Fixed Currency Regimes and the Time Pattern of Trade Effects

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Abstract: This paper assesses duration-specific treatment effects of fixed currency regimes on bilateral trade along a duration path of up to 25 years. We find that country-pairs with fixed exchange rate regimes trade more, but only after about 8 years.

Keywords: Curreny unions; Bilateral trade; Treatment effects; Stratified matching
JEL classification: C14; C22; F14; F31; F33

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1 Introduction

Studies on the impact of currency regimes on trade tend to assume that effects materialize immediately and stay constant afterwards (see, e.g., Rose, 2000; Persson, 2001; Glick and Rose, 2002; De Sousa, 2012). This paper parts with this assumption and estimates the impact of currency tying on trade along the regime duration path for 25 years of post-Bretton Woods data between 1974 and 2004. We find that, *on average*, bilateral trade responds in a significantly positive way to currency tying, but only after at least 8 years.

These results are obtained by stratified matching, eliminating observable differences between treated and untreated country-pairs. Trade effects are identified without strong func-

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tional form assumptions about selection on observables while ensuring a high degree of comparability of matched units.

2 Econometric model

We focus on the *average treatment effect on the treated* (ATT) of a fixed currency regime on bilateral trade as a function of regime duration. To control for the bias associated with non-random *entry into* and *durations of* such regimes, we account for *selection on observables* through matching on the propensity score (see Persson, 2001; Dorn and Egger, 2012).

Denote the years elapsed since adoption of a currency regime – *fixed or not* – by D. Define the indicator F_{ijtD} which is unity (zero) if country-pair ij is observed with (without) a fixed currency regime for at least D subsequent periods at time $t \in \{1973 + D, ..., 2004\}$. Define *treatment* and *counterfactual* changes in bilateral trade between the period prior to entering a regime and its duration of D as $\Delta Y^1_{ijtD} = Y^1_{ijtD} - Y^1_{ijt0}$ and $\Delta Y^0_{ijtD} = Y^0_{ijtD} - Y^0_{ijt0}$, respectively. Denote the set of observables relevant for predicting selection and outcomes at duration D in year t as $\underline{\boldsymbol{X}}_{ijtD} = (\Delta\tilde{\boldsymbol{X}}_{ij(t-1)(D-1)}, \tilde{\boldsymbol{X}}_{ij(t-1)(D-1)}, \boldsymbol{X}^*_{ij}, \boldsymbol{\lambda}_D)$, where $\tilde{\boldsymbol{X}}_{ij(t-1)(D-1)}$ is a vector of time-variant observables measured at $t-1$, $\Delta\tilde{\boldsymbol{X}}_{ij(t-1)(D-1)} = \tilde{\boldsymbol{X}}_{ij(t-1)(D-1)} - \tilde{\boldsymbol{X}}_{ij(t-D-1)0}$ are changes in observables since a state persists, $\boldsymbol{X}^*_{ij}$ is a vector of time-invariant observables, and $\boldsymbol{\lambda}_D$ is a $(31 - D)$ row vector of zeros except for a one in the column associated with t, the corresponding parameter on which captures all common macroeconomic shocks at t. Clearly, $\Delta\tilde{\boldsymbol{X}}_{ij(t-1)0} = 0$ and $\underline{\boldsymbol{X}}_{ijt1} = (\tilde{\boldsymbol{X}}_{ij(t-1)0}, \boldsymbol{X}^*_{ij}, \boldsymbol{\lambda}_D)$.

The ATT of fixed currency regime duration D on bilateral trade, $ATT(D)$, is defined as the expected difference in potential outcomes after duration D relative to control country-pairs that did not fix currencies for the same duration. For estimating $ATT(D)$, we invoke conditional (mean) independence with regard to the elements in $\underline{\boldsymbol{X}}_{ijtD}$ so that

$$ATT(D) = \mathbb{E}\big[\mathbb{E}(\Delta Y^1_{ijtD} - \Delta Y^0_{ijtD} | \underline{\boldsymbol{X}}_{ijtD}, F_{ijtD} = 1)\big] \quad \forall D, \tag{1}$$

where the outer expectation is with respect to the range of observables.[1] When invoking an additional balancing condition on $\underline{\boldsymbol{X}}_{ijtD}$, the propensity score function $\pi(\cdot)$ is a scalar-valued metric of similarity with respect to each element of $\underline{\boldsymbol{X}}_{ijtD}$ in (1).

To estimate $ATT(D)$ we employ *stratified matching on the propensity score*. Compared to *gravity equations* which are often modeled as linear in fixed exchange rate regime indicators and other variables (see Rose, 2000, 2001; Glick and Rose, 2002; De Sousa, 2012), stratified

[1] A more demanding alternative to that would be invoking conditional (mean) independence with regard to the sequence $(\tilde{\boldsymbol{X}}_{ij(t-1)(D-1)}, \tilde{\boldsymbol{X}}_{ij(t-2)(D-2)}, \ldots, \tilde{\boldsymbol{X}}_{ij(t-D-1)0})$.

matching relaxes strong functional form assumptions concerning the control function about $\underline{\boldsymbol{X}}_{ijtD}$. Moreover, matching applies a tight support condition about country-pairs used to identify the unobserved part of the inner expectation in expression (1), required to establish that $\mathbb{E}(\Delta Y^0_{ijtD}|\underline{\boldsymbol{X}}_{ijtD}, F_{ijtD}=0) = \mathbb{E}(\Delta Y^0_{ijtD}|\underline{\boldsymbol{X}}_{ijtD}, F_{ijtD}=1)$.

For this, we employ a data-driven partitioning algorithm suggested in Dorn (2012). Let $\mathcal{N}_D$ and N_D denote the set and the number of observations at duration D, respectively, and let $\mathcal{X}_D = \{\underline{\boldsymbol{X}}_{ijtD}\}_{ijt\in\mathcal{N}_D}$ denote the associated set of observed values for the regressors. Then, $\hat{\mathcal{N}}_D \subseteq \mathcal{N}_D$, $\hat{N}_D$, and $\hat{R}_D$ are the subset of observations satisfying the support condition, the corresponding number of observations, and the estimated number of strata required to balance the marginal regressor distributions, respectively. Hence, we estimate $ATT(D)$ by

$$\widehat{ATT}(D) = \sum_{r=1}^{\hat{R}_D} \frac{\sum_{ijt\in\mathcal{N}_D^1} \mathbf{1}[\underline{\boldsymbol{X}}_{ijtD} \in \hat{\mathcal{X}}_{rD}]}{\sum_{r=1}^{\hat{R}_D}\sum_{ijt\in\mathcal{N}_D^1} \mathbf{1}[\underline{\boldsymbol{X}}_{ijtD} \in \hat{\mathcal{X}}_{rD}]} \left(\frac{\sum_{ijt\in\mathcal{N}_D^1} \mathbf{1}[\underline{\boldsymbol{X}}_{ijtD} \in \hat{\mathcal{X}}_{rD}]\Delta Y^1_{ijtD}}{\sum_{ijt\in\mathcal{N}_D^1} \mathbf{1}[\underline{\boldsymbol{X}}_{ijtD} \in \hat{\mathcal{X}}_{rD}]} - \frac{\sum_{klt\in\mathcal{N}_D^0} \mathbf{1}[\underline{\boldsymbol{X}}_{kltD} \in \hat{\mathcal{X}}_{rD}]\Delta Y^0_{kltD}}{\sum_{klt\in\mathcal{N}_D^0} \mathbf{1}[\underline{\boldsymbol{X}}_{kltD} \in \hat{\mathcal{X}}_{rD}]} \right), \quad (2)$$

where for treated ijt and controls klt, $\underline{\boldsymbol{X}}_{ijtD} \in \hat{\mathcal{X}}_{rD}$ and $\underline{\boldsymbol{X}}_{kltD} \in \hat{\mathcal{X}}_{rD}$ represent the additional support condition for comparability of country-pairs, and $\mathcal{N}_D^1$ and $\mathcal{N}_D^0$ are the subsets of treated and untreated units at D, respectively. The partitions $\hat{\mathcal{X}}_{1D}, \ldots, \hat{\mathcal{X}}_{\hat{R}_D D}$ are estimated sub-populations of $\mathcal{X}_D$, each of them associated with a unique stratum on the (open) unit interval for the propensity score.

3 Empirical analysis

3.1 Data and specification

We use unbalanced panel data on 10,091 country-pairs for the years 1974-2004 and consider fixed and non-fixed regime durations of up to 25 years. We define (de facto) fixed exchange rate regimes using the classification of Klein and Shambaugh (2008). Two countries' currencies are considered as mutually fixed, if both have the same anchor or if one trading partner's legal tender is the other country's anchor currency.

Outcome ΔY_{ijtD} is the log change in bilateral trade from 0 to D for pair ij in t, using data on exports and imports from the Direction of Trade Statistics (International Monetary Fund). $ATT(D)$ is a function of $\underline{\boldsymbol{X}}_{ijtD}$. The subvectors $(\tilde{\boldsymbol{X}}_{ij(t-1)(D-1)}, \Delta\tilde{\boldsymbol{X}}_{ij(t-1)(D-1)})$ are based on the following five time-varying regressors: the log of the sum of two countries' nominal GDPs (*bilateral market size*); *similarity* of two countries' current GDP (the former and the

latter variable are based on data from the Centre d'Études Prospectives et d'Informations Internationales' Gravity Dataset);[2] *relative factor endowment differences* proxied by the absolute value of log real per capita income differences (World Development Indicators, World Bank); and two distinct measures of *economic volatility*, namely the absolute difference of the coefficients of variation for real GDP per capita in i and j measured over three years and for inflation in i and j measured over the same three years (World Development Indicators, World Bank).[3] $\boldsymbol{X}_{ij}^{*}$ contains measures of *geography* and *common culture* (log bilateral distance, binary contiguity, binary colonial relationship, binary common official or primary language; the data are from the Geography Database of the Centre d'Études Prospectives et d'Informations Internationales).

3.2 Estimation results

Table 1 with Columns (I)-(X) summarizes estimated ATTs and some other sample characteristics. Column (I) refers to specific levels of duration D. Columns (II) and (III) report numbers of all and fixed currency regime observations per D.[4] Column (IV) provides D-specific OLS estimates of $ATT(D)$ invoking conditional mean independence parametrically and utilizing *all* observations N_D per D. These estimates stem from regressions of the form $\Delta\hat{Y}_{ijtD} = \widehat{ATT}(D)_{OLS} \cdot F_{ijtD} + \underline{\boldsymbol{X}}_{ijtD}\hat{\boldsymbol{\beta}}_D$, pooling all $N_D = N_D^1 + N_D^0$ treated and untreated observations for duration D. $\underline{\boldsymbol{X}}_{ijtD}$ is based on the specification in Section 2 and the variables described in Section 3.1. The (potentially biased) $\widehat{ATT}(D)_{OLS}$ suggest that, *on average*, fixed currency regimes do not affect trade significantly.

The remaining columns are based on matching. For this, we employ $\underline{\boldsymbol{X}}_{ijtD}$ in D-specific logit models to estimate the probability of having a fixed versus non-fixed currency regime for D subsequent periods. Jointly, the $\underline{\boldsymbol{X}}_{ijtD}$ are highly relevant as expected for selection on observables to be plausible. Across all D, we obtain pseudo-R^2 values in the interval $[0.43; 0.82]$ and maximum attainable Matthew's correlation coefficients[5] in the interval

[2] This is constructed as $\log\{1-[GDP_{i(t-1)}^{current}/(GDP_{i(t-1)}^{current}+GDP_{j(t-1)}^{current})]^2-[GDP_{j(t-1)}^{current}/(GDP_{i(t-1)}^{current}+GDP_{j(t-1)}^{current})]^2\}$.

[3] Both measures are constructed from the estimated residuals for the years $t-1$ to $t-3$ from fixed effects regressions of the variables (real GDP per capita or inflation) on their first and second lags including country- and time-specific fixed effects. Observe that dynamic fixed effects regressions with 30 years of data lead to virtually unbiased estimates of parameters and residuals. The residuals reflect shocks and the coefficients of variation based on them reflect average sizes of shocks on economies for the previous three years.

[4] A country-pair may adopt a fixed regime, abandon it, adopt it again, and, hence, may surface several times (though in different years t) for a given duration, as in competing risk models.

[5] Matthew's correlation coefficient measures the quality of a binary choice model with regard to numbers of true unitary and true zero versus false unitary and false zero predictions. As binary classifications are a function of the unobserved cutoff probability for the propensity score, the maximum attainable Matthew's correlation coefficient corresponds to the coefficient-maximizing choice for the cutoff probability.

[0.69; 0.95], indicating suitability of the regressors to explain treatment participation.

For the r^{th} stratum of the estimated $\pi(\cdot)$ for duration D, balancing must be satisfied for all observables. For this, the p-values of all underlying Kolomogorov-Smirnov tests for the stratum must be strictly greater than a pre-specified type I error $\alpha \in \{0.1, 0.15\}$, so that the type II error (of a potentially false comparison) is sufficiently small. Different levels of α lead to different stratifications.

Each of the three-column blocs (V)-(VII) and (VIII)-(X) contains the same type of information: $\widehat{ATT}(D)$ as an aggregate treatment effect across all estimated strata for D; the percentage of observations N_D which passes the balancing tests and is used for estimation, $\hat{N}_D\%$; and the estimated number of distinct balancing strata per D, $\hat{R}_D$.

For both levels of α, the results suggest a significantly positive $ATT(D)$ on trade after 8, 11, 14, 17, 19, and 21 years in a fixed currency regime. Estimates based on $\alpha = 0.15$ provide for more stringent stratification and balancing on average and suggest that after 8 years in a fixed currency regime, the cumulative effect on bilateral trade amounts to about $100(\exp(0.32) - 1) \approx 37\%$ (roughly $100(1.37^{1/8} - 1) \approx 4.6\%$ per annum) relative to the level of trade prior to entering the regime. After 21 years, that cumulative effect amounts to $100(\exp(1.25) - 1) \approx 250\%$ ($100(2.25^{1/21} - 1) \approx 5.8\%$ per annum). Finally, after 24 years the treatment effect on the treated is estimated to have declined to $100(1.96^{1/24} - 1) \approx 2.8\%$ per annum. These results suggest that the effect of fixed currency regimes on trade does not materialize immediately[6] but only after several periods, it increases between 8 and 21 years, and potentially fades out in the very long run.

Our identification strategy allows for further disaggregation of strata-averaged estimates $\widehat{ATT}(D)$ underlying Column (VIII) in Table 1 into $\widehat{ATT}(\pi, D)$ which is specific to D and strata-specific propensity scores. This is illustrated in Figure 1 which contains two bits of information: point estimates $\widehat{ATT}(\pi, D)$ represented by dots as underlying the averages in Column (VIII) of Table 1;[7] and a smooth estimate of $\widehat{ATT}(\pi, D)$ as a function of D and π, which permits extrapolation of the relationship in $\pi - D$-space. In the figure, significantly negative ATTs are highly likely in the short run, but in the long run significantly positive effects become increasingly likely. This is also indicated by the bold contour line at the bottom of Figure 1 separating all positive and negative effects $\widehat{ATT}(\pi, D)$ within $\pi - D$-space.

[6]This is consistent with the evidence on the lack of positive treatment effects of currency unions in the short run when considering heterogeneous treatment effects on trade in Dorn and Egger (2012).

[7]There, red (blue) color indicates that $\widehat{ATT}(\pi, D) > 0$ ($\widehat{ATT}(\pi, D) \leq 0$), and dark (light) color indicates statistical significance (insignificance).

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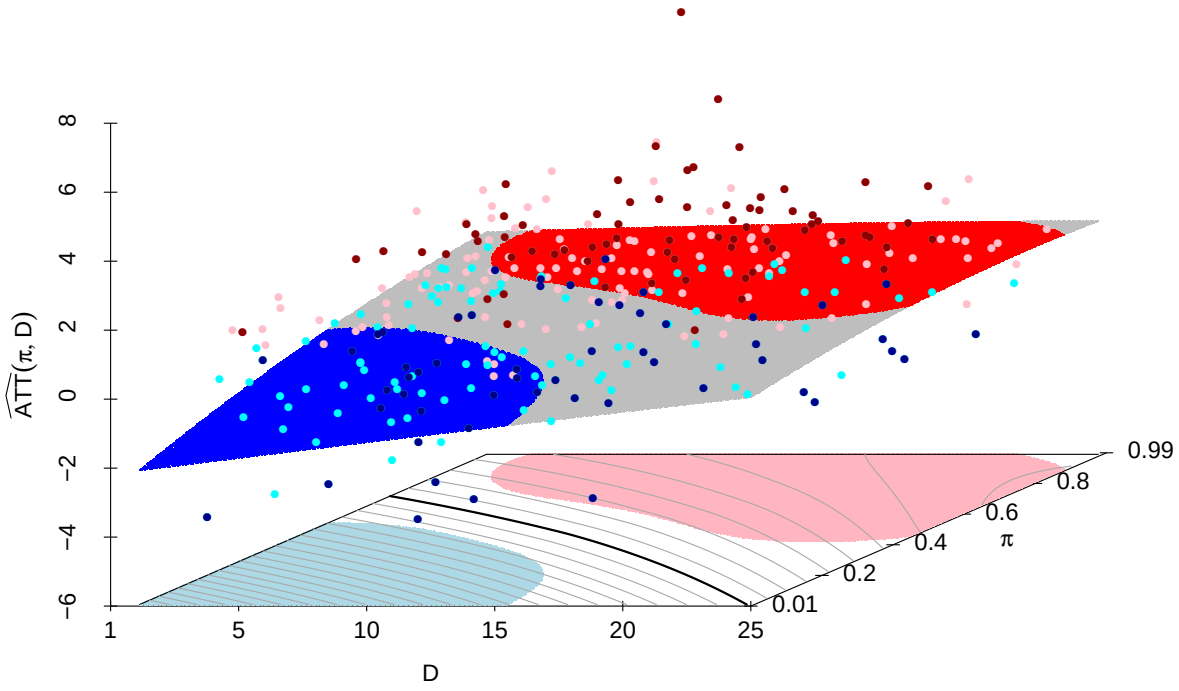
Table 1: The effect of fixed currency regime durations (D) on bilateral trade

(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)
				Stratified matching					
D	N_D		OLS	$\alpha = 0.1$			$\alpha = 0.15$		
	All	Fixes	$\widehat{ATT}(D)$	$\widehat{ATT}(D)$	$\hat{N}_D\%$	$\hat{R}_D$	$\widehat{ATT}(D)$	$\hat{N}_D\%$	$\hat{R}_D$
1	665	447	−0.03	0.04	40.0 %	26	−0.06	26.2 %	24
			(0.10)	(0.08)			(0.14)		
2	533	350	0.05	0.07	25.5 %	24	−0.33**	15.3 %	16
			(0.15)	(0.15)			(0.14)		
3	529	345	0.09	0.23	20.0 %	20	0.04	14.4 %	18
			(0.13)	(0.15)			(0.17)		
4	557	350	−0.20	−0.06	37.7 %	21	0.00	22.2 %	21
			(0.13)	(0.13)			(0.17)		
5	459	271	−0.15	0.31	28.6 %	19	0.15	19.1 %	22
			(0.16)	(0.20)			(0.19)		
6	460	273	0.10	−0.27	19.6 %	18	0.03	11.2 %	12
			(0.19)	(0.26)			(0.24)		
7	450	269	0.03	0.03	27.2 %	21	0.51**	10.1 %	12
			(0.18)	(0.19)			(0.21)		
8	536	342	0.13	0.43***	26.1 %	17	0.32*	14.6 %	15
			(0.17)	(0.16)			(0.17)		
9	542	347	0.17	0.11	32.1 %	22	0.15	18.2 %	15
			(0.21)	(0.18)			(0.28)		
10	546	352	0.14	0.25	29.9 %	20	−0.24	11.2 %	14
			(0.21)	(0.17)			(0.26)		
11	471	280	0.07	0.68***	25.1 %	21	0.77**	11.6 %	15
			(0.20)	(0.17)			(0.32)		
12	472	280	−0.06	0.27	29.4 %	16	−0.04	15.8 %	18
			(0.20)	(0.18)			(0.18)		
13	474	286	−0.04	0.27	60.0 %	20	0.17	19.2 %	19
			(0.19)	(0.38)			(0.20)		
14	420	259	−0.01	0.32*	21.9 %	17	0.61***	19.4 %	19
			(0.21)	(0.17)			(0.19)		
15	421	257	−0.01	0.55**	27.5 %	14	0.15	18.3 %	16
			(0.24)	(0.26)			(0.22)		
16	282	191	−0.22	0.65***	18.8 %	8	0.06	9.4 %	6
			(0.29)	(0.16)			(0.29)		
17	284	190	−0.06	0.66**	65.1 %	7	0.64**	62.7 %	6
			(0.26)	(0.28)			(0.29)		
18	252	157	−0.05	0.07	5.4 %	3	0.06	4.0 %	3
			(0.32)	(0.15)			(0.12)		
19	258	163	0.01	0.63***	12.3 %	8	0.60***	9.1 %	7
			(0.30)	(0.18)			(0.11)		
20	259	151	−0.17	0.16	28.6 %	11	0.43*	24.0 %	11
			(0.23)	(0.17)			(0.23)		
21	263	153	−0.30	0.66***	51.9 %	7	1.25***	10.9 %	6
			(0.24)	(0.21)			(0.31)		
22	265	155	−0.17	0.21	27.8 %	7	0.75**	16.0 %	7
			(0.28)	(0.28)			(0.31)		
23	265	155	−0.14	0.67	25.5 %	8	0.40	16.8 %	6
			(0.28)	(0.42)			(0.65)		
24	266	156	0.15	0.33	67.0 %	9	0.96**	9.4 %	5
			(0.23)	(0.44)			(0.41)		
25	162	129	−0.02	0.16	18.3 %	3	0.62	22.0 %	4
			(0.37)	(0.38)			(0.45)		

1. ***, **, and * indicate significance at 1%, 5%, and 10%, respectively. Bootstrapped standard errors are reported in parentheses. D refers to duration, N_D to the number of observations, $\hat{N}_D\%$ is the percentage of observations used for matching and $\hat{R}_D$ the number of strata. $\widehat{ATT}(D)$ are estimated average treatment effects of the treated (by OLS or stratified matching).
2. α refers to the cutoff probability for the Kolmogorov-Smirnov tests to establish equivalence among the marginal regressor distributions within strata.
3. Each estimator (OLS and matching) controls for the observables in $\underline{\boldsymbol{X}}_{ijtD}$ defined in the text in a more or less restrictive way.

Figure 1: The effect of fixed currency regime durations on bilateral trade in $\pi - D$-space



1. Points are stratum-specific point estimates underlying the averages in Column (VIII) of Table 1. Red (blue) color indicates a positive effect (negative effect). Dark (light) points indicate statistical significance (insignificance) at least at 10%.
2. The surface is based on local quadratic regression (with optimum bandwidth estimated by generalized cross-validation). The red (blue) area indicates estimates bounded above (below) zero by a 95% (point-wise) confidence interval.
3. The bold black contour line indicates the zero-effect divide in $\pi - D$-space. The shaded areas indicate significant estimates as projected into $\pi - D$-space.