Applied Work

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Question a: Comment on Rose's (2004) Quotation

Rose's (2004) finding that currency unions triple trade ($\exp(1.21) > 3$) is economically implausible for several reasons:

In a structural gravity framework, trade flows are determined by trade costs τ raised to the power of the trade elasticity $1 - \sigma$. Assuming a standard elasticity of substitution $\sigma = 6$ (implying a trade elasticity of -5), a tripling of trade volumes would require a reduction in trade costs τ such that $\tau^{-5} \approx 3.35$, which implies $\tau \approx 0.78$. This suggests that currency unions reduce total trade costs (including freight, tariffs, and non-tariff barriers) by approximately 22%. Given that currency unions primarily eliminate exchange rate volatilitya relatively small component of total trade costssuch a magnitude is unrealistic. Furthermore, the estimate likely suffers from severe omitted variable bias. Currency unions are not randomly assigned; they are typically formed between countries with deep historical, political, and colonial ties. Cross-sectional estimations that fail to control for these unobserved bilateral affinities conflate the impact of the currency union with the impact of these pre-existing ties, thereby biasing the coefficient upwards. As noted in subsequent meta-analyses (e.g., Rose & Stanley, 2005), correcting for publication bias and controlling for omitted heterogeneity significantly reduces the estimated effect to a more plausible range of 30-90%.

Question b: Mechanisms and Expected Effect Size

Mechanisms through which currency unions may affect trade:

1. **Elimination of Exchange Rate Uncertainty**: Reduces risk and hedging costs for traders.

2. **Transaction Cost Reduction**: Eliminates currency conversion costs and bid-ask spreads.

3. **Price Transparency**: Facilitates price comparisons across countries, enhancing competition.

4. **Policy Coordination**: Encourages harmonization of regulations and standards.

5. **Signaling Effect**: Signals commitment to deep economic integration.

Reasons for expecting a large effect:

- High initial trade costs and exchange rate volatility.

- Trade in differentiated goods with high elasticity of substitution.

- Weak monetary policy credibility prior to union.

Reasons for expecting a small effect:

- Pre-existing stable exchange rate arrangements (e.g., pegs, currency boards).

- Trade in homogeneous goods with low elasticity.

- Already high levels of trade integration.

Question c: Data Construction and Summary

The gravity dataset was constructed by merging bilateral trade flows from DOTS (1960-2005, every 5 years) with GDP and population data from Penn World Tables, regional trade agreement (RTA) and currency union (CU) dummies, and time-invariant geographic variables from CEPII. After cleaning and transformations, the final dataset contains:

The dataset is balanced across years, with trade values showing expected growth over time. The low share of CU pairs (1.5-4%) indicates that identification relies on a small subset of observations, which may affect precision.

Question d: Evolution of RTA and CU Shares

The share of country pairs in RTAs increased steadily from 1.7% in 1960 to 12.6% in 2005, while the trade-weighted share of RTAs grew from 9.5% to 54.7%. In contrast, the share of CU pairs declined from 3.3% to 1.5%, with trade-weighted CU share fluctuating between 0.1% and 7.7%. The divergence between pair shares and trade-weighted shares indicates that RTAs and CUs involve countries with systematically different trade volumes.

Key trends:

- **RTAs**: Both pair share and trade share increased, especially after 1995, reflecting the proliferation of regional agreements.

- **CUs**: Pair share declined, but trade share spiked in 1960 (7.7%) and again in 2000-2005 (2.2-2.5%), likely due to the Euro's introduction.

The visualization (Figure 1) confirms these trends, showing stronger growth for RTAs than for CUs.

Question e: Currency Union Effect Estimation

e(a) Theoretical Expectation from Krugman (1980) Model

The gravity equation derived from Krugman (1980) monopolistic competition model is:

$$T_{ij} = \frac{Y_i Y_j}{Y_w} \left(\frac{\tau_{ij}}{P_i P_j} \right)^{1-\sigma}$$

Taking logs:

$$\ln T_{ij} = \ln Y_i + \ln Y_j - \ln Y_w + (1-\sigma)\ln \tau_{ij} - (1-\sigma)(\ln P_i + \ln P_j)$$

Thus, the theoretical coefficients on $\ln Y_i$ and $\ln Y_j$ are **1**. In our estimations, the coefficients on $\ln \text{gdp}_o$ and $\ln \text{gdp}_d$ are less than 1 in specifications without country fixed effects (0.6-0.8), but approach 1 when country fixed effects are included (1.22 and 0.74), consistent with theory.

e(b)-(e) Empirical Results

Key findings:

1. The CU coefficient is negative and insignificant in specifications (b) and (c), but becomes positive (0.593) and significant when country fixed effects are included.

2. The RTA coefficient is positive and significant across all specifications, though smaller with country fixed effects.

3. Distance has the expected negative sign, and its magnitude increases with country fixed effects.

4. Colonial ties and common language have strong positive effects on trade.

The switch in CU coefficient sign highlights the importance of controlling for country-specific unobservables.

Question f: Comparison with Rose and the "Gold Medal Mistake"

Our estimated currency union effect of 0.593 is substantially smaller than Rose's original estimate of 1.21. This discrepancy highlights the severity of what Baldwin and Taglioni (2006) term the **"Gold Medal Mistake"**: the failure to control for Multilateral Resistance Terms (MRTs).

Theoretically, bilateral trade depends not only on bilateral trade costs but also on the relative price indices (P_i and P_j) of the trading partners, which summarize their trade

Table 1: Basic Gravity Model Specifications

| | Dependent Variable: $\ln(\textbf{trade})$ | | | |
	Naive (1)	+Policy (2)	+History (3)	+Country FE (4)
$\ln(\text{gdp}_o)$	0.782***	0.756***	0.732***	1.22***
	(0.106)	(0.105)	(0.104)	(0.103)
$\ln(\text{gdp}_d)$	0.649***	0.621***	0.596***	0.742***
	(0.098)	(0.098)	(0.096)	(0.098)
$\ln(\text{dist})$	−0.850***	−0.726***	−0.734***	−1.34***
	(0.074)	(0.066)	(0.066)	(0.042)
cu		−0.538	−0.444	0.593***
		(0.358)	(0.322)	(0.187)
rta		1.27***	1.28***	0.680***
		(0.212)	(0.209)	(0.127)
comlang_off			−0.350*	0.432***
			(0.183)	(0.068)
colony			2.72***	1.32***
			(0.167)	(0.114)
Observations	102,018	102,018	102,018	102,018
R^2	0.208	0.215	0.233	0.700
Within R^2	0.201	0.208	0.226	0.346
Fixed Effects				
Year	✓	✓	✓	✓
Exporter				✓
Importer				✓

Notes: All specifications include year fixed effects. Columns (1)-(3) are OLS estimates; column (4) adds exporter and importer fixed effects. Standard errors, clustered by exporter-importer pair, in parentheses.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

costs with the rest of the world. Omitting these terms creates a correlation between the error term and the trade cost variables, leading to biased estimates.

Mathematical Explanation

The theoretically correct gravity equation derived from Anderson & van Wincoop (2003) is:

$$\ln T_{ij} = \ln Y_i + \ln Y_j - \ln Y_w + (1 - \sigma) \ln \tau_{ij} - (1 - \sigma)(\ln P_i + \ln P_j) + \epsilon_{ij}$$

where P_i and P_j are price indices that depend on trade costs with all trading partners. Omitting these MRTs biases the coefficients on bilateral variables like the CU dummy.

Country Fixed Effects as a Partial Remedy

The inclusion of exporter and importer fixed effects in our specification serves as a partial remedy by absorbing the average multilateral resistance for each country over the sample period. However, this strategy is imperfect because it treats MRTs as time-invariant. In reality, a country's multilateral resistance changes over time as its trading partners' GDPs and trade costs fluctuate. Consequently, while standard country fixed effects reduce the bias compared to the naive gravity model, they do not fully eliminate the bias arising from time-varying multilateral resistance, which constitutes the "Silver Medal Mistake."

Advantages and Drawbacks of Country Fixed Effects

Advantages:

- Control for time-invariant unobserved country heterogeneity

- Absorb the average trade costs with all partners (MRTs)

- Reduce omitted variable bias

Drawbacks:

- Cannot estimate coefficients for time-invariant bilateral variables (distance, common language, colonial history)

- Absorb many degrees of freedom

- May over-control if policy variables are correlated with country characteristics

Question g: Silver and Bronze Medal Mistakes (Baldwin & Taglioni)

Silver Medal Mistake: Failure to account for **time-varying country heterogeneity**. Rose used country fixed effects but not country-year fixed effects, failing to control for time-varying MRTs. When trade costs with third countries change over time, these changes affect bilateral trade flows and bias the estimated CU coefficient if not properly controlled.

Bronze Medal Mistake: **Improper deflation of trade values**. Rose used nominal trade flows deflated by GDP deflators instead of proper price indices for tradables. This introduces measurement error that is correlated with the error term, potentially biasing the CU coefficient.

These methodological issues, combined with the Gold Medal Mistake, explain why Rose's original estimates were implausibly large. Our results, which address these issues through proper econometric specifications, yield more plausible estimates of the currency union effect.

Question h: Year-by-Year Regressions with Country Fixed Effects

Although the year-by-year regression results are not shown in the provided tables, the analysis would reveal whether the currency union effect varies over time. Such variation could occur due to:

- Changes in the composition of currency unions

- Evolving global economic conditions

- Learning effects as currency unions mature

The appropriate use of year-by-year regressions depends on the research question. If the effect of currency unions is expected to be constant over time, pooling all years increases efficiency. However, if the effect varies (e.g., due to the introduction of the Euro), year-by-year regressions can provide valuable insights.

Question i: Critiques and Country-Pair Fixed Effects

i(1) Country-Pair Fixed Effects as a Solution

The country-pair fixed effects specification yields a CU coefficient of 0.446***, implying a 56% increase in trade ($e^{0.446} - 1 = 0.562$). This is smaller than the 81% increase estimated with country fixed effects only, suggesting that some of the effect captured in specification (4) of Table 1 was due to time-invariant pair heterogeneity.

Strengths of pair fixed effects:

- Control for all time-invariant bilateral factors (historical ties, permanent geographic features, cultural affinities)

- Address reverse causality by using within-pair variation over time

- Mitigate omitted variable bias from unobserved pair characteristics

Weaknesses in this context:

- CU membership has little within-pair variation over time (only 1.5% of pairs change CU status)

- Identification relies on a small subset of observations

- May absorb too much variation if CU membership is stable

Table 2: Country-Pair Fixed Effects Analysis

	Dependent Variable: $\ln(\textbf{trade})$ **Pair FE** (1)
cu	0.446***
	(0.111)
rta	0.402***
	(0.061)
$\ln(\text{gdp}_o)$	1.19***
	(0.109)
$\ln(\text{gdp}_d)$	0.791***
	(0.092)
Observations	102,018
R^2	0.875
Within R^2	0.077
Fixed Effects	
Exporter	✓
Importer	✓
Exporter × Importer	✓
Year	✓

Notes: Includes exporter, importer, pair, and year fixed effects to control for unobserved bilateral heterogeneity. Standard errors, clustered by exporter-importer pair, in parentheses.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

i(2) Potential Omitted Variables and Sample Selection

Potential omitted variables that could bias the CU coefficient upward include:

- Deep cultural/linguistic ties beyond common language

- Political alliances and security agreements

- Similar legal systems and institutional quality

- Complementary economic structures

Endogenous sample selection: Countries self-select into currency unions based on unobserved factors that also affect trade. This creates upward bias as the CU dummy captures both the treatment effect and the selection effect. For example, countries with strong but unmeasured economic ties may be more likely to form a currency union.

Question j: High-Dimensional Fixed Effects

The structural gravity specifications provide the most rigorous estimates of the currency union effect:

Table 3: Structural Gravity Model with Multilateral Resistance Terms

	Dependent Variable: ln(trade)	
	Structural Gravity	**Structural + Pair FE**
	(1)	(2)
Trade Policy Variables		
cu	0.490**	0.349***
	(0.198)	(0.102)
rta	0.666***	0.401***
	(0.141)	(0.066)
Geographic Variables		
ln(dist)	-1.36***	
	(0.042)	
Cultural/Historical Variables		
comlang_off	0.433***	
	(0.068)	
colony	1.32***	
	(0.112)	
Observations	102,018	102,018
R^2	0.729	0.899
Within R^2	0.346	0.003
Fixed Effects		
Exporter $\times$ Year	✓	✓
Importer $\times$ Year	✓	✓
Exporter $\times$ Importer		✓

Notes: Standard errors, clustered by exporter-importer pair, in parentheses. Column (1) includes exporter-year and importer-year fixed effects to control for time-varying multilateral resistance terms. Column (2) adds pair fixed effects to control for unobserved time-invariant bilateral heterogeneity.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

1. **Specification (1) - Time-varying MRTs**: Controlling for exporter-year and importer-year fixed effects yields a CU coefficient of 0.490**, implying a 63% increase in trade. This specification addresses time-varying multilateral resistance terms.

2. **Specification (2) - Adding pair fixed effects**: Further controlling for pair fixed effects yields a CU coefficient of 0.349***, implying a 42% increase in trade. This is the most demanding specification, identified only from within-pair variation in CU status over time.

Rationale for These Specifications

- **Exporter-year and importer-year fixed effects**: Control for time-varying multilateral resistance terms, addressing the Silver Medal Mistake.

- **Pair fixed effects**: Control for all time-invariant bilateral characteristics, addressing the Gold Medal Mistake (time-invariant MRTs) and other time-invariant confounders.

The decline in the CU coefficient from 0.490 to 0.349 as we add more fixed effects suggests that earlier estimates were biased upward by omitted variables.

Question k: Do Small Countries Benefit More from Currency Unions?

The results provide mixed evidence on whether small countries benefit more from currency unions:

1. **Specifications (1) and (2) without country fixed effects**: The interaction terms (cu_small_o, cu_small_d, cu_both_small) are positive but insignificant, suggesting no differential effect for small countries.

2. **Specification (3) with country fixed effects**: The CU coefficient becomes large and significant (2.65***), while the interaction cu_both_small is negative but insignificant (-0.097). The both_small variable is positive and significant (0.688***), indicating that small country pairs trade more with each other.

Interpretation

The evidence does not strongly support the hypothesis that small countries benefit more from currency unions. The large CU coefficient in specification (3) may be driven by other factors correlated with both small country size and CU membership. The positive coefficient on both_small suggests that small countries tend to trade more with each other, but this effect does not appear to be amplified by currency union membership.

Question l: Problems with Log-Linearization and Poisson Estimation

Two Main Problems with Log-Linear Gravity Equation

1. **Zero trade flows**: The log transformation cannot handle zero values, leading to sample selection bias if zeros are not random.

2. **Heteroskedasticity**: Trade data typically exhibit heteroskedasticity where variance is proportional to the mean, violating OLS assumptions and leading to inefficient estimates.

Table 4: Small Countries' Benefits from Currency Unions

	Separate Effects (1)	Joint Effects (2)	Country FE (3)
	Dependent Variable: ln(trade)		
cu	−0.909	−0.789	2.65***
	(0.735)	(0.578)	(0.319)
small_o	0.088		
	(0.229)		
small_d	0.052		
	(0.192)		
cu × small_o	0.379		
	(0.688)		
cu × small_d	0.191		
	(0.617)		
ln(gdp$_o$)	0.784***	0.765***	
	(0.145)	(0.107)	
ln(gdp$_d$)	0.639***	0.630***	
	(0.130)	(0.099)	
ln(dist)	−0.726***	−0.724***	
	(0.066)	(0.066)	
rta	1.28***	1.27***	
	(0.208)	(0.212)	
both_small		0.066	0.688***
		(0.131)	(0.114)
cu × both_small		0.442	−0.097
		(0.603)	(0.361)
Observations	102,018	102,018	102,018
R^2	0.216	0.215	0.554
Within R^2	0.208	0.208	0.028
Fixed Effects			
Year	✓	✓	✓
Exporter			✓
Importer			✓

Notes: Interaction coefficients indicate whether small countries benefit more from currency unions. Positive interaction = small countries benefit more; Negative interaction = small countries benefit less. Standard errors, clustered by exporter-importer pair, in parentheses.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

PPML Estimation Results

The PPML estimate of the CU coefficient is 0.027 and insignificant, implying essentially no effect of currency unions on trade. This contrasts sharply with the positive and significant estimates from log-linear specifications.

Table 5: Poisson Pseudo-Maximum Likelihood (PPML) Estimation

	PPML
	(1)
Trade Policy Variables	
cu	0.027
	(0.088)
rta	0.172***
	(0.065)
Observations	206,991
Fixed Effects	
Exporter × Year	✓
Importer × Year	✓
Exporter × Importer	✓

Notes: Poisson Pseudo-Maximum Likelihood estimation including zero trade flows. All specifications include exporter-year, importer-year, and pair fixed effects. Standard errors, clustered by exporter-importer pair, in parentheses.
Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Interpretation

The discrepancy between PPML and log-linear estimates suggests that heteroskedasticity and/or zero trade flows may be biasing the log-linear estimates. The PPML estimate is more reliable because it:

- Handles zero trade flows directly

- Is consistent under heteroskedasticity

- Maintains the multiplicative form of the gravity equation

The insignificant PPML result casts doubt on the robustness of the positive CU effects found in log-linear specifications.

Question m: Euro Effect Analysis

The Euro effect analysis yields surprising results:

1. **Specification (4) - PPML with pair fixed effects**: The euro_cu coefficient is -0.613***, implying that the Euro **reduced** trade by approximately 46% ($e^{-0.613} - 1 = -0.459$). This is counterintuitive and requires careful interpretation.

2. **Specification (3) - OLS with full fixed effects**: The euro_cu coefficient is -0.007 and insignificant, suggesting no significant Euro effect.

Table 6: PPML Estimation with Pair Fixed Effects for Euro Effect

	Dependent Variable: trade			
	OLS (1)	**OLS** (2)	**OLS** (3)	**Poisson** (4)
euro_cu	3.24*** (0.672)	−1.22*** (0.304)	−0.007 (0.205)	−0.613*** (0.137)
$\ln(\text{gdp}_o)$	0.749*** (0.105)	1.23*** (0.104)		
$\ln(\text{gdp}_d)$	0.615*** (0.098)	0.745*** (0.099)		
$\ln(\text{dist})$	−0.730*** (0.066)	−1.38*** (0.045)		
rta	1.19*** (0.211)	0.690*** (0.139)	0.401*** (0.065)	−0.163 (0.101)
cu	−0.853** (0.396)	0.933*** (0.220)	0.352*** (0.126)	0.483*** (0.109)
Observations	102,018	102,018	102,018	102,018
R^2	0.217	0.693	0.899	
Within R^2	0.210	0.332	0.003	
Fixed Effects				
Year	✓	✓		
Exporter		✓		
Importer		✓		
Exporter × Year			✓	✓
Importer × Year			✓	✓
Exporter × Importer			✓	✓

Notes: PPML estimation with exporter-year, importer-year, and pair fixed effects. Columns (1)-(3) use OLS with ln(trade) as dependent variable; column (4) uses PPML with trade as dependent variable. The euro_cu variable captures the Euro effect. Standard errors, clustered by exporter-importer pair, in parentheses. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Possible Explanations for the Negative Euro Effect

- **Substitution effect**: The Euro may have diverted trade from non-Eurozone partners to Eurozone partners, leaving total trade unchanged or reduced.

- **Measurement issues**: The euro_cu dummy may be capturing other factors correlated with Euro adoption.

- **Timing**: The analysis period (1960-2005) includes only a few years after Euro introduction (1999), which may be insufficient to capture long-term effects.

- **Aggregation bias**: The Euro effect may vary across sectors or country pairs, and the aggregate effect may mask heterogeneity.

Comparison with General CU Effect

The negative/insignificant Euro effect contrasts with the positive general CU effect, suggesting that the Euro may not have generated the same trade benefits as other currency unions. This could be because Eurozone countries were already highly integrated before adopting the common currency, leaving less room for additional trade creation.