766) |
| Regime 4 (Crawling peg) | 0.017 | 0.110*** | 0.022** | 0.098*** |
| | (1.479) | (2.737) | (2.030) | (2.781) |
| Regime 5 (Crawling band) | 0.037*** | -0.004 | 0.064*** | 0.034 |
| | (4.408) | (-0.204) | (6.617) | (1.073) |
| Regime 6 (Moving band) | 0.021** | -0.001 | 0.024*** | 0.073*** |
| | (2.430) | (-0.066) | (2.803) | (3.361) |
| Distance | -0.000*** | -0.000*** | -0.000*** | -0.000*** |
| | (-5.689) | (-3.747) | (-5.284) | (-2.625) |
| Common border | 0.033 | -0.020 | 0.033 | -0.029 |
| | (1.502) | (-0.571) | (1.608) | (-0.785) |
| Common language | 0.033*** | 0.081*** | 0.038*** | 0.074*** |
| | (3.569) | (3.919) | (4.312) | (3.597) |
| Colony | -0.086*** | -0.073** | -0.092*** | -0.043 |
| | (-5.025) | (-2.278) | (-5.465) | (-1.419) |
| Religion | 0.053*** | 0.267*** | 0.050*** | 0.222*** |
| | (7.307) | (6.299) | (7.200) | (5.362) |
| N | 28541 | 4824 | 30938 | 5020 |
| $R^2$ | 0.62 | 0.68 | 0.61 | 0.70 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country **i-time** and country **j-time** fixed effects included but not reported.*

Table 2.17: Effect of exchange rate regimes on business cycle synchronization across time periods

| | (1) Period [1,4] | (2) Period [1,3] | (3) Period [3,5] | (4) Period [4,5] |
|---|---|---|---|---|
| Bilateral Trade (PCA, standardized) | 0.028*** | 0.034*** | 0.028*** | 0.029*** |
| | (6.434) | (7.587) | (6.152) | (5.566) |
| Specialization (standardized) | 0.039*** | 0.054*** | 0.038*** | 0.040*** |
| | (9.750) | (7.621) | (11.807) | (11.539) |
| Fiscal integration (standardized) | 0.044*** | 0.028*** | 0.057*** | 0.034*** |
| | (12.827) | (5.508) | (19.997) | (11.405) |
| Inflation correlation (standardized) | 0.011** | 0.052*** | 0.044*** | 0.038*** |
| | (2.489) | (6.900) | (11.917) | (9.790) |
| Openness (standardized) | 0.660*** | -0.007 | 0.334*** | 0.051*** |
| | (34.942) | (-0.093) | (31.915) | (4.082) |
| Regime 1 (NSLT / Currency union) | 0.096*** | 0.046 | 0.102*** | 0.061*** |
| | (4.876) | (0.886) | (6.524) | (3.732) |
| Regime 2 (Currency board) | 0.031 | -0.073 | 0.012 | -0.011 |
| | (1.428) | (-1.209) | (0.638) | (-0.602) |
| Regime 3 (De facto peg) | 0.108*** | 0.160*** | 0.053*** | 0.035 |
| | (4.687) | (4.169) | (2.703) | (1.644) |
| Regime 4 (Crawling peg) | -0.012 | -0.016 | 0.017 | 0.021* |
| | (-0.762) | (-0.550) | (1.449) | (1.704) |
| Regime 5 (Crawling band) | -0.008 | 0.096*** | -0.003 | 0.022** |
| | (-0.876) | (6.029) | (-0.293) | (2.376) |
| Regime 6 (Moving band) | 0.034*** | 0.062*** | 0.046*** | -0.001 |
| | (2.989) | (3.036) | (5.237) | (-0.153) |
| N | 15784 | 5578 | 28736 | 24056 |
| $R^2$ | 0.45 | 0.27 | 0.48 | 0.56 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country **i** and country **j** fixed effects included but not reported.*

TABLE 2.18: Effect of exchange rate regimes on business cycle synchronization: *De-jure* versus *de-facto* regimes for periods 4 and 5 only

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | De-facto regimes | | De-jure regimes | |
| | Yearly | Quarterly | Yearly | Quarterly |
| Bilateral Trade (PCA, standardized) | 0.029*** | 0.027*** | 0.025*** | 0.027*** |
| | (5.566) | (7.010) | (5.240) | (7.025) |
| Specialization (standardized) | 0.040*** | 0.013** | 0.042*** | 0.011* |
| | (11.539) | (2.187) | (12.684) | (1.858) |
| Fiscal integration (standardized) | 0.034*** | 0.033*** | 0.041*** | 0.036*** |
| | (11.405) | (5.084) | (13.786) | (5.525) |
| Inflation correlation (standardized) | 0.038*** | 0.052*** | 0.030*** | 0.051*** |
| | (9.790) | (6.378) | (8.680) | (6.471) |
| Openness (standardized) | 0.051*** | -0.105*** | 0.028** | -0.129*** |
| | (4.082) | (-4.708) | (2.168) | (-5.250) |
| Regime 1 (NSLT / Currency union) | 0.061*** | 0.165*** | | |
| | (3.732) | (5.720) | | |
| Regime 2 (Currency board) | -0.011 | 0.048 | | |
| | (-0.602) | (1.456) | | |
| Regime 3 (De facto peg) | 0.035 | 0.193*** | | |
| | (1.644) | (3.750) | | |
| Regime 4 (Crawling peg) | 0.021* | 0.198*** | | |
| | (1.704) | (4.747) | | |
| Regime 5 (Crawling band) | 0.022** | 0.063*** | | |
| | (2.376) | (2.997) | | |
| Regime 6 (Moving band) | -0.001 | 0.031** | | |
| | (-0.153) | (1.961) | | |
| De-jure Regime 1 (NSLT / Curerncy union) | | | 0.232*** | 0.138*** |
| | | | (9.495) | (4.702) |
| De-jure Regime 2 (Currency board) | | | 0.020 | -0.044 |
| | | | (0.856) | (-1.274) |
| De-jure Regime 3 (Conventional peg) | | | -0.014 | 0.154*** |
| | | | (-1.100) | (3.331) |
| De-jure Regime 4 (Stabilized and crawling) | | | -0.036* | -0.186*** |
| | | | (-1.738) | (-3.512) |
| De-jure Regime 5 (Horizontal bands and other managed) | | | 0.103*** | 0.191*** |
| | | | (5.396) | (6.218) |
| De-jure Regime 6 (Managed floating) | | | 0.047*** | 0.067*** |
| | | | (5.876) | (3.072) |
| N | 24056 | 3962 | 24762 | 4054 |
| $R^2$ | 0.56 | 0.50 | 0.56 | 0.49 |

*t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors clustered at country-pair level. Country **i** and country **j** fixed effects included but not reported.*

# Chapter 3

# Effective Exchange Rate Regimes and Inflation

BY JAKUB KNAZE*

## 3.1 Introduction

Currently available exchange rate regimes classifications aim to capture different aspects of exchange rate arrangements, each offering distinctive advantages tailored to analyse specific macroeconomic outcomes. Despite the substantial heterogeneity in the individual classifications, they all share a common characteristic: Each classification aims to find an *anchor currency* in terms of which stability or flexibility of a given currency is being defined.[1] In this paper we argue that these *unilateral* approaches focused on finding an anchor currency are uninformative about exchange rate regimes relationship prevailing vis-à-vis all other currencies. The use of traditional unilateral classifications might be subject to bias because currency stabilised against one anchor currency may at the same time float against many other currencies. The degree to which the flexibility of an exchange rate

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[1]For example, Klein and Shambaugh (2008b) test each country's currency against the dollar, all major currencies, and major regional currencies to find any potential fixed exchange rate relationship. The authors admit that anchor currency determination is difficult for countries that generally float, do not peg for a substantial amount of time, or switch base currencies (Klein and Shambaugh (2010), p. 212). The authors then use judgement to determine the base currency, with the US dollar used as default if no better candidate was found.

regime is limited depends on the volume of financial transactions that take place between individual currencies.

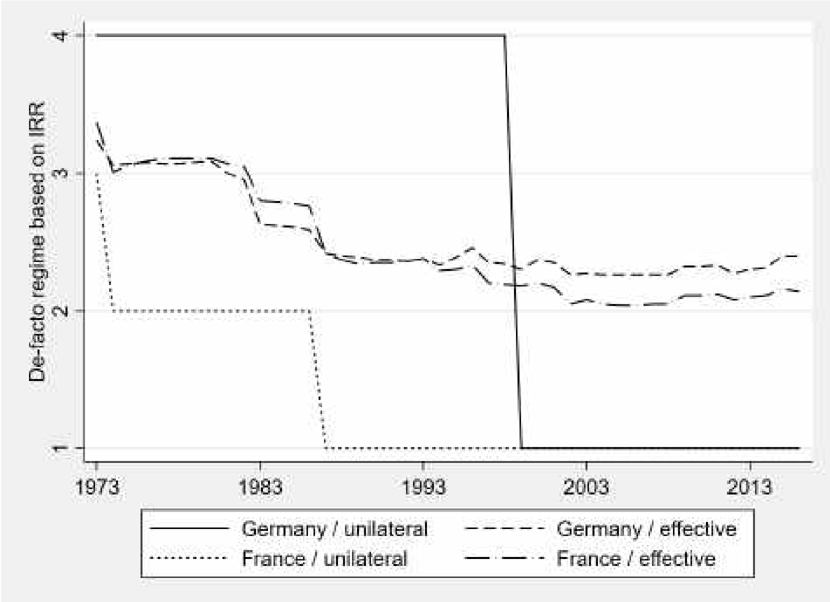
We argue that this classification problem is particularly pronounced when analysing the effect of exchange rate regimes on inflation performance. Looking only at the arrangements against an anchor currency is uninformative if the anchor accounts only for a small share of cross-border transactions of the respective anchoring country. The underlying assumption from the theoretical models is that – via relative purchasing power parity (PPP) – the anchor currency country determines the full set of traded goods prices. This assumption may be questionable if the anchor country accounts only for a small trade share of a pegging country.

We use trade as a proxy for the size of bilateral financial transactions. For example, Bermuda and Bangladesh are two countries that are unilaterally classified as having hard peg against the U.S. dollar. The exchange rate regime stability of Bermuda is very high due to it's proximity to the U.S. because the U.S. makes the largest share in Bermuda's total trade. Thus, a country that pegs to the U.S. dollar and trades a lot with the U.S. (and other U.S. dollar peggers) will have effectively a very high degree of exchange rate regime stability. However, the effective exchange rate stability of Bangladesh as an official U.S. dollar pegger is rather low, because Bangladesh trades most with China, India and the European Union.[2] In the case of Bangladesh, the other exchange rate regimes matter much more than for Bermuda since a unilateral exchange rate regime only imperfectly anchors domestic prices in Bangladesh.

To take this heterogeneity more precisely into account, we propose a new measurement approach to the generalized assessment of currency stability. Our new effective trade-weighted exchange rate regimes classification is based on the de-jure and de-facto *bilateral* exchange rate regimes introduced by Harms and Knaze (2018) combined with information on countries' trade relationships. The biggest advantage of the bilateral framework is that it allows us to consider both *direct* and *indirect* exchange rate regimes connections. Bilateral connections of each country pair in the world are considered simultaneously. This means that not only the direct connections (Bermuda against the U.S.) but also all indirect connections (Bermuda against Bangladesh and other U.S. dollar peggers) are considered simultaneously. Bilateral regimes are weighted by bilateral trade weights of each

[2]The U.S. dollar and Euro are freely floating. Chinese Renminbi and Indian Rupee have some forms of soft peg arrangements against the U.S. dollar, thus being more flexible than a hard peg of Bangladesh.

FIGURE 3.1: Unilateral and effective de-facto (IRR-based) exchange rate regimes in France and Germany for the years from 1973 to 2016



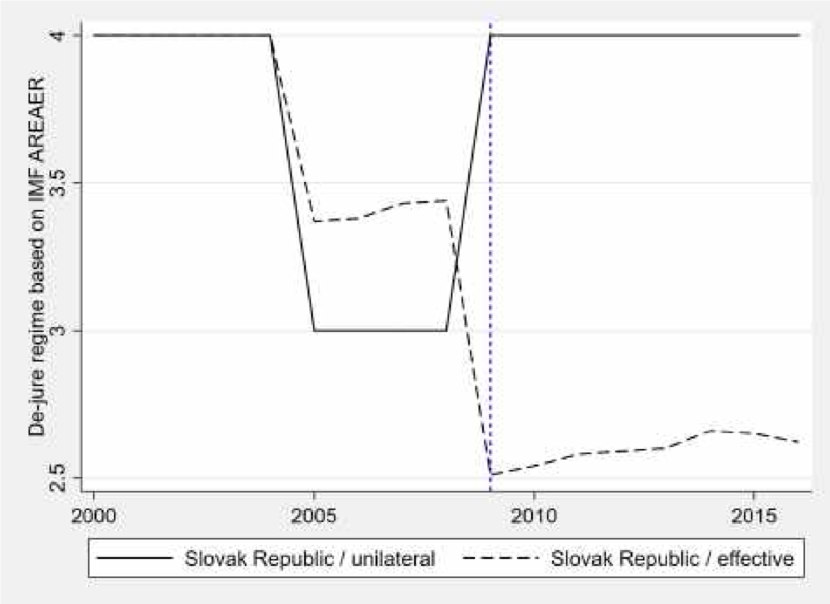

Mapping of the exchange rate regimes is shown in Table 3.5 in Appendix 3.A.1. Higher value denotes more flexible exchange rate regime. Own computation based on Ilzetzki et al. (2017) and Harms and Knaze (2018).

counterparty to obtain de-jure and de-facto *effective* exchange rate regimes [henceforth *eERR*] classification for each country. We provide a detailed comparison of the new classification approach to two traditional unilateral classifications: unilateral de-jure exchange rate regime by IMF (2016) [henceforth *IMF*] as published in the Annual Reports on Exchange Arrangements and Exchange Restrictions and unilateral de-facto classifications introduced by Ilzetzki et al. (2017) [henceforth *IRR*].[3]

The following two examples illustrate the advantages of using the *eERR* measure. Figure 3.1 plots the exchange rate regimes of Germany and France mapped into four categories from least flexible (Regime 1) to most flexible (Regime 4), comparing the *IRR* and the new *eERR* classification for the years from 1973 to 2016. Ilzetzki et al. (2017) categorise Germany since 1973 as free-floating (Regime 4) and from 1999 (upon joining the Eurozone) as having no separate legal tender (Regime 1). In turn, France is classified since 1974 as a de-facto moving band (Regime 2)

[3]A detailed description of the different unilateral classifications and their unique characteristics is provided in Table 3.4 in Appendix 3.A.1. Note that the *IMF* improved its methodology in the AREAER to take into account the cases when de-jure and de-facto exchange rate regimes differ, such that both de-jure and de-facto data are available. However, we follow the convention in the academic literature by calling the *IMF* classification as de-jure and *IRR* classification as de-facto.

Figure 3.2: Unilateral and effective de-jure (AREAER-based) exchange rate regime in Slovak Republic for the years from 2000 to 2016




Mapping of the exchange rate regimes is shown in Table 3.5 in Appendix 3.A.1. Higher value denotes more flexible exchange rate regime. Blue dashed line denotes the Eurozone entry year. Own computation based on IMF (2016) and Harms and Knaze (2018).

and reclassified in 1986 as officially pegged to the Deutsche Mark (Regime 1). We argue that the reclassification of Germany from the most floating to the least flexible regime upon the Euro introduction in 1999 is not justifiable by the underlying structural change. In fact, Germany was not effectively freely floating long before 1999 because many countries (such as France) used the Deutsche Mark as their anchor currency, thus implicitly limiting the fluctuation of the Deutsche Mark against these currencies. Our newly constructed trade-weighted effective exchange rate regimes measure shows a more subtle message: The effective exchange rate regime was becoming continually less flexible in smaller steps already since 1973. We see from Figure 3.1 that the effective exchange rate regime in France and Germany developed very similarly across time.

Another example using the de-jure dataset based on the *IMF* is shown in Figure 3.2. The IMF initially classified Slovak Republic as free-floating. The exchange rate regime was reclassified as hard peg in the year 2005 when Slovak Republic joined the ERM II as a precondition to joining the Eurozone. However, upon joining the Euro in 2009, the unilateral regime was reclassified back to the most flexible regime as the *IMF* treats Euro as a free-floating regime. We argue that this is not an appropriate classification to characterise the volatility of Slovakia's currency, conditional on the country having intense trade relationships with other members of the currency union. In fact, we would expect the effective exchange rate flexibility to *decrease* if a country becomes part of the currency union. We can see in Figure 3.2 that the *effective* exchange rate regime measure provides a more nuanced classification of the implied stability of the exchange rate regime: Exchange rate regime flexibility decreased following the adoption of the ERM II in 2005 and fell down even further following the adoption of the Euro in 2009. Interestingly, we can observe a slight increase in the exchange rate regime flexibility since 2009, which is likely driven by the fact that the trade of Slovak Republic became more intensive with countries having a floating regime against the Euro.

The examples show how the use of traditional (unilateral) exchange rate regimes classifications may suffer from measurement problems: First, countries that peg their exchange rate cannot fully eliminate all exchange rate movements if they are open to financial transactions with the whole world. These countries can peg at most to one currency at the time. Second, countries or country groups with potential anchor currencies (U.S., Germany or Eurozone) cannot claim to be completely free floating because decisions of other countries to peg to their currency directly imposes the exchange rate stability onto the respective *anchor*. Thus, our new *eERR* classification provides a more nuanced assessment of the effective stability of exchange rate regimes.

We deliberately focus our attention to the exchange rate *regimes* instead of looking only at the exchange rate *volatilities* as suggested by Ghosh et al. (2013). Exchange rate regime is a policy variable that consists of three main aspects: ex-post observed exchange rate movements; official announcements and behaviour of foreign exchange reserves. Looking only at the ex-post exchange rate movements might bias our results when the latter two aspects are expected to be of particular importance. The additional information on *foreign exchange reserves* is essential because – in a world of greater capital mobility – countries use foreign exchange reserves as a tool to stabilize their exchange rate (Ilzetzki et al., 2017). Further, the inflation benefit of a fixed exchange rate regime should be attributed to the effect of a credible *announcement* of the monetary authority rather than the observed exchange rate volatility.

For this reason, our paper primarily focuses on two underlying classifications for the new *eERR* measure: The *IMF* classification on *de-jure* exchange rate regimes since the IMF publishes data on countries' official exchange rate regimes as announced by monetary authorities. Further, we also use the *IRR* classification by

Ilzetzki et al. (2017) on the *de-facto* exchange rate regimes. Beyond the information on exchange rate movements, *IRR* take the evolution of foreign exchange reserves as well as official announcements of policymakers into account. Compared to *IMF*, *IRR* adjust their data for cases in which the observed behaviour of the exchange rate differs from the announced exchange rate regime (hence *de-facto*).[4] We use trade data to proxy for the size of financial transactions taking place between individual countries. We follow the previous literature where the trade data is commonly used to construct the effective exchange *rates* (see ECB (2019) or Ghosh et al. (2013)). We also use three different trade-weighting approaches to avoid excessive volatility in the trade weights due to abrupt changes in trade flows.

The estimated effects of exchange rate regimes on inflation performance show some surprising results: First, the results for hard pegs confirm findings of the previous literature that hard pegs are associated with significantly lower inflation compared to freely floating regimes. However, the results for the *effective* classification are both stronger and more statistically significant compared to the traditional *unilateral* classifications. Second, the conclusion of the previous literature using unilateral classification is that soft pegs either do not matter or are even detrimental to inflation performance (e.g. Ghosh et al., 2011).

The results of the new *eERR* classification reverse this "traditional wisdom": we find that both narrow and wide soft pegs are associated with significantly lower inflation compared to freely floating regimes, with the effect being about half as large compared to hard pegs. The results hold for the entire sample as well as for the sub-sample of low and middle-income countries. We find no effect of exchange rate regimes on inflation for high-income countries. The results are also strongly economically significant: Average inflation reduction of countries which adopt soft pegs is about the size of the effect associated with inflation targeting policies. The results remain statistically significant once the money growth is taken into account, suggesting that the results are driven by a substantial *credibility* effect that goes beyond the pure *discipline* effect operating through monetary growth.

The rest of the paper is structured as follows: Section 3.2 demonstrates why the (effective) exchange rate regimes matter for inflation performance and provides a short summary of the previous empirical results using the (unilateral) exchange rate regimes classifications. Section 3.3 describes the construction of the de-jure and de-facto *effective* exchange rate regimes measure and outlines our empirical

[4] The latter classification has the advantage of having a much larger time span. Overall, our results are always very consistent across both classifications.

methodology. Section 3.4 presents our benchmark empirical results. Section 3.5 discusses further extensions and robustness tests, and section 3.6 concludes.

## 3.2 Literature review on the role of exchange rate regimes on inflation

### 3.2.1 Theoretical considerations on the role of exchange rate regimes in inflation stabilization

Theoretical models on the effect of exchange rate stabilization on inflation by Edwards (1993) and Calvo and Végh (1999) mention several channels – especially inflation inertia and lack of credibility – that determine the success of an inflation stabilisation program. However, none of the models gives insight into *which* exchange rate anchor a country should choose. This can be explained by a dominant role of the U.S. dollar as the sole anchor currency used in stabilisation programs in Argentina, Brazil, Chile, Israel, Mexico and Uruguay in the past century (Calvo and Végh, 1999). However, countries experienced an important wave toward capital market integration since the mid-1990s (Ilzetzki et al., 2017). Nowadays, each country is being financially interconnected not only with its anchor country but also with other countries across the world. We argue that the decision to *whom* to anchor the currency becomes more relevant than ever to assess the success of an inflation stabilization program.

The concern about an appropriate assessment of currency stability and a relevant anchor currency in the financially interconnected world has been recently raised in the literature. For example, Wang and Liu (2018) introduce concept of a "triangular" purchasing power parity (PPP) to test the validity of the PPP existence for a country like China that pegs its currency to the US dollar but conducts most trade activities with the European Union. Such considerations are of a particular importance if we observe that the volatility of the effective exchange rates lies significantly above (or below) the bilateral rate against the anchor currency. Additional concern highlighted by Dubas et al. (2005) is that central banks increasingly diversify their reserve holdings away from the US dollar-denominated assets. For a small open economy (SMOPEC) in a multilateral world we need a multilateral approach to assess the effective exchange rate regime stability. To illustrate this claim – assuming that the law of one price holds – the relative purchasing parity for a SMOPEC economy in the multi-country world can be written as:

$$\Delta p_t^i = \Gamma[\Delta p_t^j + \Delta e_t^{ji}] + (1-\Gamma)[\sum_{k=1}^{N} \Delta p_t^k + \Delta e_t^{ki}] \qquad (3.1)$$

where $\Gamma \in (0,1)$ and $\Delta p_t^i$ denotes the change in consumer's (tradable) price index of a country $i$ that depends on changes in the consumer price index of a country $j$ ($\Delta p_t^j$) and $\Delta e_t^{ji}$ denotes changes in the nominal exchange rate of country $i$ against an anchor country $j$. If $\Gamma = 1$ the equation converges to the classical two-country scenario assuming that the law of one price (LOP) holds. The LOP with fixed exchange rates between the country $i$ and an anchor country $j$ then implies that the world price level determines the price level in the domestic country $i$ completely if $\Delta e_t^{ji} = 0$ (Nordhaus, 1976). If, however, $\Gamma < 1$ such that the country $i's$ goods basket comprises of goods from $k$ other countries, the price determination channel would be much weaker the smaller $\Gamma$ gets. Therefore, the degree of "imported" price stability depends on the anchor currency $j's$ share in country $i's$ traded goods basket. Further, if other countries are pegging to the same anchor currency $j$, the prices to the country $i$ are also anchored indirectly with these other anchoring countries – a feature taken into account in our new dataset.

Equation 3.1 illustrates how the implementation of a given exchange rate regime peg pins down the (traded) goods prices. This channel is expected to bring down inflation. In addition to this effect, there is an additional credibility effect from exchange rate stabilisation if the ex-ante commitment itself lowers inflationary expectations in a credible way. Calvo and Végh (1999) note that stopping inflation is not necessarily rooted in fundamentals but to a large extent in policy credibility, with a key role of institutional and political arrangements. Therefore, countries with a high inflation rate usually choose an anchor currency of a country whose inflation performance they want to mimic (Ilzetzki et al., 2017). Since the pegging is assumed to be costly, fixed exchange rate regimes may provide a pre-commitment device as long as the costs of breaking the peg are sufficiently large (Ghosh et al., 2003). But exactly because there are costs associated with inflation stabilisation, each stabilization program has a chance to fail. The more credible a stabilization plan is, the lower the inflation persistence that might put the stabilisation program at risk. Hence, we expect an inflation program to be more credible if the chosen anchor currency is an important trading partner (e.g. currency with large $\Gamma$ in the equation 3.1) because the costs of pegging to this currency are ceteris paribus lower.[5]

### 3.2.2 Empirical evidence

Literature on the effect of exchange rate regimes on inflation performance investigates both *total* and *direct* effects of pegging. The former effect known as a "discipline" effect operates through monetary growth as a direct constraint on monetary independence of the central bank. The latter effect is an additional effect that can be identified once we control for the money growth and stems from the "credibility" effect working through inflation expectations (Ghosh et al., 2003). Among the most recent studies, Ghosh et al. (2014) focus on the credibility effect arising from formal commitments. The authors distinguish between de-jure and de-facto exchange rate regimes, claiming that the former have greater credibility. Based on the policy credibility models, de-jure commitments are expected to better anchor inflationary expectations. The authors find that credible de-jure pegs that are also de-facto implemented have inflation lower by 4 percentage points than de-facto pegs alone. Using an alternative de-facto classification, Klein and Shambaugh (2010) find that pegs are associated with inflation lower by around 4 percentage points compared to non-pegs for both industrial and developing countries. However, both studies use only binary classification of "pegs" and "non-pegs", thus implicitly ignoring the variety of soft pegs. This might neglect a piece of important information since intermediate regimes (soft pegs) might allow an intermediate degree of exchange rate flexibility in return for an intermediate degree of monetary independence (Frankel, 2019).

Studies by Ghosh et al. (2003) and Ghosh et al. (2011) also take intermediate regimes into account. Ghosh et al. (2003) find that de-jure hard pegs are associated with inflation 10.5 percentage points lower than under floating rates. Surprisingly, intermediate regimes are found to be associated with inflation higher by 3 percentage points than free-floating regimes. The positive coefficient was found to be driven by a group of upper to middle-income countries. Similarly, Ghosh et al. (2011) find that de-jure pegs are associated with inflation lower by 5 percent compared to intermediate or floating regimes. Intermediate regimes

[5] For example, the 1980s were marked by a period when higher-inflation European Monetary System (EMS) member countries tried to achieve disinflation by "importing" the Bundesbank's credibility (Ghosh et al., 2003). The pegging of French Frank to Deutsche Mark can be deemed as less costly compared to French Frank being pegged to the U.S. Dollar, because France and Germany were most important trading partners with highly synchronised business cycles.

are found to have even *higher* average inflation than freely floating regimes, with the coefficient being particularly large and significant when "de-facto" and "peg-consensus" classifications were used. The findings of the previous literature thus suggest that soft pegs either do not matter or are even detrimental for inflation performance.

Further, our investigation must be considered in light of the findings that pegged exchange rate regimes are associated with lower inflation, but they are also more susceptible to crises. Ghosh et al. (2015) found that free-floats are the least vulnerable to crises. Although hard pegs were not especially susceptible to banking or currency crises, they were found to be more prone to growth collapses. Therefore, the incidences of currency devaluations and high inflation episodes following the currency crises might possibly outweigh the initial inflation benefits. We discuss the implications and robustness of our results in light of currency crises episodes in Section 3.5.

## 3.3 Data and Methodology

### 3.3.1 Data on effective exchange rate regimes

We construct our *eERR* measure by following the intuition of Ghosh et al. (2013), who investigate the role of exchange rate *volatilities* as a determinant of current account adjustment. We construct a bilateral trade weight between a country $i$ and a country $j$ in a year $t$ as follows:

$$weight_{ij,t} = \frac{exports_{ij,t} + imports_{ij,t}}{\sum_{k=1}^{n}(exports_{ik,t} + imports_{ik,t})} \tag{3.2}$$

where $weight_{ij,t}$ is a trade weight of a country $j$ in country $i's$ total trade (exports plus imports).[6] A higher weight implies a more important trading partner. Bilateral trade is used as a proxy for the size of financial flows in line with the literature on effective exchange *rates*. As a second step, we combine the information on bilateral exchange rate regimes and trade weights to obtain:

$$eERR_{i,t} = \sum_{j=1}^{n} regime_{ij,t} * (weight_{ij,t-1} + weight_{ij,t-2} + weight_{ij,t-3})/3 \tag{3.3}$$

[6]Note that the $weight_{ij,t}$ is not the same as the weight of $weight_{ji,t}$ because total trade of country $i$ is different than total trade of country $j$ in denominator.

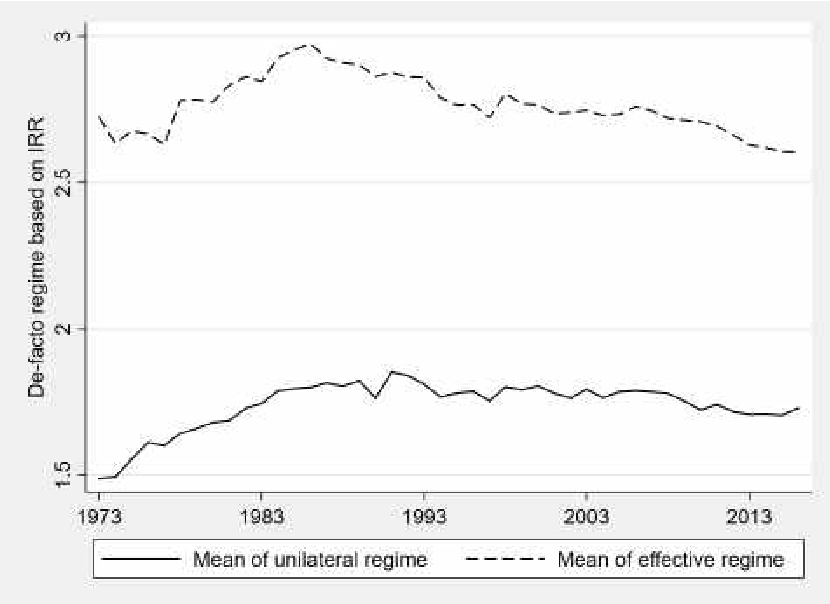
where $eERR_{i,t}$ denotes the *unilateral* effective exchange rate regime of a country $i$ in a year $t$. Variable $regime_{ij,t}$ denotes a bilateral de-jure or de-facto exchange rate regime between countries $i$ and $j$ in a year $t$ ranging from 1 to 4 as computed by Ghosh et al. (2013). The bilateral exchange rate regime in year $t$ is multiplied by the average trade weights of previous three years $t-1$; $t-2$ and $t-3$. We compute this average to eliminate the effects of short-term fluctuations in trade volumes to identify the most important trading partners in the long run. We use alternative weighting approaches in our robustness tests to ensure that the results are not driven by our specific weighting choice. Alternatives include weighting by the trade weights centred around the current period $t$ and updating the weights only every five years following the intuition of the ECB (2019).

Bilateral *de-jure* regimes are based on the *IMF* and originally take values from 1 to 10. Bilateral *de-facto* regimes are based on the *IRR* and originally take values from 1 to 13.[7] Table 3.5 in Appendix 3.A.1 shows our mapping of both de-jure and de-facto regimes into four coarse regimes, from regime 1 (least flexible) to regime 4 (free-floating). Our reasons for the choice of a coarser classification are twofold: First, weighting of the exchange rate regimes assumes that the regimes are sorted in a strictly linear order, which is problematic in a very fine classification. For example, it is hard to tell whether crawling pegs or crawling bands are more flexible. Therefore, a coarser classification allows for clear-cut differences that reliably differentiate the stability of each exchange rate regime. Second, a split into four categories makes the exchange rate regimes more comparable with the previous literature and across de-jure and de-facto classifications.

Figure 3.3 shows the evolution of simple means of unilateral and effective de-facto (*IRR*-based) classifications over time. It is not surprising that the *eERR* measure is on average more flexible than the unilateral classification since even countries strongly pegged to a unilateral anchor also trade with countries that are freely floating against that anchor. We see that until the 1990s both series showed a similar trend. Later on, the mean of unilateral regimes showed no significant changes, but we can observe a fall in the effective trade-weighted measure back to the levels seen in 1973. A sample split between income groups plotted in Figure 3.4 shows that the observed fall in the *eERR* measure can be attributed to a larger extent to the group of high-income countries. Surprisingly, we see that the high-income country group since the early 2000s had effectively less flexible regimes

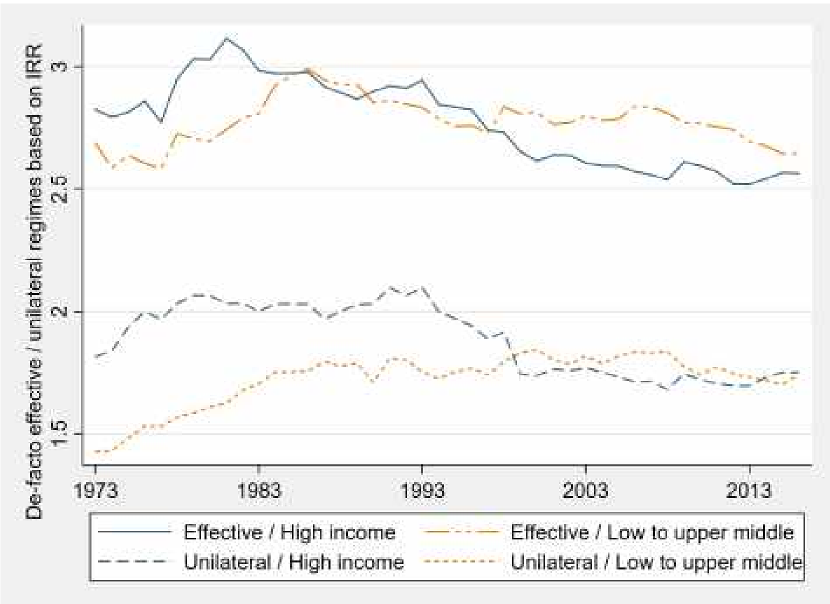
[7] The residual IRR regimes “freely falling” (Regime 14) and “dual market in which parallel market data is missing” (Regime 15) are excluded by default.

FIGURE 3.3: Average value of the unilateral and weighted *de-facto* (IRR-based) exchange rate regimes over time



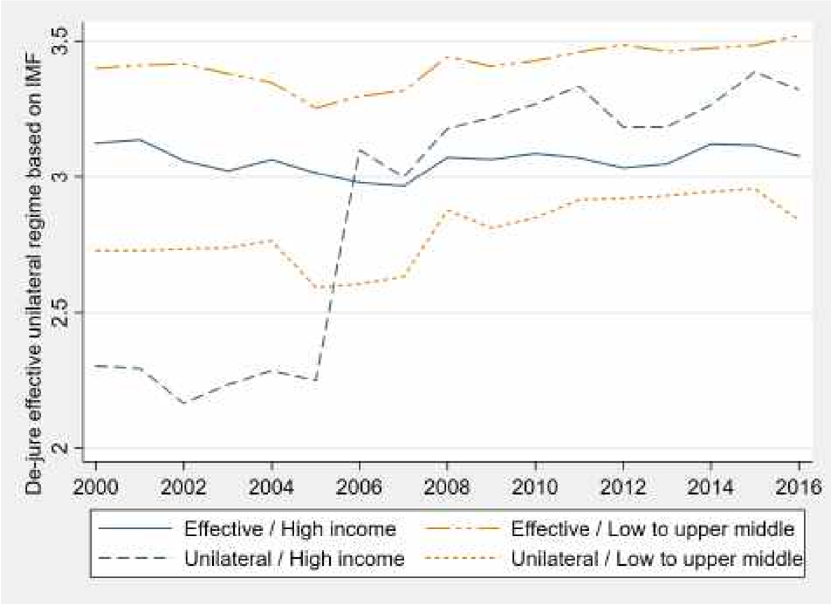

Mapping of the exchange rate regimes is shown in Figure 3.5 in Appendix. Higher value denotes more flexible exchange rate regime. Own computation using yearly data.

FIGURE 3.4: Average value of the *de-facto* effective exchange rate regimes (IRR-based) over time: split by income groups




Mapping of the exchange rate regimes is shown in Table 3.5 in Appendix 3.A.1. Higher value denotes more flexible exchange rate regime. Own computation using yearly data.

FIGURE 3.5: Average value of the *de-jure* effective exchange rate regimes (IMF-based) over time: split by income groups



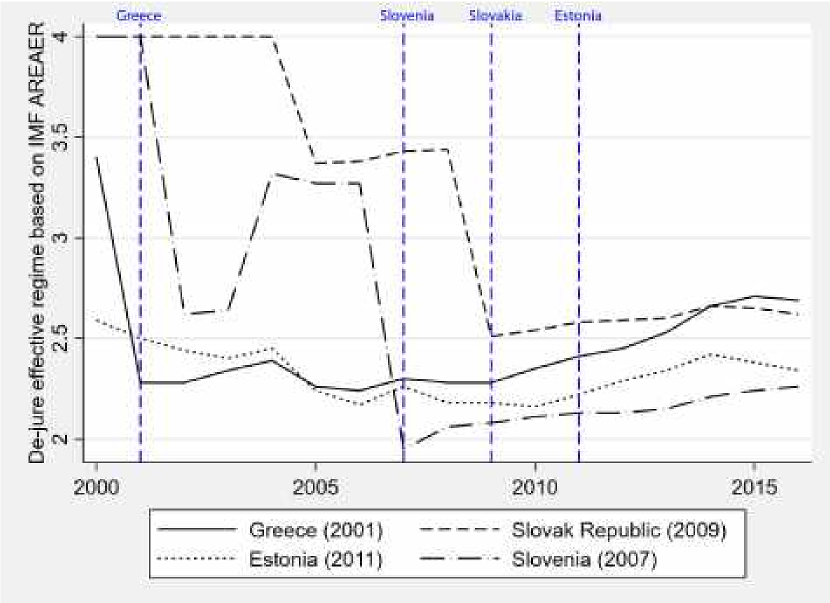

Mapping of the exchange rate regimes is shown in Table 3.5 in Appendix 3.A.1. Higher value denotes more flexible exchange rate regime. Own computation using yearly data.

than the group of non-high-income countries. This is driven mostly by the Euro effect.

The evolution of the *de-jure* classifications is plotted in Figure 3.5. The jump in the *unilateral* IMF classification from the year 2005 to 2006 towards more flexible exchange rate regimes (blue dashed line) reveals the problem of using the original IMF data in the estimation. This change does not imply any underlying structural change but a mere change in the IMF methodology: Until the year 2005, IMF classified Eurozone countries – being a member of the euro area – as having an exchange rate arrangement *with no separate legal tender* (Regime 1). The data covering years 2006 and later classify Eurozone countries as having a *freely floating exchange rate arrangement* (Regime 4) since the exchange rate of the euro against the US dollar and many other currencies is flexible (Harms and Knaze, 2018). We find no such bias in the *eERR* de-jure measure (blue solid line), with the trend being stable and similar to the de-facto measure in Figure 3.4 over the covered period from 2000 to 2016. Simple means of the full sample using the *de-jure* classifications are plotted in Figure 3.9 in Appendix 3.A.1.

Focusing on the Euro effect using the new *eERR* measure, it can be seen in Figure 3.6 that the size of the reduction in exchange rate flexibility upon Euro adoption is not the same across all Eurozone countries. The Euro adoption (marked with the

Figure 3.6: Value of the *de-jure* (IMF-based) effective exchange rate regimes in selected EU-countries before and after the Euro adoption




Mapping of the exchange rate regimes is shown in Figure 3.5 in the Appendix 3.A.1. Higher value denotes a more flexible exchange rate regime. Blue dashed lines denote the entry years for Greece, Slovenia, Slovak Republic and Estonia in the years 2001, 2007, 2009 and 2011, respectively. Own computation using yearly data.

blue dotted lines) of Greece and Slovenia led to a significant reduction in the *de-jure* effective exchange rate regime flexibility. Conversely, the effective exchange rate regime of Estonia stayed basically unchanged because Estonia had adopted very strong peg against the Euro long before the Euro was adopted as an official currency. Thus, changes in the effective exchange rate regimes following the Euro adoption tend to be heterogeneous even in structurally similar countries.

We recall that our *effective* measure of exchange rate regimes is a continuous variable. However, the unilateral exchange rate regime classifications are split into 4 distinct categories ranging from most stable (Regime 1, hard pegs) to least stable (Regime 4, freely floating) as shown in Table 3.5 in Appendix 3.A.1. Therefore, we map our *eERR* measure into four quantiles to facilitate the comparison with unilateral classifications. We find that unilateral and effective measures are correlated with a correlation coefficient of 0.74. However, it can be seen in Table 3.1 that the number of observations falling into each category differs quite substantially. While the unilateral IRR classification classifies only 234 country-year observations as freely floating, the effective classification assigns a free-floating regime to 1,390 country-year observations. The difference in the number of observations using the

IMF classifications is less pronounced but still substantial.[8] Throughout our paper, we use the split of the *eERR* measure into these four quantiles to facilitate the comparison with previous studies. The results using the original *continuous* measure are also reported. The use of the split does not alter our results in any way and the results remain robust and consistent.

Our de-jure and de-facto *eERR* measures can be considered as a combination of two classification approaches: On the one hand, the *eERR* measure contains policy information beyond observed exchange rate *volatility* (such as the behaviour of reserves and official announcements) in line with the traditional unilateral classifications. On the other hand, it takes into account exchange rate regime arrangements against all trading partners according to the relative importance of each partner following Ghosh et al. (2013). A different approach to the construction of an *effective* exchange rate classification was introduced by Dubas et al. (2005), where the authors use a measure of *effective* exchange rate regimes on economic growth. However, the authors model the de-jure regimes econometrically as an outcome of a multinomial logit choice problem based on the country's observed exchange rate movements. This in our view does not mitigate the measurement bias when assessing the inflation performance, as the observed exchange rate movements do not necessarily capture the role of *ex-ante* announcements.

#### 3.3.1.1 Data on remaining macroeconomic variables

Remaining data sources and summary statistics for all variables are listed in Tables 3.6 and 3.7 in Appendix 3.A.1. We split the sample using the World Bank's analytical classification using the Atlas methodology into (1) high-income and (2) low-income, lower-middle-income and upper-middle-income country groups. This classification has the advantage of being time-varying and covers the years from 1987 to 2016. For example, Czech Republic was classified as a middle-income country only until the year 2005 before becoming a high-income country. Thus, the Atlas methodology allows a more precise split of our sample.[9]

[8] Note that we are not able to split the IMF data into four *equal* quantiles because the majority of the observations (34.57 percent) already reach maximum value (4) of the flexibility index. Therefore, we assign those observations into regime 4 and split the remaining observations into three equal quantiles.

[9] The classification is available under `https://datahelpdesk.worldbank.org/knowledgebase/articles/906519`. Please note that our sample includes observations starting already from the year 1981 but the World Bank classification starts only in the year 1987 or later. In order not to lose any observations, we use the income status values for these past observations as published in the first available year of the Atlas dataset.

TABLE 3.1: Summary statistics for the unilateral and weighted de-facto (IRR-based) exchange rate regimes classifications

| IRR de-facto classification | Unilateral IRR | | Effective IRR | |
|---|---|---|---|---|
| | Obs. | % Share | Obs. | % Share |
| Regime 1 / Hard pegs | 3,781 | 51.39 | 1,399 | 24.88 |
| Regime 2 / Soft pegs narrow | 1,925 | 26.17 | 1,415 | 25.16 |
| Regime 3 / Soft pegs wide | 1,417 | 19.26 | 1,420 | 25.25 |
| Regime 4 / Freely floating | 234 | 3.18 | 1,390 | 24.72 |
| **IMF de-facto classification** | **Unilateral IMF** | | **Effective IMF** | |
| | Obs. | % Share | Obs. | % Share |
| Regime 1 / Hard pegs | 1,240 | 39.07 | 621 | 21.77 |
| Regime 2 / Soft pegs narrow | 420 | 13.23 | 623 | 21.84 |
| Regime 3 / Soft pegs wide | 228 | 7.18 | 622 | 21.81 |
| Regime 4 / Freely floating | 1,286 | 40.52 | 986 | 34.57 |

Note: The effective classification is a *continuous* variable split into four dummies to facilitate the comparison with the traditional unilateral exchange rate regime classifications. The IRR-based effective classification was split into four equal quantiles. The IMF-based effective classification classified 34.56 percent of country-years observations as free-floating (maximum value of the continuous measure). The remaining 63.44 percent of country-year observations were split into three equal quantiles.

### 3.3.2 Empirical specification

We expect from the theory a relative ranking of inflation performance across regimes such that the average inflation rate should be lowest for hard pegs, followed by narrow and wide soft pegs, and highest under free floats. To test whether our predictions hold empirically, we test the effects of individual exchange rate regime dummies on inflation performance as follows:

$$\begin{aligned}\pi_{it} = \beta_0 + \beta_1 X_{it} + \beta_{HP} HardPeg_{it} + \beta_{SPN} SoftPegNarrow_{it} + \\ \beta_{SPW} SoftPegWide_{it} + v_t + \epsilon_{it}\end{aligned} \tag{3.4}$$

where $\pi_{it}$ denotes the annual inflation rate for a country $i$ at the time $t$. We follow Ghosh et al. (2014) and transform the inflation variable as $\pi/(1+\pi)$ to take into account hyperinflation observations. $HardPeg_{it}$, $SoftPegNarrow_{it}$ and $SoftPegWide_{it}$ are the regimes' dummy variables as mapped in Table 3.5. The freely floating dummy is excluded, such that the betas reflect the differential impact of regime dummy on inflation, relative to the case of free-floating. $X_{it}$ includes other likely determinants of inflation performance as mentioned in the previous literature: current and lagged money growth, trade and financial openness, current fiscal balance (percent of GDP) and real GDP growth; $v_t$ denotes year fixed effects; and $\epsilon_{it}$ is a random error term. Initially, we do *not* include country fixed effects because we would identify only the effect through time variation in exchange rate regimes, which is problematic because exchange rate regimes change only slowly. Instead, we follow Ghosh et al. (2014) by including region-specific fixed effects where we use the geographical and development status groups decomposition by the UNCTAD.[10] Country fixed effects are included in robustness tests in section 3.5. We cluster the standard errors at the country level to control for the possible correlation in the error term.[11]

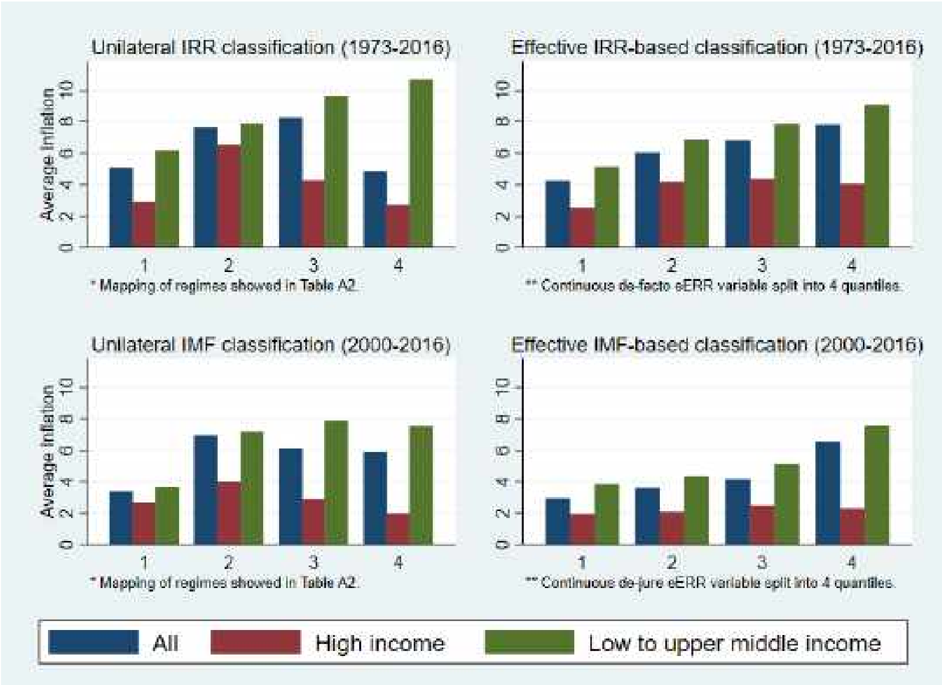
We note that the original *IRR* classification uses a separate *freely falling* category for regimes with very high inflation rate (over 40 percent per annum; regime 14 in Table 3.5 in Appendix 3.A.1). Observations for these cases were excluded in the construction of our de-facto *eERR* measure as this regime is treated as a residual category. Still, we find that such hyper-inflationary cases frequently coincide with the incidences of banking, currency or sovereign debt crises. We want to make sure that our results are not driven by hyperinflation periods that occur during currency crises. For example, Tsangarides (2012) found that the growth performance for pegs was not different from that of floats during the recent global financial crisis. However, pegs appeared to be faring worse for the recovery period 2010-2011.

In addition to the fact that the *freely falling* observations are excluded by default in the classification, we further analyse incidences of currency crises in robustness tests in section 3.5. Our concern is mitigated by comparing both *IMF-* and *IRR-based* classification, where the former classification does not contain a separate *freely falling* category. Also, this classification covers only the period after the year 2000 when only relatively few currency crises occurred. Our results between these two classifications and periods remain almost identical, suggesting that our results are not driven by hyper-inflationary or currency crises periods.

[10] The classification is available under `https://unctadstat.unctad.org/EN/Classifications/DimCountries_DevelopmentStatus_Hierarchy.pdf`.

[11] Note that the previous studies such as Ghosh et al. (2014) and Klein and Shambaugh (2010) also use the 2SLS estimation as a robustness check. For example, Ghosh et al. (2014) use the lagged values of real GDP growth, fiscal balance and money growth as instruments. Klein and Shambaugh (2010) use dummies if the country pegged its currency continually for three or five years as instruments. Given the lack of agreement on which common instruments are appropriate to use, we do *not* follow this approach. The authors show that the benchmark results remain robust to those specifications and the endogeneity seem to be appropriately controlled for already in the benchmark specification.

Figure 3.7: Average inflation across different exchange rate regime classifications




Note: Average inflation using exchange rate regime dummies ranging from least flexible (Hard pegs / Regime 1), to most flexible (Free floats / Regime 4). Note: Due to categorisation/normalisation, the effective exchange rate regimes were transformed into four quantiles.

## 3.4 Exchange rate regimes and inflation: Empirical results

We begin our analysis by plotting the average inflation rate associated with each exchange rate regime using both *de-jure* and *de-facto* data in Figure 3.7. Our results show some striking differences between *unilateral* and *effective* exchange rate regimes classifications. The unilateral *IRR* classification (see upper-left part) shows on average the expected correlation such that higher exchange rate stability is associated with lower inflation. However, we also find some surprising outliers. Across the sample of all countries (blue bars), we see that the average inflation was lowest in countries with a freely floating regime (Regime 4). This seems to be driven mostly by high-income countries where average inflation shows a hump-shaped pattern (see the red bars). Such outliers mostly disappear when the measure of an effective exchange rate regime is used (upper-right part). The *eERR* measure shows a linearly increasing association between inflation and more flexible exchange rate regimes. This pattern is particularly strong for low to middle-income countries.

The unilateral de-jure *IMF* classification for the years 2000-2016 (lower-left part) shows similar hump-shaped correlation as the *IRR* regimes. It is surprising that soft pegs (Regimes 2 and 3) seem to be associated with a higher average inflation rate than free floats. Further, the high-income countries classified as freely floating seem to have lowest average inflation. This is possibly driven by the fact that the *IMF* classifies the Eurozone countries as freely floating from the year 2006 onwards (Regime 4). These patterns disappear when an effective measure is used (lower-right part). While inflation rates are not correlated with exchange rate regimes in high-income countries since the 2000s, average inflation in low to middle-income countries with freely floating regimes is twice as high as in countries with effective hard pegs. We note the strikingly similar pattern for both *IMF* and *IRR effective* measures, which holds despite the differences in datasets and time periods covered.

These findings are driven by changes in the sample composition between unilateral and effective classifications. The correlation coefficient between the classifications is 0.74 and 0.73 for the *de-facto* and *de-jure* classifications, respectively. Observations for countries that differ most strongly between unilateral and effective IRR-based classifications are shown in Figure 3.10 in Appendix 3.A.1. For example, the effective exchange rate regime of the Eurozone countries differs across countries: While Austria and Belgium are classified as having a hard peg (Regime 1), Finland is classified as narrow soft peg (Regime 2) and Ireland is (for few years) even classified as having a wide soft peg (Regime 3). Further, the anchor currencies (Germany, U.S.) unilaterally classified as freely floating (Regime 4) are effectively classified as soft pegs. Lastly, a group of commodity exporters such as Qatar and Oman are being classified unilaterally as hard pegs (Regime 1) but effectively as free floaters (Regime 4). We will show in Section 3.5 that our results are robust to the exclusion of these commodity-exporting countries.

### 3.4.1 Benchmark results

We follow the convention in the literature and report both *total* (without money growth rate) as well as *direct* (with money growth rate) effects of exchange rate regimes on inflation. If the exchange rate regime affected inflation only through the *disciplinary* channel imposed on monetary policy, we would expect to find no effect of exchange rate regimes on inflation once we control for the money growth rate (Klein and Shambaugh, 2010). The inclusion of the money growth rate in our specification allows us to conveniently distinguish between the *disciplinary* and *expectations* channels of the exchange rate regimes on inflation. The benchmark

TABLE 3.2: Unilateral and effective *IRR*-based classification (de-facto): Inflation performance under different exchange rate regimes from the estimation of the benchmark equation 3.4 with *total* and *direct* effects, sample covers years from 1981 to 2016

| | [A] | | | [B] | | |
|---|---|---|---|---|---|---|
| | Unilateral IRR classification | | | Effective IRR-based classification | | |
| **Total effect** | (1) | (2) | (3) | (4) | (5) | (6) |
| | All | High* | Low/Middle* | All | High* | Low/Middle* |
| Regime 1 / Hard pegs | -1.346 | 0.577 | -3.965** | -2.991*** | -0.247 | -4.528*** |
| | (0.826) | (0.475) | (1.573) | (0.693) | (0.403) | (0.856) |
| Regime 2 / Soft pegs narrow | 1.482** | 0.863* | -0.352 | -1.286** | -0.288 | -1.764** |
| | (0.739) | (0.514) | (1.444) | (0.649) | (0.405) | (0.773) |
| Regime 3 / Soft pegs wide | 1.407* | 0.952** | 0.037 | -0.944* | -0.386 | -1.300** |
| | (0.745) | (0.370) | (1.416) | (0.557) | (0.385) | (0.656) |
| Openness | -0.001 | 0.001 | -0.003 | -0.002 | 0.002 | -0.007 |
| | (0.004) | (0.003) | (0.005) | (0.004) | (0.003) | (0.006) |
| Financial Openness | -4.150*** | -3.536*** | -3.377*** | -4.011*** | -3.947*** | -2.849*** |
| | (0.707) | (1.256) | (0.748) | (0.765) | (1.467) | (0.752) |
| Fiscal balance | 0.002 | 0.009 | 0.006 | -0.046*** | 0.009 | -0.040*** |
| | (0.005) | (0.016) | (0.004) | (0.008) | (0.014) | (0.007) |
| Real GDP growth | 0.002 | -0.006 | -0.001 | 0.008 | -0.006 | 0.008 |
| | (0.022) | (0.031) | (0.027) | (0.022) | (0.032) | (0.027) |
| N | 3636 | 1136 | 2500 | 3375 | 1094 | 2281 |
| $R^2$ | 0.29 | 0.54 | 0.26 | 0.29 | 0.54 | 0.25 |

| | [C] | | | [D] | | |
|---|---|---|---|---|---|---|
| | Unilateral IRR classification | | | Effective IRR-based classification | | |
| **Direct effect** | (7) | (8) | (9) | (10) | (11) | (12) |
| | All | High* | Low/Middle* | All | High* | Low/Middle* |
| Regime 1 / Hard pegs | -1.406** | 0.575 | -2.819*** | -2.011*** | 0.182 | -3.242*** |
| | (0.572) | (0.406) | (0.933) | (0.517) | (0.316) | (0.641) |
| Regime 2 / Soft pegs narrow | 0.661 | 0.533 | -0.184 | -0.942* | 0.024 | -1.477** |
| | (0.540) | (0.472) | (0.864) | (0.500) | (0.329) | (0.579) |
| Regime 3 / Soft pegs wide | 0.805 | 0.527 | 0.517 | -0.759* | -0.037 | -1.194** |
| | (0.558) | (0.315) | (0.866) | (0.424) | (0.308) | (0.498) |
| Money growth | 0.122*** | 0.050*** | 0.126*** | 0.119*** | 0.051*** | 0.123*** |
| | (0.021) | (0.018) | (0.022) | (0.024) | (0.019) | (0.026) |
| Lag money growth | 0.070*** | 0.069*** | 0.066*** | 0.076*** | 0.069*** | 0.071*** |
| | (0.008) | (0.023) | (0.007) | (0.011) | (0.022) | (0.012) |
| Openness | -0.000 | 0.003 | -0.001 | -0.002 | 0.003 | -0.006 |
| | (0.003) | (0.002) | (0.004) | (0.003) | (0.002) | (0.005) |
| Financial Openness | -2.551*** | -3.569*** | -2.103*** | -2.171*** | -3.660*** | -1.491** |
| | (0.576) | (0.994) | (0.600) | (0.587) | (1.051) | (0.605) |
| Fiscal balance | -0.004 | -0.004 | 0.000 | -0.027** | 0.001 | -0.019* |
| | (0.006) | (0.016) | (0.004) | (0.012) | (0.015) | (0.010) |
| Real GDP growth | -0.093*** | -0.060* | -0.092*** | -0.085*** | -0.060* | -0.078* |
| | (0.030) | (0.031) | (0.034) | (0.032) | (0.030) | (0.039) |
| N | 3375 | 965 | 2410 | 3135 | 943 | 2192 |
| $R^2$ | 0.46 | 0.62 | 0.43 | 0.45 | 0.62 | 0.41 |

* Sample split using the World Bank income groups classification (Atlas method) where "High" denotes high income and "Low/middle" denotes low, low-middle, and upper-middle income country groups (time-varying). Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is the annual inflation rate transformed as $\pi/(1+\pi)$. Clustered standard errors (at country level) are reported in parentheses. All specifications include a constant term; region-specific and year effects (not reported).

results from the estimation of the baseline equation 3.4 using the *IRR* exchange rate regimes classification are reported in Table 3.2.

The *total effect* is reported in the upper part of Table 3.2. We find that the results of the unilateral *IRR* classification (columns 1 to 3 in section [A]) are consistent with the previous literature. We find that hard pegs are associated with inflation being lower by around 4 percentage points for low to middle-income countries compared to freely floating regimes (column 3), which is about the same as what Ghosh et al. (2013) have found. The coefficient remains negative but it is not significant for the whole sample (column 1). We also find that narrow soft pegs in the whole sample are associated with higher inflation compared to freely floating regimes similar to the findings of Ghosh et al. (2013). Importantly, these puzzling results change once the new *eERR* measure in columns (4) to (6) in section [B] is used. Hard pegs are associated with inflation lower by around 3 percent for the whole sample. The result seems to be driven in particular by the group of low to middle-income countries (column 6), whereas we find no effect for high-income countries. Further, narrow and wide soft pegs are also associated with lower inflation across all country groups by around 1 to 1.5 percentage points compared to free floats, with the results being driven by the group of low to middle-income countries.

The *direct* effect on inflation – when current and lagged money growth rates are included – is reported in the bottom part of Table 3.2. We find that only hard pegs for all and low to middle-income countries remain significant if the unilateral *IRR* classification is used (columns 7 and 9 in section [C]). The coefficients become stronger and more statistically significant once our new *eERR* measure is used (columns 10 to 12 in section [D]). We find that narrow and wide soft pegs remain negative and statistically significant for the whole sample and the group of low to middle-income countries, whereas the exchange rate regimes remain insignificant for the high-income countries.

The bottom line of our findings is that exchange rate regimes matter more than suggested by unilateral classifications. The *eERR* coefficients for the *total* effect (columns 4-6) are lower than for the *direct* effect (columns 10-12), which is not surprising given that the latter captures only the additional *expectations* channel. However, the results are not reduced by much, suggesting that the *expectations* channel is even more important than the *disciplinary* channel. Therefore, low to middle-income countries have the possibility to gain additional credibility by pegging to another currency, which helps to anchor future expectations. Thus, our results strengthen the findings of the previous literature on the role of exchange rate regimes as a significant determinant of inflation. Monetary policy in high-income countries is likely to be already very credible, such that no further gains from changing expectations by pegging an exchange rate can be realised. Hence, the low and insignificant effects for the group of high-income countries are not surprising.

### 3.4.2 Results using IMF-based exchange rate regimes classification

We argued that the effect of pegging on inflation reduction is expected to be particularly strong in the case of an *ex-ante* commitment. Even if the *IRR* classification takes *announcements* into account, only the actually de-facto implemented exchange rate regimes are reported. To isolate the effect of credible announcements, we also want to analyse the role of an official *de-jure* exchange rate regimes. Therefore, we re-estimate our results of the equation 3.4 using the *IMF* de-jure classification for the years from 2000 to 2016. The results are reported in Table 3.3.[12]

Using the unilateral *IMF* classification (columns 1 and 2 in section [A]), we find that only hard pegs are associated with lower inflation rates compared to freely floating regimes. When our new *eERR* measure is used (columns 3 and 4 in section [B]), we find the coefficients for hard pegs to be even stronger. In addition, we find that the *eERR* coefficients for narrow and wide soft pegs are negative and strongly statistically significant. The strength of the effect is approximately halved when we look only at the *direct* effect taking the money growth rate into account (columns 5 to 8 in sections [C] and [D]). Although we have the *IMF* data available only from the year 2000, the results between the *IRR* and *IMF* classifications are very consistent. This suggests that the inflation benefit of pegging is not only a phenomenon of the past but continues to be equally relevant following the 2000s.

The results in Table 3.3 report the *IMF de-jure* classification. We also report the results using the *IMF de-facto* classification[13] in Table 3.8 in Appendix 3.A.2. We find that the results are very consistent, but the size of the coefficients is slightly

[12]Note that we do not report the insignificant results for the *high-income* countries, as the insignificance for this groups was obvious already in Figure 3.7. The results are available upon request.

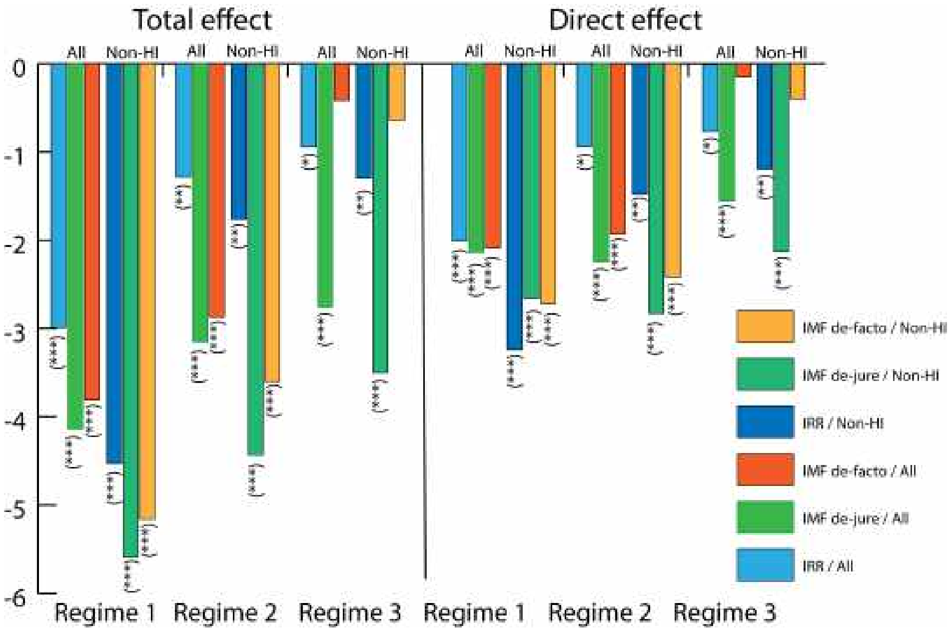
[13]IMF provides information on both de-jure and de-facto classifications but we follow the convention in the literature by calling the IMF data *de-jure*.

TABLE 3.3: Unilateral and effective *IMF*-based classification (de-jure): Inflation performance under different exchange rate regimes from the estimation of the benchmark equation 3.4 with *total* and *direct* effects, sample covers years from 2000 to 2016

| | [A] | | [B] | |
|---|---|---|---|---|
| | *Unilateral (IMF)* | | *Effective (IMF-based)* | |
| **Total effect** | (1) | (2) | (3) | (4) |
| | All | Low/Middle* | All | Low/Middle* |
| De-jure Regime 1 / Hard pegs | -4.149*** | -5.451*** | -4.143*** | -5.592*** |
| | (0.861) | (0.983) | (0.834) | (1.115) |
| De-jure Regime 2 / Soft pegs narrow | -0.065 | -0.647 | -3.519*** | -4.436*** |
| | (1.109) | (1.159) | (0.815) | (0.993) |
| De-jure Regime 3 / Soft pegs wide | 0.159 | 0.345 | -2.765*** | -3.498*** |
| | (0.934) | (1.331) | (0.749) | (0.929) |
| Openness | 0.005 | 0.008 | 0.006 | 0.007 |
| | (0.006) | (0.011) | (0.005) | (0.011) |
| Financial Openness | -3.346*** | -3.438*** | -3.234*** | -3.305*** |
| | (0.923) | (1.022) | (0.922) | (1.008) |
| Fiscal balance | -0.076* | -0.069 | -0.108*** | -0.085 |
| | (0.040) | (0.057) | (0.038) | (0.053) |
| Real GDP growth | -0.073 | -0.111 | -0.071 | -0.108 |
| | (0.057) | (0.069) | (0.058) | (0.069) |
| N | 2365 | 1688 | 2399 | 1720 |
| $R^2$ | 0.25 | 0.21 | 0.23 | 0.18 |
| | [C] | | [D] | |
| | *Unilateral (IMF)* | | *Effective (IMF-based)* | |
| **Direct effect** | (5) | (6) | (7) | (8) |
| | All | Low/Middle* | All | Low/Middle* |
| De-jure Regime 1 / Hard pegs | -2.532*** | -3.336*** | -2.141*** | -2.661*** |
| | (0.483) | (0.540) | (0.479) | (0.615) |
| De-jure Regime 2 / Soft pegs narrow | 0.089 | -0.176 | -2.248*** | -2.833*** |
| | (0.745) | (0.773) | (0.527) | (0.663) |
| De-jure Regime 3 / Soft pegs wide | 0.808 | 0.603 | -1.553*** | -2.134*** |
| | (0.799) | (1.085) | (0.430) | (0.495) |
| Money growth | 0.095*** | 0.096*** | 0.095*** | 0.097*** |
| | (0.012) | (0.013) | (0.012) | (0.013) |
| Lag money growth | 0.109*** | 0.109*** | 0.112*** | 0.113*** |
| | (0.008) | (0.009) | (0.008) | (0.009) |
| Openness | 0.002 | 0.001 | 0.003 | 0.001 |
| | (0.003) | (0.006) | (0.003) | (0.006) |
| Financial Openness | -1.650*** | -1.765** | -1.563** | -1.608** |
| | (0.615) | (0.693) | (0.623) | (0.691) |
| Fiscal balance | -0.078*** | -0.079* | -0.099*** | -0.089** |
| | (0.028) | (0.042) | (0.027) | (0.039) |
| Real GDP growth | -0.169*** | -0.195*** | -0.163*** | -0.187*** |
| | (0.041) | (0.050) | (0.042) | (0.051) |
| N | 2274 | 1634 | 2309 | 1666 |
| $R^2$ | 0.51 | 0.48 | 0.49 | 0.46 |

* Sample split using the World Bank income groups classification (Atlas method) where "Low/middle" denotes low, low-middle and upper-middle income country groups (time-varying). Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is the annual inflation rate transformed as $\pi/(1+\pi)$. Clustered standard errors (at country level) are reported in parentheses. All specifications include a constant term; region-specific and year effects.

FIGURE 3.8: Overview of the *effective* exchange rate regimes coefficients (compared to Regime 4 / freely floating) across different classifications and country groups




* Sample split using the World Bank income groups classification (Atlas method) where "Non-HI" denotes low, low-middle and upper-middle income country groups (time-varying). Robust standard errors in parantheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is the annual inflation rate transformed as $\pi/(1+\pi)$ such that the coefficients sizes denotes inflation performance (in percentage points) lower compared to free-floating regimes.

lower than for the *de-jure* classification. Figure 3.8 provides an overview of the all *effective* exchange rate regimes coefficients across different classifications and country groups considered so far. The size of the coefficients is largest for the *IMF de-jure* classification compared to the *IMF de-facto* or *IRR* classifications, which can be seen as a confirmation of the finding of Ghosh et al. (2014) that de-jure announcements seem to be of a particular importance in reducing inflation.

Equally importantly, we estimate the equation 3.4 by replacing the individual exchange rate regime dummies with a continuous variable ranging from 1 (least flexible) to 4 (most flexible) to check the consistency given that the original *eERR* measure is a continuous variable. The results are reported in Table 3.9 in Appendix 3.A.2. We expect the sign of the coefficients to be positive since more flexible exchange rate regimes are expected to be associated with higher average inflation rates. We find that this is indeed the case for both unilateral (columns 1 to 3) and effective classifications (columns 4 to 6) for the whole sample as well as for the low to middle-income countries. The coefficients for the effective classification turn out to be larger than for the unilateral classification. The *unilateral* coefficient using the *IMF de-jure* classification for the high-income country group (columns 14 and 20) turns out to be negative and statistically significant. Thus, the *unilateral* classification suggests that less flexible regimes are associated with higher average inflation. However, the coefficient turns out to be insignificant once we use the *effective* classification (columns 17 and 23), which is in line with our previous findings.

## 3.5 Extensions and Robustness Tests

### 3.5.1 Alternative trade weights

Our new *eERR* classification hinges on a key assumption that the weight of each bilateral trading partner is properly measured. Three-year averages of the past three periods were used in the benchmark results to measure the importance of each trading partner in order to avoid excessive volatility caused by one-time shocks in trade flows. Given the large importance of this assumption, we report the results of two additional weighting approaches in Table 3.10 in Appendix 3.A.2. The coefficients from the benchmark results are reported in columns (1) and (4). We find that our results remain almost identical when weighting using the three-years averages centred around the current year $t$ is used (columns 2 and 5) or when updating the weights only every five years (columns 3 and 6). The differences in the coefficients are even smaller when we use the IMF-based effective classification, confirming that our results are not driven by a particular weighting scheme.

### 3.5.2 Comparison to inflation targeting countries

The inflation targeting policy has been adopted by around 40 countries since its first adoption by New Zealand in the year 1990 (IMF, 2020). Given the rising importance of this framework in recent years, we investigate whether the adoption of inflation targeting policies has had a larger effect compared to the traditional exchange rate regimes policies. We note that inflation targeting policy is not constrained to one particular type of exchange rate regime. Ilzetzki et al. (2017) find that inflation targeting countries encompass a very broad spectrum of exchange arrangements ranging from crawling arrangements to free floats. To test the relative performance of these two policies we include a dummy variable in our benchmark specification for country-year observations of countries that adopted an inflation targeting policy. The results are reported in Table 3.11 in Appendix

3.A.2. We find that countries that adopt inflation targeting policies have significantly lower inflation rates. The size of the inflation reduction effect is at par with the effect stemming from the adoption of narrow and soft pegs (Regimes 2 and 3). In line with our benchmark results, the effect of hard pegs (Regime 1) is almost twice as large compared to both soft pegs and inflation-targeting policies. We conclude that the adoption of an inflation targeting framework does not render the role of exchange rate regimes as irrelevant. In particular, almost 40 percent of the inflation targeting countries involved soft pegs arrangements such as crawling pegs Ilzetzki et al. (2017). This suggest that inflation targeting policies can be used *complementary* to the exchange rate regimes policies as an efficient tool in reducing inflation.

### 3.5.3 Country fixed effects estimation

Our benchmark results include only year and region-specific fixed effects using group dummies differentiated by geographical and development status. This approach followed by Ghosh et al. (2014) is preferable since exchange rate regimes are slow-moving variables such that an identification of the effect would not be possible if no changes in regimes occurred over the selected period. Nevertheless, given the large time span covered in the *IRR-based* effective classification, we also report the results using the country fixed effects in Table 3.12 in Appendix 3.A.2.[14] We find that the *total effect* (columns 1 and 2) remains both large and strongly statistically significant in line with our benchmark results. When the *direct effect* (columns 3 and 4) is considered, the soft pegs (Regimes 2 and 3) coefficients remain negative and significant but hard pegs (Regime 1) for the low to middle-income country group become insignificant. Given the extremely restrictive nature of this specification, these findings further support our hypothesis that exchange rate regimes are an important determinant of inflation performance.

### 3.5.4 Exclusion of the commodity exporters

We showed in Figure 3.10 in Appendix 3.A.1 that countries with biggest composition changes between the *unilateral* and *effective* classifications are the commodity-exporting countries such as Quatar, Oman or United Arab Emirates. These classification differences can be plausibly justified: These resource-rich countries are

[14]We do not report country fixed effects using the *IMF-based de-jure* effective classification due to the short time period and too few changes in exchange rate regimes over this period.

mostly pegging to the U.S. dollar but they are exporting their natural resources to the whole world, with the U.S. making only a relatively minor share of their total exports. Thus, our classification algorithm works as desired. However, a large share of exports of these countries is likely to be denominated in the U.S. dollar because oil exports are mostly denominated in the U.S. dollar (Friberg and Wilander, 2008).

Given the fact that currency in which prices are set has significant implications for exchange rate pass-through to import prices (Bacchetta and van Wincoop, 2005), the relative purchasing power parity channel of price determination might be much weaker if large share of bilateral trade is denominated in some international currency such as the U.S. dollar. Our results might be mostly affected by this bias in the case of countries with large natural resources due to the role of the U.S. dollar as a currency denomination of these exports. Therefore, we report the results using only observations *without* commodity-exporting countries – defined as countries with commodities export share larger than 10 percent of the GDP – reported in Table 3.13 in Appendix 3.A.2. We find that our results remain robust, particularly in the low to middle-income countries group, which suggests that are results are *not* driven by a specific group of the resource-rich countries.

### 3.5.5 Other extensions and robustness tests

Another concern in our investigation is that incidences of currency devaluations and high inflation episodes following currency crises might possibly outweigh the initial inflation benefits. To investigate the effect of currency crises on inflation performance when currency crises happened, we split the sample by observations with and without currency crisis in Table 3.14 in Appendix 3.A.2. Columns (1) to (4) show only results for the country-years observations starting 3 years before and up to 3 years after a currency crisis in a country occurred. Indeed, we find that all coefficient turn out to be statistically insignificant during the currency crisis period, suggesting that all inflation-reducing benefits are lost once country faces a currency crisis. Results for country-years observations with non-crisis periods *excluded* (columns 5 to 8) remain consistent in line with our benchmark results, with the exception of wide soft pegs (Regime 3) which remain negative but turn out to be no longer statistically significant.

Results limited to country-year observations where inflation was below 5 percent per year are reported in Table 3.15 in Appendix 3.A.2. We find that only hard pegs (Regime 1) remain significant when the *IRR-based* effective classification is used (columns 1 to 4). The coefficients for the *IMF-based* effective classification (columns 5 to 8) are lower than our benchmark results but remain negative and statistically significant, suggesting that the inflation-reduction benefit from pegging applies even for countries with relatively low inflation rates.

As a further extension, we limit the sample for countries with capital inflows of more than 2.5 percent of GDP (see Table 3.16 in Appendix 3.A.2), which does not affect our benchmark results. The same specification for observations with current account balance of more than 2 percent of GDP is reported in columns 5 to 8. For these countries, Ghosh et al. (2011) found surprising positive effect of pegging on inflation, whereas our results remain mostly insignificant. Lastly, the results also remain consistent once we limit the sample of the *IRR-based* effective classification to start only from the year 2000 to be in line with the *IMF-based* classifications.[15]

## 3.6 Conclusion

This paper argued that currently available *unilateral* exchange rate regimes classifications are not well suited to capture aspects of exchange rate regimes relevant to inflation performance. We proposed a new measure of *effective* exchange rate regimes to take into account the relationship of each country against all countries across the world. When analysing the effects of exchange rate regimes on inflation performance, Rose (2011) argued that the effect is small and uncertain. Our results using the new *effective* classification are in strong contrast to the finding that exchange rate regimes – in particular soft pegs – do not matter or are even detrimental to the inflation performance.

We found that the pegged exchange rate regimes reduce inflation more than suggested by traditional *unilateral* classifications. In particular, not only hard pegs but also narrow and wide soft pegs are associated with significantly lower inflation rates when comparing to the free-floating regimes. These results are not a phenomenon of the past: Our results remain strongly statistically and economically significant also for the current period beginning from the year 2000. Overall, pegging an exchange rate in low to middle-income countries is at least as efficient tool in reducing inflation as the use of inflation targeting policies, which were found to have a complementary benefit on top of the former effect.

[15] The results are available upon request.

# Chapter 3: Appendix

## 3.A Appendix

### 3.A.1 Data description

Table 3.4: Summary of unilateral exchange rate regimes classifications

| Label | Authors | Years available | Observations | Number of regimes |
|---|---|---|---|---|
| *AREAER* | IMF | 2000-2016 (offline from 1950) | 2,751 | 10 (8 before 2009) |
| *IRR* | Ilzetzki, Reinhardt and Rogoff | 1973-2016 (original from 1946) | 8,293 | 13 (plus 2 residuals) |
| *KS* | Klein and Shambaugh | 1960-2014 | 8,850 | 2 (peg/no peg), 3 or 4 |
| *LYS* | Levy-Yeyati and Sturzenegger | 1974-2013 | 4,485 | 4 (peg/int/cp/float) |

| Label | Internet links: |
|---|---|
| *AREAER* | https://www.elibrary-areaer.imf.org/ |
| *IRR* | https://www.ilzetzki.com/irr-data |
| *KS* | https://www2.gwu.edu/~iiep/about/faculty/jshambaugh/data.cfm |
| *LYS* | https://www.hks.harvard.edu/centers/cid/publications/faculty-working-papers/classifying-exchange- |

| Label | Construction |
|---|---|
| *AREAER* | De-jure regimes based on official information and de-facto regimes adjusted by IMF staff.<br>(not compatible with prior 2000 data as regimes structure changed frequently) |
| *IRR* | Actual exchange rate behavior (market-determined rates)<br>Merged information on capital controls and exchange rate regimes<br>We use NEW versions up to 2016: focus on choice of anchor (explicitly determined)<br>Allows for de facto baskets of currencies as anchors.<br>Classify de jure inflation targeting cases and pay attention to the Eurozone.<br>(1) look at the Er volatility first (2) look at a pre-announced (!) exchange rate arrangement<br>(3) distinguish managed and freely floating based on external sources |
| *KS* | Based on policy trilemma, looks at official exchange rate band<br>The base country is the currency to which a country pegs or would peg if it were pegging<br>Look at bilateral exchange rates to find potential base currency.<br>Only judgment used to determine countries that generally float:<br>Base is the currency with historical importance for the local country, the nearby dominant<br>economy to which other currencies were pegged or the US dollar as a default. |
| *LYS* | Cluster analysis: group according to the relative volatility of exchange rates and reserves. |

| Label | Design |
|---|---|
| *AREAER* | Focus on de-jure commitments<br>De-jure and de-facto results are more comparable (Ghosh et al., 2010)<br>Higher proportion of other classifications (IRR, LYS) agree with the IMF's classification than any other classification (Ghosh et al., 2010) |
| *IRR* | Best suited for analyses on transactions<br>Does not measure well central bank commitments - the original 2004 version |
| *KS* | The base is determined based on observed exchange rate volatility, possibly endgeoenous.<br>Not appropriate for countries for which the official exchange rate is not the most economically relevant.<br>Simple and clear rules, widely available.<br>Does not use information on capital controls and exchange rate regimes (as IRR do). |
| *LYS* | Emphasis on actual behavior<br>No distinction between sterilised and unsterilized interventions<br>Omits some undeclared de facto pegs<br>High data requirement |

Table 3.5: Mapping of unilateral and effective exchange rate regimes

| Ilzetzki, Reinhardt and Rogoff (IRR) | Regime 4-way | Effective weight | Mapped regime (de-facto) |
|---|---|---|---|
| 1. No separate legal tender or currency union | $Regime_1$ | 1 | Hard peg |
| 2. Pre announced peg or currency board arrangement | $Regime_1$ | 1 | Hard peg |
| 3. Pre announced horizontal band that is narrower than or equal to +/-2% | $Regime_1$ | 1 | Hard peg |
| 4. De facto peg | $Regime_1$ | 1 | Hard peg |
| 5. Pre announced crawling peg; de facto moving band narrower than or equal to +/-1% | $Regime_2$ | 2 | Soft peg narrow |
| 6. Pre announced crawling band / de facto horizontal band that is narrower than or equal to +/-2% | $Regime_2$ | 2 | Soft peg narow |
| 7. De facto crawling peg | $Regime_2$ | 2 | Soft peg narrow |
| 8. De facto crawling band that is narrower than or equal to +/-2% | $Regime_2$ | 2 | Soft peg narrow |
| 9. Pre announced crawling band that is wider than or equal to +/-2% | $Regime_3$ | 3 | Soft peg wide |
| 10. De facto crawling band that is narrower than or equal to +/-5% | $Regime_3$ | 3 | Soft peg wide |
| 11. Moving band that is narrower than or equal to +/-2% | $Regime_3$ | 3 | Soft peg wide |
| 12. De facto moving band +/-5%/ Managed floating | $Regime_3$ | 3 | Soft peg wide |
| 13. Freely floating | $Regime_4$ | 4 | Freely floating |
| *Residuals* | | | |
| 14. Freely falling | - | - | - |
| 15. Dual market in which parallel market data is missing | - | - | - |

| IMF *de-jure* and *de-facto* (AREAER) | Regime 4-way | Effective weight | Mapped regime |
|---|---|---|---|
| *Hard pegs* | | | |
| 1. No separate legal tender | $Regime_1$ | 1 | Hard peg |
| 2. Currency board arrangement | $Regime_1$ | 1 | Hard peg |
| *Soft pegs* | | | |
| 3. Conventional pegged arrangement | $Regime_1$ | 1 | Hard peg |
| 4. Stabilized arrangement | $Regime_2$ | 2 | Soft peg narow |
| 5. Crawling peg | $Regime_2$ | 2 | Soft peg narow |
| 6. Crawling band / Crawling-like arrangement | $Regime_2$ | 2 | Soft peg narow |
| 7. Pegged within horizontal bands | $Regime_3$ | 3 | Soft peg wide |
| 8. Other managed (residual) | $Regime_3$ | 3 | Soft peg wide |
| *Floating arrangements* | | | |
| 9. (Managed) floating | $Regime_4$ | 4 | Freely floating |
| 10. Free (Independently) floating | $Regime_4$ | 4 | Freely floating |

| Klein and Shambaugh (KS) | Regime 4-way | Effective weight | Mapped regime |
|---|---|---|---|
| 1. Zero change | $Regime_1$ | - | Hard peg |
| 2. 1% band | $Regime_2$ | - | Soft peg narow |
| 3. 2% band | $Regime_3$ | - | Soft peg wide |
| 4. No peg | $Regime_4$ | - | Freely floating |
| *Residuals* | | | |
| 5. One-time devaluation/revaluation | - | - | - |

| Levy-Yeyati and Sturzenegger (LYS) | Regime 4-way | Effective weight | Mapped regime |
|---|---|---|---|
| 1. Fix | $Regime_1$ | - | Hard peg |
| 2. Inter (Dirty) | $Regime_2$ | - | Soft peg narow |
| 3. Inter (Dirty/CP) | $Regime_3$ | - | Soft peg wide |
| 4. Float | $Regime_4$ | - | Freely floating |

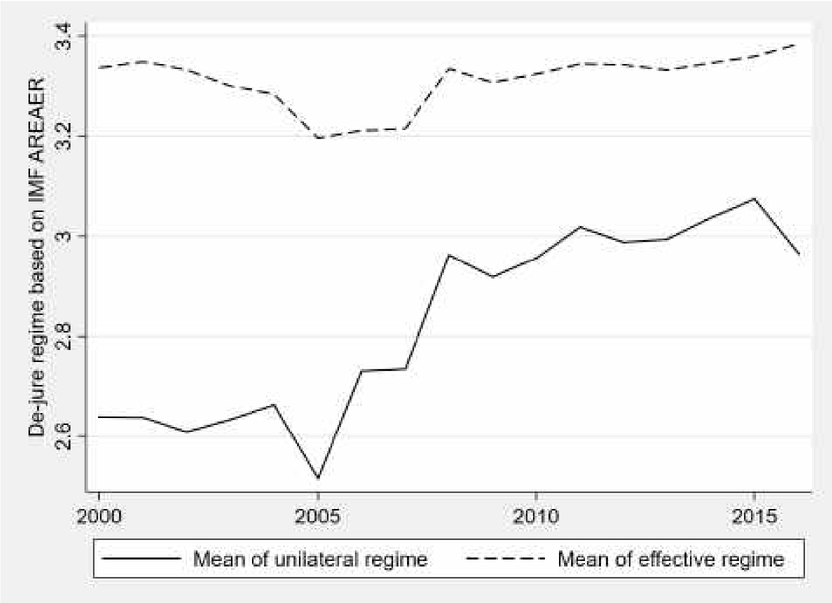
Table 3.6: Data sources

| **Variable** | **Description** | **Source** |
|---|---|---|
| | *Main variables* | |
| Regime IMF-based (de-jure) | Bilateral IMF-based *de-jure* exchange rate regime, years 2000-2016 | (Harms and Knaze 2018), International Economics Website |
| Regime IMF-based (de-facto) | Bilateral IMF-based *de-facto* exchange rate regime, years 2000-2016 | |
| Regime IRR-based de-facto | Bilateral IRR-based *de-facto* exchange rate regime, years 1973-2016 | |
| Bilateral trade | Bilateral trade flows, years 1973-2016 | IMF, Direction of Trade Statistics |
| eERR IMF-based (de-jure) | Effective IMF-based *de-jure* exchange rate regime | Own computation |
| eERR IMF-based (de-facto) | Effective IMF-based *de-facto* exchange rate regime | Own computation |
| eERR IRR-based (de-facto) | Effective IRR-based *de-facto* exchange rate regime | Own computation |
| Inflation | Inflation change: Prices, Consumer Price Index, All items, Percentage change, Corresponding period previous year, Percent | IMF, IFS |
| | *Other control variables* | |
| Openness | Trade (percent of GDP) | World Bank, WDI |
| Financial Openness | The Chinn-Ito Financial Opennes Index, (Chinn and Ito 2006) | Chinn-Into Website |
| Fiscal balance | General government net lending/borrowing (percent of GDP) | IMF, World Economic Outlook |
| Real GDP growth | Percentage change in real GDP. | World Bank, WDI |
| (Lag) Money growth | (Lagged) broad money growth (annual %) | IMF, IFS and data files provided by the World Bank |
| Commodity exporters | Countries with general government commodity revenues above 10 percent of GDP. | IMF, World Commodity Exporters |
| Currency crises range | Dummy for country-years observations with a currency crisis with a range of +/- 3 years | (Valencia and Laeven 2012) |
| Excessive capital inflows | Country-years observations where current account balance was above 2.5 percent of GDP. | World Bank, WDI and own computation |
| Inflation targeting | Country-year observations for inflation targeting countries. | IMF, F&D Article |

Table 3.7: Summary statistics

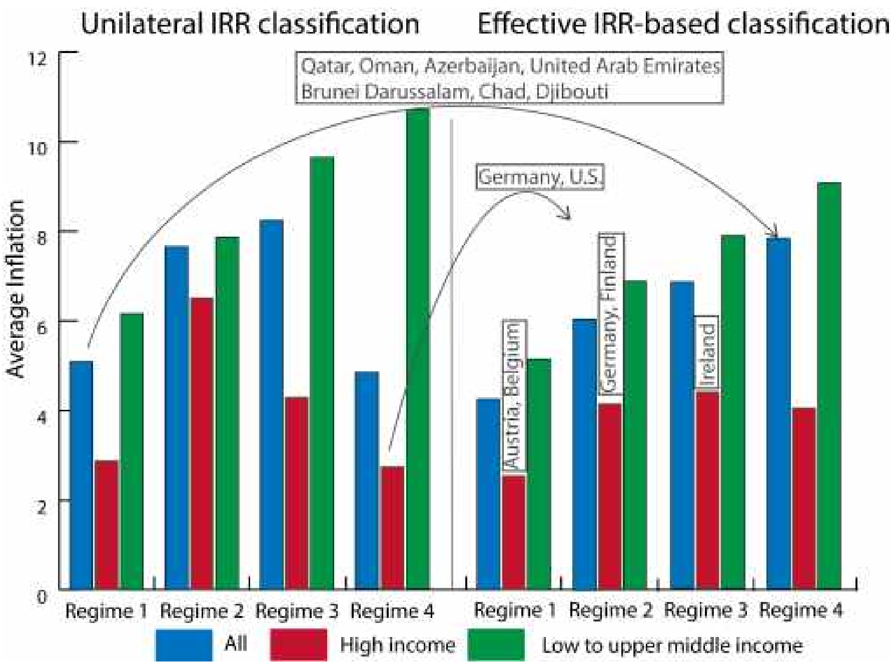
| | **From** | **To** | **Obs** | **Mean** | **Std. Dev.** | **Min** | **Max** | **Unit** |
|---|---|---|---|---|---|---|---|---|
| | | | | *Main variables* | | | | |
| eERR IMF-based (de-jure) | 2000 | 2016 | 2,835 | 3.31 | 0.807 | 1.12 | 4 | Categorical |
| eERR IMF-based (de-facto) | 2000 | 2016 | 2,852 | 3.15 | 0.794 | 1.12 | 4 | Categorical |
| eERR IRR-based (de-facto) | 1981 | 2016 | 5,624 | 2.75 | 0.666 | 1.11 | 4 | Categorical |
| Inflation | 1981 | 2016 | 6,415 | 8.92 | 17.71 | -22.13 | 99.58 | Percent |
| | | | | *Other control variables* | | | | |
| Openness | 1981 | 2016 | 6,507 | 81.27 | 52.38 | .021 | 531.73 | Index |
| Financial Openness | 1981 | 2016 | 6,782 | .45 | .36 | 0 | 1 | Index |
| Fiscal balance | 1981 | 2016 | 4,900 | -2.83 | 15.56 | -557.5 | 122.2 | Percent of GDP |
| Real GDP growth | 1981 | 2016 | 6,847 | 3.67 | 6.36 | -64.04 | 149.97 | Percent |
| (Lag) Money growth | 1981 | 2016 | 6,494 | 33.01 | 266.13 | -99.86 | 12513 | Percent |
| Commodity exporters | 1981 | 2016 | 9,020 | .117 | .321 | 0 | 1 | Dummy |
| Currency crises range | 1981 | 2016 | 9,020 | .169 | .374 | 0 | 1 | Dummy |
| Current account to GDP | 1981 | 2016 | 5,886 | -3.27 | 11.00 | -240.52 | 62.30 | Percent of GDP |
| Inflation targeting | 1981 | 2016 | 9,020 | .057 | .232 | 0 | 1 | Dummy |

FIGURE 3.9: Average value of unilateral and weighted de-facto (IMF-based) exchange rate regimes over time




Mapping of the exchange rate regimes is shown in Figure 3.5 in Appendix. Higher value denotes more flexible exchange rate regime. Own computation using yearly data.

FIGURE 3.10: Average inflation across different exchange rate regime classifications: Selected countries with largest differences in classification



### 3.A.2 Additional output figures and tables

TABLE 3.8: Unilateral and effective *IMF*-based classification (**de-facto**): Inflation performance under different exchange rate regimes from the estimation of the benchmark equation 3.4 with *total* and *direct* effects, sample covers years from 2000 to 2016

| | [A] | | [B] | |
|---|---|---|---|---|
| | *Unilateral (IMF)* | | *Effective (IMF-based)* | |
| **Total effect** | (1) | (2) | (3) | (4) |
| | All | Low/Middle* | All | Low/Middle* |
| Regime 1 / Hard pegs | -3.731*** | -5.087*** | -3.811*** | -5.161*** |
| | (0.822) | (1.002) | (0.882) | (1.144) |
| Regime 2 / Soft pegs narrow | 0.053 | -0.470 | -2.868*** | -3.550*** |
| | (0.628) | (0.753) | (0.747) | (0.961) |
| Regime 3 / Soft pegs wide | 1.857** | 1.914* | -0.415 | -0.639 |
| | (0.786) | (0.999) | (0.666) | (0.826) |
| Openness | 0.004 | 0.005 | 0.004 | 0.005 |
| | (0.005) | (0.010) | (0.006) | (0.011) |
| Financial Openness | -3.701*** | -3.603*** | -3.022*** | -2.941*** |
| | (0.957) | (1.052) | (0.974) | (1.068) |
| Fiscal balance | -0.070** | -0.071 | -0.129*** | -0.098* |
| | (0.035) | (0.056) | (0.039) | (0.055) |
| Real GDP growth | -0.093 | -0.128* | -0.069 | -0.102 |
| | (0.061) | (0.071) | (0.057) | (0.068) |
| N | 2600 | 1878 | 2402 | 1723 |
| $R^2$ | 0.23 | 0.20 | 0.22 | 0.17 |
| | [C] | | [D] | |
| | *Unilateral (IMF)* | | *Effective (IMF-based)* | |
| **Direct effect** | (5) | (6) | (7) | (8) |
| | All | Low/Middle* | All | Low/Middle* |
| Regime 1 / Hard pegs | -2.320*** | -3.161*** | -2.090*** | -2.717*** |
| | (0.477) | (0.576) | (0.516) | (0.659) |
| Regime 2 / Soft pegs narrow | -0.086 | -0.439 | -1.928*** | -2.421*** |
| | (0.433) | (0.510) | (0.430) | (0.575) |
| Regime 3 / Soft pegs wide | 1.723*** | 1.511** | -0.146 | -0.437 |
| | (0.578) | (0.722) | (0.430) | (0.521) |
| Money growth | 0.094*** | 0.094*** | 0.097*** | 0.099*** |
| | (0.010) | (0.010) | (0.011) | (0.012) |
| Lag money growth | 0.113*** | 0.113*** | 0.112*** | 0.112*** |
| | (0.008) | (0.008) | (0.008) | (0.009) |
| Openness | 0.002 | 0.001 | 0.001 | -0.000 |
| | (0.003) | (0.005) | (0.003) | (0.006) |
| Financial Openness | -1.975*** | -1.921*** | -1.422** | -1.390* |
| | (0.641) | (0.713) | (0.653) | (0.724) |
| Fiscal balance | -0.069** | -0.082** | -0.112*** | -0.097** |
| | (0.027) | (0.040) | (0.027) | (0.041) |
| Real GDP growth | -0.186*** | -0.211*** | -0.162*** | -0.183*** |
| | (0.040) | (0.049) | (0.042) | (0.051) |
| N | 2487 | 1813 | 2312 | 1669 |
| $R^2$ | 0.49 | 0.46 | 0.49 | 0.45 |

* Sample split using the World Bank income groups classification (Atlas method) where “High” denotes high income and “Low/middle” denotes low, low-middle and upper-middle income country groups (time-varying). Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, * $p < 0.01$. Dependent variable is the annual inflation rate transformed as $\pi/(1+\pi)$. Clustered standard errors (at country level) are reported in parentheses. All specifications include a constant term and region-specific and year effects.

Table 3.9: Unilateral and effective *IRR*- and *IMF*-based classifications as a **continuous** variable: Inflation performance under different exchange rate regimes from the estimation of the benchmark equation 3.4 with *total* and *direct* effects

| | All | High* | Low/Middle* | All | High* | Low/Middle* |
|---|---|---|---|---|---|---|
| **IRR / Total effect** | (1) | (2) | (3) | (4) | (5) | (6) |
| Unilateral IRR Regime / Continuous | 1.105*** | -0.016 | 1.994*** | | | |
| | (0.273) | (0.171) | (0.348) | | | |
| Effective IRR Regime / Continuous | | | | 1.727*** | 0.129 | 2.565*** |
| | | | | (0.374) | (0.239) | (0.458) |
| Openness | -0.002 | 0.001 | -0.004 | -0.002 | 0.002 | -0.006 |
| | (0.004) | (0.003) | (0.006) | (0.004) | (0.003) | (0.006) |
| Financial Openness | -4.356*** | -3.820*** | -3.135*** | -4.164*** | -3.834*** | -2.934*** |
| | (0.730) | (1.281) | (0.755) | (0.746) | (1.415) | (0.758) |
| Fiscal balance | 0.002 | 0.015 | 0.005 | -0.047*** | 0.007 | -0.041*** |
| | (0.005) | (0.015) | (0.004) | (0.008) | (0.014) | (0.007) |
| Real GDP growth | 0.012 | -0.005 | 0.006 | 0.009 | -0.010 | 0.008 |
| | (0.022) | (0.031) | (0.027) | (0.022) | (0.032) | (0.027) |
| **IRR / Direct effect** | (7) | (8) | (9) | (10) | (11) | (12) |
| Unilateral IRR Regime / Continuous | 0.889*** | -0.119 | 1.583*** | | | |
| | (0.195) | (0.120) | (0.251) | | | |
| Effective IRR Regime / Continuous | | | | 1.142*** | -0.075 | 1.789*** |
| | | | | (0.265) | (0.177) | (0.336) |
| Money growth | 0.126*** | 0.051*** | 0.128*** | 0.119*** | 0.051*** | 0.123*** |
| | (0.020) | (0.018) | (0.022) | (0.024) | (0.019) | (0.026) |
| Lag money growth | 0.072*** | 0.070*** | 0.068*** | 0.076*** | 0.069*** | 0.071*** |
| | (0.008) | (0.023) | (0.008) | (0.011) | (0.022) | (0.012) |
| Openness | -0.001 | 0.003 | -0.002 | -0.002 | 0.003 | -0.005 |
| | (0.003) | (0.002) | (0.004) | (0.003) | (0.002) | (0.005) |
| Financial Openness | -2.603*** | -3.676*** | -1.879*** | -2.253*** | -3.611*** | -1.535** |
| | (0.583) | (0.928) | (0.602) | (0.574) | (1.022) | (0.605) |
| Fiscal balance | -0.004 | -0.002 | 0.000 | -0.027** | -0.001 | -0.020* |
| | (0.006) | (0.015) | (0.005) | (0.012) | (0.015) | (0.010) |
| Real GDP growth | -0.090*** | -0.060* | -0.089*** | -0.085*** | -0.061* | -0.078** |
| | (0.029) | (0.031) | (0.034) | (0.032) | (0.031) | (0.038) |
| N | 3375 | 965 | 2410 | 3135 | 943 | 2192 |
| $R^2$ | 0.45 | 0.62 | 0.42 | 0.45 | 0.62 | 0.41 |
| **IMF de-jure / Total effect** | (13) | (14) | (15) | (16) | (17) | (18) |
| Unilateral IMF Regime / Continuous | 1.331*** | -0.444** | 1.753*** | | | |
| | (0.282) | (0.186) | (0.322) | | | |
| Effective IMF Regime / Continuous | | | | 2.206*** | 0.068 | 2.852*** |
| | | | | (0.445) | (0.258) | (0.574) |
| Openness | 0.006 | -0.000 | 0.008 | 0.004 | 0.002 | 0.007 |
| | (0.006) | (0.002) | (0.011) | (0.005) | (0.002) | (0.011) |
| Financial Openness | -3.461*** | -3.811*** | -3.463*** | -3.375*** | -3.495** | -3.351*** |
| | (0.927) | (1.360) | (1.021) | (0.943) | (1.422) | (1.024) |
| Fiscal balance | -0.075* | -0.011 | -0.065 | -0.115*** | -0.020 | -0.081 |
| | (0.040) | (0.028) | (0.057) | (0.039) | (0.026) | (0.054) |
| Real GDP growth | -0.069 | 0.017 | -0.108 | -0.080 | 0.006 | -0.120* |
| | (0.057) | (0.045) | (0.070) | (0.058) | (0.048) | (0.069) |
| **IMF de-jure / Direct effect** | (19) | (20) | (21) | (22) | (23) | (24) |
| Unilateral IMF Regime / Continuous | 0.798*** | -0.391** | 1.055*** | | | |
| | (0.155) | (0.159) | (0.173) | | | |
| Effective IMF Regime / Continuous | | | | 1.239*** | 0.009 | 1.526*** |
| | | | | (0.258) | (0.234) | (0.326) |
| Money growth | 0.096*** | 0.055** | 0.097*** | 0.095*** | 0.056** | 0.096*** |
| | (0.012) | (0.026) | (0.013) | (0.011) | (0.027) | (0.012) |
| Lag money growth | 0.110*** | 0.063** | 0.110*** | 0.111*** | 0.063** | 0.112*** |
| | (0.008) | (0.024) | (0.009) | (0.008) | (0.026) | (0.009) |
| Openness | 0.002 | 0.001 | 0.001 | 0.001 | 0.003 | 0.001 |
| | (0.003) | (0.002) | (0.006) | (0.003) | (0.002) | (0.006) |
| Financial Openness | -1.671*** | -3.315*** | -1.740** | -1.667*** | -3.109*** | -1.619** |
| | (0.627) | (1.085) | (0.710) | (0.633) | (1.111) | (0.698) |
| Fiscal balance | -0.077*** | -0.025 | -0.076* | -0.103*** | -0.033 | -0.088** |
| | (0.028) | (0.027) | (0.042) | (0.027) | (0.024) | (0.040) |
| Real GDP growth | -0.165*** | -0.037 | -0.192*** | -0.168*** | -0.044 | -0.194*** |
| | (0.041) | (0.048) | (0.051) | (0.042) | (0.051) | (0.050) |
| N | 2274 | 640 | 1634 | 2309 | 643 | 1666 |
| $R^2$ | 0.50 | 0.49 | 0.48 | 0.49 | 0.47 | 0.45 |

TABLE 3.10: Observations with varying trade weights: *direct* and *indirect* effects using *IRR*- and *IMF*-based *effective* classifications

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | | *All countries* | | | *Non-HI countries* | |
| **IRR de-facto classification** | (t-3 to t-1) | (t-1 to t+1) | (5 years) | (t-3 to t-1) | (t-1 to t+1) | (5 years) |
| Effective IRR regime / Continuous | 1.142*** | 1.058*** | 1.028*** | 1.789*** | 1.692*** | 1.578*** |
| | (0.265) | (0.270) | (0.261) | (0.336) | (0.344) | (0.333) |
| Money growth | 0.119*** | 0.120*** | 0.120*** | 0.123*** | 0.124*** | 0.124*** |
| | (0.024) | (0.023) | (0.022) | (0.026) | (0.025) | (0.024) |
| Lag money growth | 0.076*** | 0.076*** | 0.076*** | 0.071*** | 0.072*** | 0.072*** |
| | (0.011) | (0.011) | (0.011) | (0.012) | (0.012) | (0.012) |
| Openness | -0.002 | -0.002 | -0.002 | -0.005 | -0.005 | -0.005 |
| | (0.003) | (0.003) | (0.003) | (0.005) | (0.005) | (0.005) |
| Financial Openness | -2.253*** | -2.278*** | -2.347*** | -1.535** | -1.556** | -1.681*** |
| | (0.574) | (0.579) | (0.590) | (0.605) | (0.609) | (0.634) |
| Fiscal balance | -0.027** | -0.010 | -0.010 | -0.020* | -0.006 | -0.008 |
| | (0.012) | (0.008) | (0.007) | (0.010) | (0.006) | (0.006) |
| Real GDP growth | -0.085*** | -0.094*** | -0.091*** | -0.078** | -0.089** | -0.085** |
| | (0.032) | (0.032) | (0.032) | (0.038) | (0.038) | (0.038) |
| N | 3135 | 3153 | 3209 | 2192 | 2209 | 2265 |
| $R^2$ | 0.45 | 0.45 | 0.44 | 0.41 | 0.41 | 0.40 |
| | (7) | (8) | (9) | (10) | (11) | (12) |
| | | *All countries* | | | *Non-HI countries* | |
| **IMF de-jure classification** | (t-3 to t-1) | (t-1 to t+1) | (5 years) | (t-3 to t-1) | (t-1 to t+1) | (5 years) |
| Effective IMF regime / Continuous | 1.239*** | 1.256*** | 1.239*** | 1.526*** | 1.544*** | 1.514*** |
| | (0.258) | (0.258) | (0.253) | (0.326) | (0.325) | (0.313) |
| Money growth | 0.095*** | 0.094*** | 0.094*** | 0.096*** | 0.095*** | 0.095*** |
| | (0.011) | (0.011) | (0.011) | (0.012) | (0.012) | (0.012) |
| Lag money growth | 0.111*** | 0.111*** | 0.111*** | 0.112*** | 0.112*** | 0.112*** |
| | (0.008) | (0.008) | (0.008) | (0.009) | (0.009) | (0.009) |
| Openness | 0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.002 |
| | (0.003) | (0.003) | (0.003) | (0.006) | (0.006) | (0.006) |
| Financial Openness | -1.667*** | -1.730*** | -1.717*** | -1.619** | -1.667** | -1.627** |
| | (0.633) | (0.647) | (0.644) | (0.698) | (0.707) | (0.690) |
| Fiscal balance | -0.103*** | -0.101*** | -0.101*** | -0.088** | -0.085** | -0.086** |
| | (0.027) | (0.027) | (0.027) | (0.040) | (0.040) | (0.039) |
| Real GDP growth | -0.168*** | -0.167*** | -0.164*** | -0.194*** | -0.194*** | -0.188*** |
| | (0.042) | (0.041) | (0.041) | (0.050) | (0.049) | (0.049) |
| N | 2309 | 2322 | 2353 | 1666 | 1678 | 1709 |
| $R^2$ | 0.49 | 0.49 | 0.49 | 0.45 | 0.45 | 0.45 |

* Sample split using the World Bank income groups classification (Atlas method). Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, * $p < 0.01$. All specifications include a constant term and region-specific and year effects.

TABLE 3.11: Controlling for inflation targeting countries: *total* and *direct* effects using both *IRR*- and *IMF*-based *effective* classifications

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | *Total effect* | | *Direct effect* | |
| **IRR de-facto classification** | All | Low/Middle | All | Low/Middle |
| Regime 1 / effective | -3.952*** | -5.376*** | -2.598*** | -3.851*** |
| | (0.707) | (0.825) | (0.560) | (0.659) |
| Regime 2 / effective | -2.031*** | -2.468*** | -1.381*** | -1.956*** |
| | (0.648) | (0.751) | (0.512) | (0.577) |
| Regime 3 / effective | -1.345** | -1.612*** | -0.998** | -1.430*** |
| | (0.527) | (0.613) | (0.414) | (0.478) |
| Inflation targeting | -2.310*** | -3.123*** | -1.292*** | -1.849*** |
| | (0.497) | (0.618) | (0.369) | (0.492) |
| Openness | -0.005 | -0.011* | -0.004 | -0.008* |
| | (0.004) | (0.006) | (0.003) | (0.005) |
| Financial Openness | -3.710*** | -2.489*** | -2.045*** | -1.289** |
| | (0.749) | (0.726) | (0.578) | (0.582) |
| Fiscal balance | -0.048*** | -0.043*** | -0.028** | -0.021** |
| | (0.008) | (0.007) | (0.012) | (0.010) |
| Real GDP growth | 0.009 | 0.014 | -0.081** | -0.069* |
| | (0.022) | (0.028) | (0.034) | (0.041) |
| Money growth | | | 0.116*** | 0.120*** |
| | | | (0.025) | (0.027) |
| Lag money growth | | | 0.074*** | 0.068*** |
| | | | (0.011) | (0.012) |
| N | 3375 | 2281 | 3135 | 2190 |
| $R^2$ | 0.30 | 0.27 | 0.46 | 0.42 |
| | (5) | (6) | (7) | (8) |
| | *Total effect* | | *Direct effect* | |
| **IMF de-jure classification** | All | Low/Middle | All | Low/Middle |
| De-jure Regime 1 / effective | -5.406*** | -6.480*** | -2.911*** | -3.264*** |
| | (0.917) | (1.095) | (0.553) | (0.621) |
| De-jure Regime 2 / effective | -4.832*** | -5.482*** | -3.028*** | -3.487*** |
| | (0.886) | (0.945) | (0.586) | (0.647) |
| De-jure Regime 3 / effective | -3.751*** | -4.148*** | -2.127*** | -2.554*** |
| | (0.836) | (0.940) | (0.492) | (0.522) |
| Inflation targeting | -3.324*** | -3.683*** | -1.862*** | -2.162*** |
| | (0.671) | (0.767) | (0.458) | (0.550) |
| Openness | 0.002 | -0.001 | 0.001 | -0.003 |
| | (0.005) | (0.011) | (0.003) | (0.006) |
| Financial Openness | -3.021*** | -3.009*** | -1.507** | -1.479** |
| | (0.835) | (0.938) | (0.594) | (0.652) |
| Fiscal balance | -0.087** | -0.078 | -0.088*** | -0.085** |
| | (0.038) | (0.052) | (0.027) | (0.039) |
| Real GDP growth | -0.075 | -0.103 | -0.162*** | -0.180*** |
| | (0.057) | (0.069) | (0.042) | (0.052) |
| Money growth | | | 0.091*** | 0.093*** |
| | | | (0.012) | (0.012) |
| Lag money growth | | | 0.110*** | 0.111*** |
| | | | (0.008) | (0.009) |
| N | 2399 | 1720 | 2309 | 1666 |
| $R^2$ | 0.26 | 0.21 | 0.50 | 0.47 |

* Sample split using the World Bank income groups classification (Atlas method). Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, * $p < 0.01$. Dependent variable is the annual inflation rate transformed as $\pi/(1+\pi)$. Clustered standard errors (at country level) are reported in parentheses. All specifications include a constant term and region-specific and year effects.

Table 3.12: Specification with country and year fixed effects: *total* and *direct* effects using IRR-based *effective* classification

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | *Total effect* | | *Direct effect* | |
| | All | Low/Middle* | All | Low/Middle* |
| Regime 1 / effective | -2.141*** | -2.273*** | -0.792* | -0.957 |
| | (0.447) | (0.623) | (0.448) | (0.608) |
| Regime 2 / effective | -1.390*** | -1.739*** | -0.684* | -1.012** |
| | (0.371) | (0.493) | (0.364) | (0.473) |
| Regime 3 / effective | -1.194*** | -1.712*** | -0.753** | -1.310*** |
| | (0.317) | (0.416) | (0.302) | (0.393) |
| Openness | -0.000 | 0.008 | 0.004 | 0.006 |
| | (0.004) | (0.006) | (0.004) | (0.005) |
| Financial Openness | -7.079*** | -5.707*** | -5.146*** | -4.094*** |
| | (0.488) | (0.716) | (0.491) | (0.666) |
| Fiscal balance | -0.028*** | -0.031*** | -0.020*** | -0.017* |
| | (0.008) | (0.010) | (0.008) | (0.009) |
| Real GDP growth | 0.011 | -0.009 | -0.063*** | -0.073*** |
| | (0.018) | (0.023) | (0.017) | (0.021) |
| Money growth | | | 0.102*** | 0.108*** |
| | | | (0.005) | (0.007) |
| Lag money growth | | | 0.067*** | 0.066*** |
| | | | (0.005) | (0.006) |
| N | 3375 | 2281 | 3135 | 2192 |
| $R^2$ | 0.09 | 0.04 | 0.22 | 0.21 |

* Sample split using the World Bank income groups classification (Atlas method). Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, * $p < 0.01$. Dependent variable is the annual inflation rate transformed as $\pi/(1+\pi)$. Country and year fixed effects used in estimation.

Table 3.13: Excluding commodity exporters: *total* and *direct* effects using both IRR and IMF based *effective* classifications

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | *Total effect* | | *Direct effect* | |
| **IRR de-facto classification** | All | Low/Middle* | All | Low/Middle* |
| Regime 1 / effective | -2.925*** | -4.525*** | -1.957*** | -3.254*** |
| | (0.754) | (0.941) | (0.546) | (0.674) |
| Regime 2 / effective | -1.133 | -1.536* | -0.750 | -1.302** |
| | (0.717) | (0.850) | (0.542) | (0.628) |
| Regime 3 / effective | -0.821 | -1.268* | -0.643 | -1.182** |
| | (0.608) | (0.709) | (0.461) | (0.541) |
| Openness | -0.002 | -0.008 | -0.001 | -0.005 |
| | (0.004) | (0.007) | (0.003) | (0.006) |
| Financial Openness | -3.862*** | -2.569*** | -2.049*** | -1.374** |
| | (0.796) | (0.749) | (0.603) | (0.599) |
| Fiscal balance | -0.084* | -0.047 | -0.078** | -0.049 |
| | (0.045) | (0.055) | (0.034) | (0.045) |
| Real GDP growth | 0.017 | -0.010 | -0.111*** | -0.126*** |
| | (0.039) | (0.047) | (0.041) | (0.047) |
| Money growth | | | 0.124*** | 0.128*** |
| | | | (0.027) | (0.029) |
| Lag money growth | | | 0.076*** | 0.070*** |
| | | | (0.012) | (0.013) |
| N | 3008 | 2045 | 2769 | 1957 |
| $R^2$ | 0.30 | 0.26 | 0.47 | 0.43 |
| | (5) | (6) | (7) | (8) |
| | *Total effect* | | *Direct effect* | |
| **IMF de-jure classification** | All | Low/Middle* | All | Low/Middle* |
| De-jure Regime 1 / effective | -3.870*** | -5.333*** | -2.121*** | -2.667*** |
| | (0.774) | (1.033) | (0.457) | (0.578) |
| De-jure Regime 2 / effective | -3.122*** | -3.970*** | -2.148*** | -2.737*** |
| | (0.697) | (0.899) | (0.510) | (0.674) |
| De-jure Regime 3 / effective | -2.026*** | -2.408*** | -1.182*** | -1.747*** |
| | (0.554) | (0.667) | (0.401) | (0.455) |
| Openness | 0.005 | 0.007 | 0.004 | 0.004 |
| | (0.004) | (0.008) | (0.003) | (0.006) |
| Financial Openness | -2.886*** | -2.961*** | -1.425** | -1.483** |
| | (0.878) | (0.960) | (0.592) | (0.652) |
| Fiscal balance | -0.074* | -0.022 | -0.058* | -0.027 |
| | (0.043) | (0.053) | (0.034) | (0.042) |
| Real GDP growth | -0.081 | -0.130 | -0.202*** | -0.249*** |
| | (0.070) | (0.082) | (0.056) | (0.065) |
| Money growth | | | 0.093*** | 0.099*** |
| | | | (0.015) | (0.017) |
| Lag money growth | | | 0.114*** | 0.120*** |
| | | | (0.016) | (0.018) |
| N | 2136 | 1550 | 2047 | 1497 |
| $R^2$ | 0.25 | 0.20 | 0.42 | 0.37 |

* Sample split using the World Bank income groups classification (Atlas method). Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, * $p < 0.01$. Dependent variable is the annual inflation rate transformed as $\pi/(1+\pi)$. Observations for countries that are commodity exporters with a commodities export share larger than 10 percent of their GDP are excluded.

Table 3.14: Taking into account periods with currency crises: *total* and *direct* effects using IRR-based *effective* classification

| | | | | |
|---|---|---|---|---|
| *Observations covering **only** currency crisis period (t-3 to t+3)* | | | | |
| | (1) | (2) | (3) | (4) |
| | All | Low/Middle* | High* | Low/Middle* |
| Regime 1 / effective | -1.203 | -2.383 | -0.091 | -0.413 |
| | (2.238) | (2.084) | (1.455) | (1.500) |
| Regime 2 / effective | -0.993 | -0.367 | 1.030 | 0.787 |
| | (1.137) | (1.169) | (0.824) | (0.832) |
| Regime 3 / effective | -2.185* | -1.413 | -0.654 | -0.610 |
| | (1.143) | (1.015) | (0.839) | (0.850) |
| Openness | 0.003 | -0.003 | 0.004 | 0.003 |
| | (0.011) | (0.011) | (0.010) | (0.010) |
| Financial Openness | -7.553*** | -6.553*** | -2.819** | -3.126** |
| | (1.735) | (1.770) | (1.309) | (1.545) |
| Fiscal balance | -0.019** | -0.020*** | 0.024** | 0.026*** |
| | (0.008) | (0.008) | (0.009) | (0.009) |
| Real GDP growth | -0.070 | -0.045 | -0.092 | -0.082 |
| | (0.051) | (0.044) | (0.056) | (0.056) |
| Money growth | | | 0.201*** | 0.204*** |
| | | | (0.030) | (0.029) |
| Lag money growth | | | 0.041* | 0.036 |
| | | | (0.023) | (0.024) |
| N | 437 | 396 | 421 | 387 |
| $R^2$ | 0.28 | 0.29 | 0.56 | 0.55 |
| *Observations **excluding** currency crisis period (t-3 to t+3)* | | | | |
| | (5) | (6) | (7) | (8) |
| | All | Low/Middle* | High* | Low/Middle* |
| Regime 1 / effective | -2.174*** | -3.635*** | -1.810*** | -3.112*** |
| | (0.515) | (0.656) | (0.432) | (0.573) |
| Regime 2 / effective | -0.704 | -1.243** | -0.813* | -1.473*** |
| | (0.496) | (0.623) | (0.429) | (0.525) |
| Regime 3 / effective | -0.093 | -0.374 | -0.175 | -0.602 |
| | (0.458) | (0.574) | (0.385) | (0.486) |
| Openness | -0.003 | -0.005 | -0.002 | -0.004 |
| | (0.003) | (0.005) | (0.002) | (0.004) |
| Financial Openness | -2.452*** | -1.391* | -1.523** | -0.762 |
| | (0.704) | (0.751) | (0.617) | (0.671) |
| Fiscal balance | -0.059** | -0.052* | -0.057*** | -0.058** |
| | (0.023) | (0.030) | (0.021) | (0.029) |
| Real GDP growth | 0.060** | 0.050 | -0.030 | -0.031 |
| | (0.025) | (0.030) | (0.025) | (0.030) |
| Money growth | | | 0.060*** | 0.057*** |
| | | | (0.007) | (0.008) |
| Lag money growth | | | 0.078*** | 0.077*** |
| | | | (0.009) | (0.010) |
| N | 2938 | 1885 | 2714 | 1805 |
| $R^2$ | 0.34 | 0.32 | 0.44 | 0.41 |

* Sample split using the World Bank income groups classification (Atlas method) where "Low/middle" denotes low, low-middle and upper-middle income country groups (time-varying). Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, * $p < 0.01$. Dependent variable is the annual inflation rate if the inflation rate was below 5 percent. Clustered standard errors (at country level) are reported in parentheses. All specifications include a constant term and region-specific and year effects.

Table 3.15: Observations with below 5 percent per year inflation: *total* and *direct* effects using both IRR and IMF de-jure based *effective* classifications

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | *Total effect* | | *Direct effect* | |
| **IRR de-facto classification** | All | Low/Middle* | All | Low/Middle* |
| Regime 1 / effective | -0.533** | -0.766*** | -0.588*** | -0.787** |
| | (0.206) | (0.285) | (0.217) | (0.303) |
| Regime 2 / effective | -0.087 | -0.241 | -0.156 | -0.304 |
| | (0.194) | (0.289) | (0.202) | (0.301) |
| Regime 3 / effective | 0.027 | 0.288 | 0.004 | 0.248 |
| | (0.167) | (0.265) | (0.175) | (0.278) |
| Openness | -0.001 | 0.001 | -0.001 | 0.000 |
| | (0.001) | (0.002) | (0.001) | (0.002) |
| Financial Openness | -0.377 | 0.270 | -0.243 | 0.296 |
| | (0.257) | (0.304) | (0.262) | (0.291) |
| Fiscal balance | -0.013 | -0.030** | -0.016 | -0.034*** |
| | (0.013) | (0.012) | (0.014) | (0.013) |
| Real GDP growth | 0.016 | 0.017* | 0.007 | 0.012 |
| | (0.010) | (0.009) | (0.011) | (0.009) |
| Money growth | | | 0.010** | 0.010* |
| | | | (0.004) | (0.006) |
| Lag money growth | | | 0.010 | 0.005 |
| | | | (0.006) | (0.007) |
| N | 1956 | 1050 | 1810 | 1013 |
| $R^2$ | 0.20 | 0.21 | 0.21 | 0.21 |
| | (5) | (6) | (7) | (8) |
| | *Total effect* | | *Direct effect* | |
| **IMF de-jure classification** | All | Low/Middle* | All | Low/Middle* |
| De-jure Regime 1 / effective | -0.655*** | -0.792*** | -0.631*** | -0.742*** |
| | (0.219) | (0.258) | (0.216) | (0.268) |
| De-jure Regime 2 / effective | -0.842*** | -1.177*** | -0.855*** | -1.189*** |
| | (0.202) | (0.247) | (0.204) | (0.263) |
| De-jure Regime 3 / effective | -0.310* | -0.579** | -0.274 | -0.496* |
| | (0.184) | (0.245) | (0.193) | (0.252) |
| Openness | -0.000 | 0.001 | -0.000 | 0.000 |
| | (0.001) | (0.003) | (0.001) | (0.003) |
| Financial Openness | -0.020 | 0.302 | 0.077 | 0.285 |
| | (0.254) | (0.290) | (0.252) | (0.279) |
| Fiscal balance | -0.034*** | -0.040*** | -0.035*** | -0.044*** |
| | (0.011) | (0.013) | (0.011) | (0.014) |
| Real GDP growth | -0.002 | -0.002 | -0.022 | -0.018 |
| | (0.023) | (0.028) | (0.022) | (0.027) |
| Money growth | | | 0.007 | 0.006 |
| | | | (0.005) | (0.006) |
| Lag money growth | | | 0.010** | 0.010 |
| | | | (0.005) | (0.006) |
| N | 1460 | 835 | 1399 | 806 |
| $R^2$ | 0.23 | 0.20 | 0.23 | 0.21 |

* Sample split using the World Bank income groups classification (Atlas method) where "Low/middle" denotes low, low-middle and upper-middle income country groups (time-varying). Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, * $p < 0.01$. Dependent variable is the annual inflation rate if the inflation rate was below 5 percent. Clustered standard errors (at country level) are reported in parentheses. All specifications include a constant term and region-specific and year effects.

TABLE 3.16: Observations for countries with capital inflows of more than 2.5 percent of GDP and current account balance above 2 percent of GDP: *total* and *direct* effects using IRR-based *effective* classification

| | *Capital inflows of more than 2.5% of GDP* | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | All | Low/Middle* | All | Low/Middle* |
| Regime 1 / effective | -3.244*** | -4.352*** | -2.695*** | -3.749*** |
| | (0.926) | (1.038) | (0.599) | (0.673) |
| Regime 2 / effective | -1.162 | -1.835** | -0.931* | -1.597*** |
| | (0.734) | (0.811) | (0.552) | (0.604) |
| Regime 3 / effective | -0.957 | -1.387* | -1.071** | -1.517** |
| | (0.670) | (0.751) | (0.529) | (0.607) |
| Openness | -0.006 | -0.004 | -0.002 | 0.002 |
| | (0.005) | (0.006) | (0.003) | (0.004) |
| Financial Openness | -3.269*** | -2.567*** | -1.592** | -1.168** |
| | (0.883) | (0.833) | (0.611) | (0.587) |
| Fiscal balance | -0.096*** | -0.063 | -0.040 | -0.005 |
| | (0.031) | (0.039) | (0.030) | (0.032) |
| Real GDP growth | 0.000 | -0.033 | -0.161*** | -0.171*** |
| | (0.038) | (0.048) | (0.035) | (0.038) |
| Money growth | | | 0.138*** | 0.139*** |
| | | | (0.036) | (0.037) |
| Lag money growth | | | 0.089*** | 0.088*** |
| | | | (0.016) | (0.017) |
| N | 1450 | 1176 | 1354 | 1103 |
| $R^2$ | 0.28 | 0.28 | 0.53 | 0.54 |
| | *Current account balance of more than 2% of GDP* | | | |
| | (5) | (6) | (7) | (8) |
| | All | Low/Middle* | All | Low/Middle* |
| Regime 1 / effective | -1.404 | -3.986** | -0.395 | -1.714 |
| | (0.951) | (1.693) | (0.922) | (1.496) |
| Regime 2 / effective | -0.777 | -0.784 | -0.895 | -1.055 |
| | (0.863) | (1.300) | (0.746) | (1.137) |
| Regime 3 / effective | -0.768 | -0.316 | -0.560 | -0.417 |
| | (0.679) | (1.065) | (0.561) | (0.936) |
| Openness | 0.001 | -0.016 | -0.003 | -0.017** |
| | (0.005) | (0.011) | (0.004) | (0.008) |
| Financial Openness | -4.564*** | -2.460 | -1.769* | -0.792 |
| | (1.723) | (1.859) | (0.939) | (1.410) |
| Fiscal balance | -0.025 | -0.045 | -0.039 | -0.073 |
| | (0.032) | (0.066) | (0.034) | (0.054) |
| Real GDP growth | -0.010 | 0.025 | -0.048 | -0.005 |
| | (0.035) | (0.051) | (0.032) | (0.038) |
| Money growth | | | 0.154*** | 0.171*** |
| | | | (0.040) | (0.037) |
| Lag money growth | | | 0.050* | 0.034 |
| | | | (0.026) | (0.031) |
| N | 908 | 443 | 820 | 438 |
| $R^2$ | 0.25 | 0.22 | 0.48 | 0.46 |

* Sample split using the World Bank income groups classification (Atlas method) where "Low/middle" denotes low, low-middle and upper-middle income country groups (time-varying). Robust standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, * $p < 0.01$. Dependent variable is the annual inflation rate if the inflation rate was below 5 percent. Clustered standard errors (at country level) are reported in parentheses. All specifications include a constant term and region-specific and year effects.

# Final Discussion

This thesis aimed to contribute to the understanding of two underlying questions that are of utmost importance for the economic profession. First, how much market freedom is required for markets to function well? Second, what are the most suitable ways to correctly measure economic variables for precise economic analysis? This thesis described free markets using an analogy of the rocking chair. Roth (2016) suggests that it might be more appropriate to see a free market as a wheel that can rotate freely because it has an axle and well-oiled bearings. That is, all markets need effective rules in order to work freely. Indeed, we saw that this is the case for the international monetary system where the lack of effective rules and international cooperation repeatedly led to a failure of the system.

Also, we should consider that each market is different, and our task should be akin to engineers learning about how to build bridges by studying those that collapse (Roth, 2016). The same impulses can make some well-designed markets succeed and other poorly designed fail. Indeed, as engineers learned by studying bridges that collapsed, countries had to learn from the disastrous incidences where exchange rate regimes failed and needed to develop tools to make the arrangements more robust for the future. The goal of this thesis was to provide better understanding of consequences of exchange rate regimes that might help policymakers to better understand the options they have, as well as to make the design of exchange rate arrangements more robust.

To reliably judge the consequences of exchange rate regime's choice, economic analysis relies crucially on the availability of high-quality data. There have been many market designs that determined the rules governing international financial markets. The design ranged from a highly coordinated international monetary system seen during the Bretton Woods System to a highly disaggregated system where every country chose its own exchange rate regime following the collapse of Bretton Woods. This thesis argued that due to the heterogeneity of the current multilateral world, appropriate measurement is crucial to learn about the consequences of an exchange rate regime choice. We hope that this thesis provided new insights into understanding the importance of correctly measuring exchange rate arrangements.

To achieve this goal, this thesis introduced three broad classifications approaches and applied those classifications to analyse three economic variables. Chapter 1 used the newly developed dataset on *bilateral de-jure exchange rate regimes* to investigate the claim that the expected stability of the nominal exchange rate is an important determinant of foreign direct investment. We found that country pairs with no separate legal tender receive significantly more FDI inflows from each other. In addition, the effect of the remaining exchange rate regimes differed between country groups. The effect of a fixed exchange rate was found to be either positive or not significantly different from zero, with the size of estimated coefficients confirming the notion that a growing extent of flexibility reduces FDI inflows to these economies.

Further, the new dataset on bilateral *de-facto* exchange rate regimes used in chapter 2 allowed us to show that exchange rate regimes play a significant role as a determinant of business cycles synchronisation between countries. We found that currency unions increase the co-movement of business cycles. We also found that the country pairs with other less flexible regimes have more synchronised business cycles. The effect was found to be positive and significant for both currency boards as well as de-facto pegs.

Chapter 3 introduced a new measure of *effective* exchange rate regimes to take into account the relationship of each country against all countries across the world. We found that fixed exchange rate regimes reduce inflation more than suggested by traditional *unilateral* classifications. In particular, not only hard pegs but also narrow and wide soft pegs were associated with significantly lower inflation rates when comparing to the free-floating regimes. Finally, as a complement to these findings we made the new dataset freely available online to be used by the research community as a basis for future research.

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## AUSBILDUNG

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### Projektmanager Datenmanagement
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**KPMG AG Wirtschaftsprüfungsgesellschaft**
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- Unterstützung des Erasmus-Koordinators, Beratung der ausländischen Studierenden
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### Kreditorenbuchhalter im Bereich Purchase to Pay

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## PUBLIKATIONEN

### Arbeitspapiere

- [redacted] und Jakub Knaze (2019): *„The Effect of Exchange Rate Regimes on Business Cycle Synchronization: A Robust Analysis“*. MPRA Paper 95182.
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### Arbeiten in Vorbereitung

- Knaze, Jakub (im Erscheinen): *„Effective Exchange Rate Regimes and Inflation“*.

## LEHRE

Übungen: International Trade | International Macroeconomics | Exchange Rates and International Capital Markets | Betreuung: Bachelor-Seminare | Bachelorarbeiten | Master-Seminare