Estimating the effect of exchange rate changes on total exports

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Motivation

Real Effective Exchange Rate (REER) regressions are ubiquitous in applied policy work (see recent discussion about Elasticity Pessimism)

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Real Effective Exchange Rate (REER) regressions are ubiquitous in applied policy work (see recent discussion about Elasticity Pessimism)

Key questions:

1. By how much do exports increase given an increase in competitiveness?
   - considers the REER as exogenous
2. By how much does the REER need to change in order to balance the current account?
   - considers the REER as endogenous

What we do

We quantify the impact of the real exchange rate on exports

1. We re-visit the theoretical foundations of *monadic* (macro-level) Real Effective Exchange Rate (REER) regression
2. We assess whether the "macro-level" approach is compatible with "meso-level" foundations of *dyadic* trade equations as found in the Gravity literature.

Use the calibrated model to

1. assess and quantify estimation biases in applied work
2. run counterfactual policy experiments

Main results (1)

With a unique elasticity of substitution (structural gravity), it is possible to go from the "meso" to the "macro" level with no aggregation bias.

We use simulations to show the main sources of bias in applied work:

1. Mis-specification
   - Exact hat notation versus log approximation
2. Omitted variables
   - Gold medal mistake

Estimation biases in the exchange rate elasticity appear overall to be a minor concern.

- bias seems to be mainly on the demand elasticity

Main results (2)

Counterfactual policy experiments

1. An appreciation of the Euro, French franc and US dollar.
2. Closing Current Account imbalances in the Euro Area

We analyze the bilateral nature of country specific changes in exports together with the implied changes in wages, prices and welfare

Literature

- Foundations of Real Effective Exchange Rate (REER)
  - Armington (1969), McGuirk (1986), Spilimbergo and Vamvakidis (2003), Bayoumi, Lee and Jayanthi (2005), Chinn (2006)
- Gravity literature and exchange rate
  - Anderson and Van Wincoop (2003), Dekle, Eaton and Kortum (2007), Head and Mayer (2014, Anderson, Vesselovsky and Yotov (2016)
- Trade Elasticity
  - Feenstra, Luck, Obstfeld and Russ (2014), Imbs and Mejean (2015)
- Global imbalances
  - Obstfeld and Rogoff (2005)

Theoretical framework: Structural gravity

- Total exports of country i

$$E_i = \sum_{n \neq i} X_{ni} = \sum_{n \neq i} \pi_{ni} X_n$$

  - X_n ... total expenditure of importer n
  - π_{ni} ... expenditure share of n on goods from i

$$\pi_{ni} = \frac{(S_i \tau_{ni})^{-\epsilon}}{\Phi_n} \qquad \text{where} \qquad \Phi_n = \sum_{k=1}^{N} (S_k \tau_{nk})^{-\epsilon}$$

  - ϵ ... trade elasticity
  - S_i ... supply (depends on underlying micro-foundation)
  - τ_{ni} ... iceberg trade costs
  - Φ_n... multilateral resistance term (price index in n)

Counterfactual analysis

- Exact hat notation (Arkolakis, Costinot, and Rodriguez-Clare (2012))

$$\widehat{x}_{ni} \equiv \frac{x'_{ni}}{x_{ni}}$$

  - x'_{ni} ... bilateral trade after the change

- **Change in total exports**

$$\widehat{E}_i = \sum_{n \neq i} \omega_{ni} \widehat{\pi}_{ni} \widehat{X}_n$$

  - $\omega_{ni} \equiv X_{ni} / E_i$ denotes the export share
  - is the weighted sum of all changes in bilateral exports
    - weights are the initial share of each bilateral flow in total exports.

Changing the exchange rate

- Bilateral import shares with **nominal exchange rate** r_i

$$\pi_{ni} = \frac{(r_i S_i \tau_{ni})^{-\epsilon}}{\Phi_n} \qquad \text{where} \qquad \Phi_n = \sum_{l=1}^{N} (r_l S_l \tau_{nl})^{-\epsilon}$$

- Change in bilateral import shares

$$\widehat{\pi}_{ni} = \frac{(r_i' w_i' \tau_{ni})^{-\epsilon} / \Phi_n'}{(r_i w_i \tau_{ni})^{-\epsilon} / \Phi_n} = \frac{(\hat{w}_i \hat{r}_i)^{-\epsilon}}{\widehat{\Phi}_n}$$

- Change in exports in international currency as:

$$\widehat{E}_i = \sum_{n \neq i} \omega_{ni} \left(\frac{(\hat{w}_i \hat{r}_i)^{-\epsilon}}{\widehat{\Phi}_n} \right) \widehat{X}_n$$

Real Exchange Rate (RER) regression

- Resulting log change in exports in international currency as:

$$\ln \widehat{E}_i = -\epsilon \ln \widehat{RER}_i + \ln \sum_{n \neq i} \omega_{ni} \left(\frac{\widehat{X}_n}{\widehat{\Phi}_n} \right). \tag{1}$$

  - where the real exchange rate (RER_i) is defined as:

$$\ln \widehat{RER}_i = \ln \hat{w}_i \hat{r}_i \tag{2}$$

- **Assuming structural gravity, there is no aggregation bias from the "meso" to the "macro" level ... if equation (1) is run**

Classical REER regressions based on McGuirk (1986)

- Consider the log change in bilateral exports given by CES demand

$$\triangle \log X_{ni} = \triangle \log X_n - (\sigma - 1) \triangle \log \left(\frac{P_{ni}}{P_n} \right)$$

- Aggregating the bilateral change across importing countries:

$$\triangle \ln E_i = \sum_{n \neq i} \omega_{ni} \triangle \ln X_n - (\sigma - 1) \sum_{n \neq i} \omega_{ni} \sum_{k \neq i} \pi_{nk} \triangle \ln \left(\frac{P_i}{P_k} \right)$$

  - ω_{ni} ... the share of export revenues of country i
  - $\triangle \ln P_n = \sum_{k=1}^{K} \pi_{nk} \triangle \ln P_k$
  - $\triangle \ln REER_i = \sum_{n \neq i} \sum_{k \neq i} \omega_{ni} \pi_{nk} \triangle \ln \left(\frac{P_i}{P_k} \right)$

Comparing Structural Gravity and McGuirk (1986)

- The exact hat change is the integral of the log changes of bilateral trade flows from the initial policy r to the new policy state r'.

$$\widehat{X_{ni}} = \int_{r}^{r'} \triangle \ln X_{ni} dr$$

- McGuirk (1986):

$$\triangle \ln E_i = -\epsilon \triangle \ln REER_i + \sum_{k \neq i} \omega_{ni} \triangle \ln X_n$$

- Exact hat algebra:

$$\ln \widehat{E}_i = -\epsilon \ln \widehat{REER}_i + \ln \sum_{n \neq i} \omega_{ni} \left(\frac{\widehat{X_n}}{\widehat{\Phi_n}} \right)$$

  - **Assuming small changes, multilateral resistance changes are integrated into the REER.**

Simulation: estimation biases for 5 specification

1. Baseline (exact hat algebra)
2. Gold medal mistake

$$\ln \widehat{E}_i = -\epsilon \ln \widehat{RER}_i + \ln \sum_{n \neq i} \omega_{ni} \widehat{X}_n$$

3. Real Effective Exchange Rate based on hat algebra

$$\ln \widehat{E}_i = -\epsilon \ln \widehat{REER}_i + \ln \sum_{n \neq i} \omega_{ni} \widehat{X}_n$$

4. Log changes (McGuirk (1986))

$$\triangle \ln E_i = -\epsilon \triangle \ln REER_i + \sum_{k \neq i} \omega_{ni} \triangle \ln X_n$$

5. Approximation via log changes with IMF weights
   - IMF weights differ from McGuirk's weights ▸ IMF

Data

- General equilibrium
  - Data from Dekle, Eaton and Kortum (2007)
  - Trade data with current account information for 40 countries in the year 2004
- Partial equilibrium
  - Data from Head and Mayer (2014)
  - Trade data of 84 countries in the year 2000
- Calibration: trade elasticity $\epsilon = 4$
- For the moment, bilateral trade flows are generated from Structural Gravity.

Results: General Equilibrium counter factual

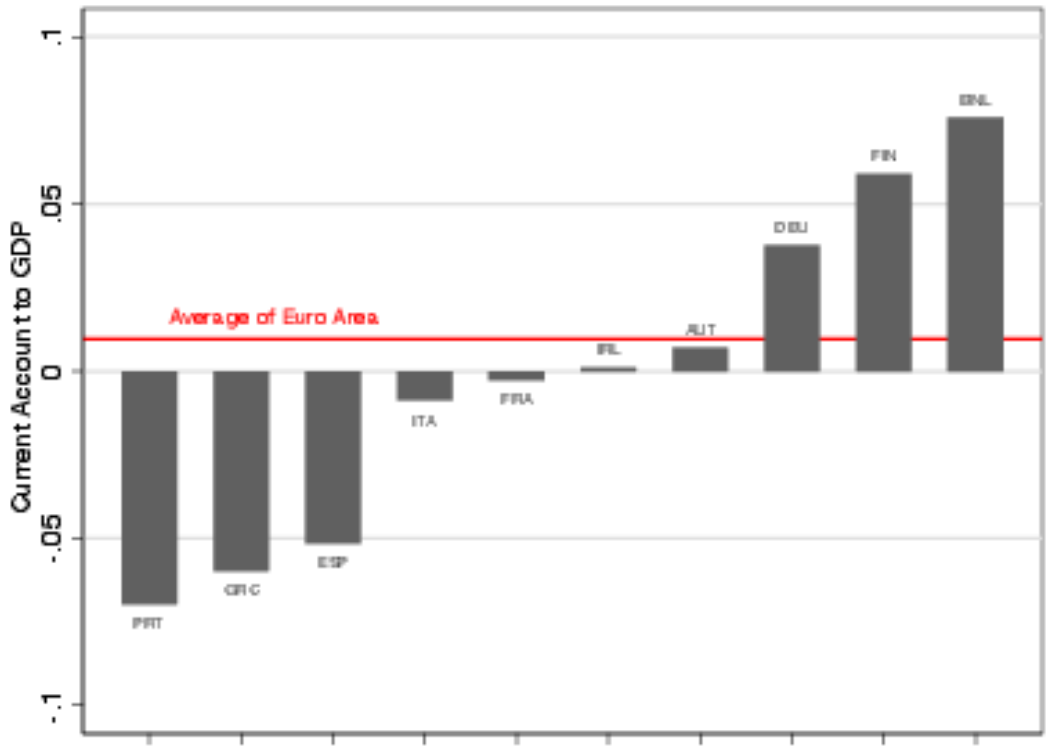
	Hat algebra			d ln version	
	Baseline	GM mistake	REER	REER	IMF
Exchange Rate	4	-3.718	-3.997	-4	-3.966
	(0)	(.161)	(.007)	(.011)	(.058)
Foreign demand	-1	-.887	.991	1.029	.61
	(0)	(.918)	(.037)	(.06)	(.325)

- Gold Medal (GM) mistake induces the largest bias
- Bias in exchange rate elasticity is negligible
- Bias in foreign demand elasticity is substantial
- Bias is more pronounced in Partial equilibrium ▸ Partial EQ
  - Monte Carlo simulations show an amplified Exchange Rate bias

General Equilibrium counter factual - Dekle, Eaton and Kortum (2007)

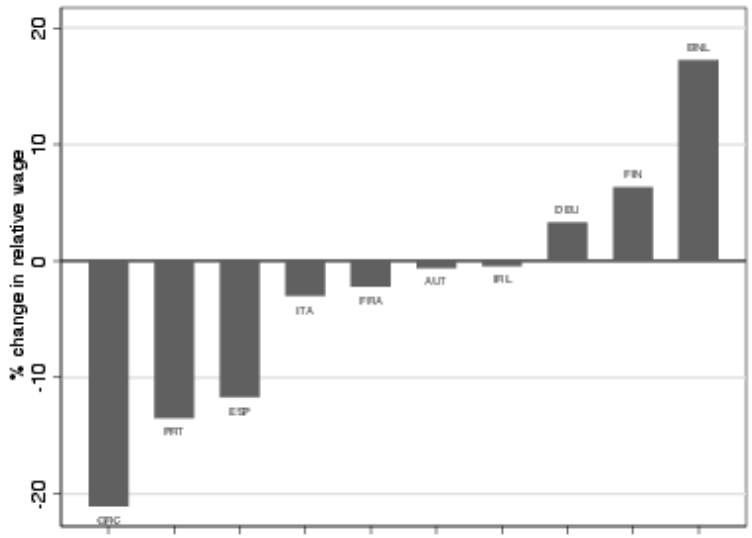
- Question: what would happen if the manufacturing sector had to adjust in order to close current account imbalances within the Euro?
- Experiment:
  - Suppose every euro member state has to have the same current account to GDP ratio as the euro area as a whole.
  - As a result, global imbalances will remain constant, only intra-euro area imbalances will be eliminated.

Current account to GDP ratio of Euro Area countries in 2004

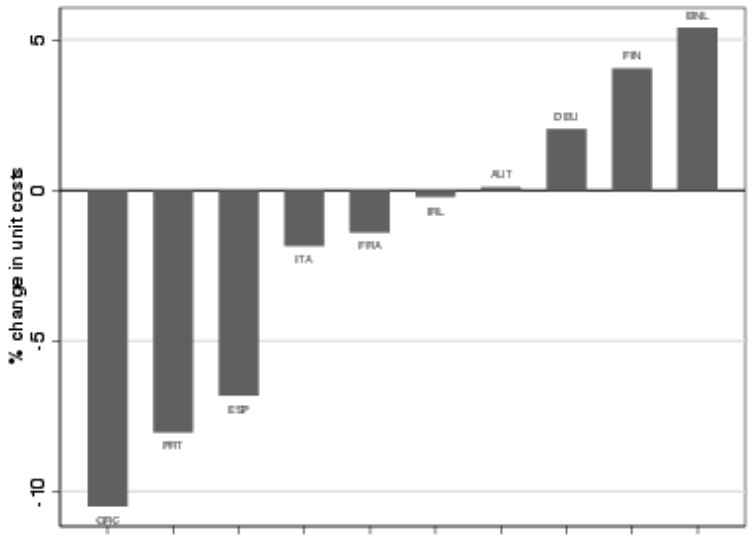


- Example: Germany has to reduce its surplus by 3 percent.

Results on wages and unit costs



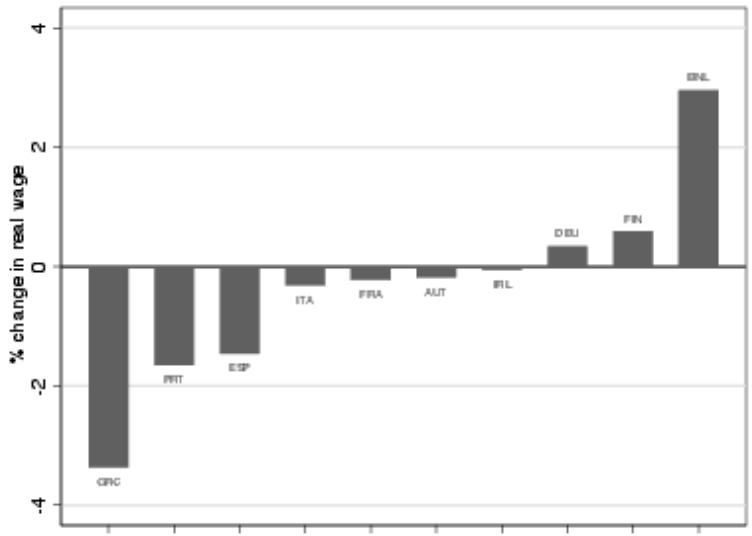
(a) Change in relative wage



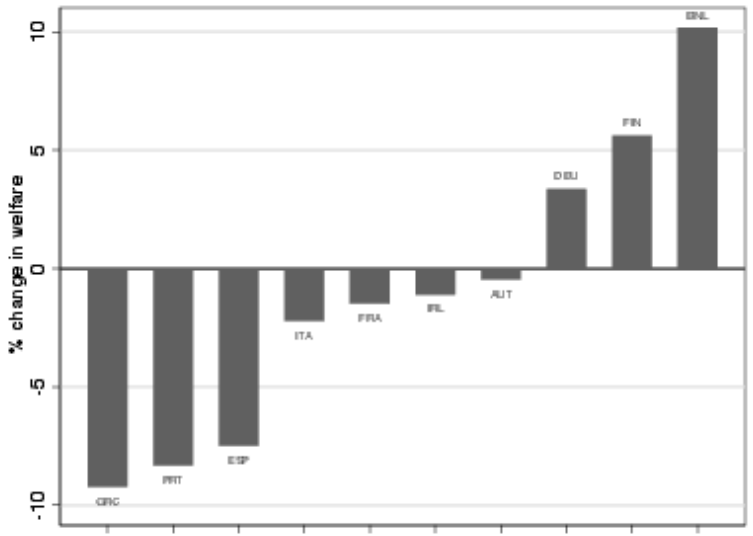
(b) Change in unit costs

- Changes in unit costs are less pronounced because of lower intermediate input prices

Results on real wages and welfare



(c) Change in real wage



(d) Change in welfare

- Changes in welfare are more pronounced because of closing the current account.

Results on closing Euro Area imbalances

- Leaving inter-temporal decision aside, welfare :
  - increase in: Germany (+4%), Finland (+6%) and the Benelux (+10%).
  - decrease in: Greece (-9%), Portugal (-8%) and Spain (-7%).
- Spillovers ▸ detailed results
  - Algeria would benefit (+0,08%)
  - Israel, Sweden, Denmark and Switzerland would lose (-0.1%)
- ▸ Partial EQ counter factual

Conclusion

- We reconnect "macro-level" monadic Real Effective Exchange Rate (REER) regressions with "meso-level" foundations of dyadic (bilateral) trade equations (Gravity)
- We quantify estimation biases due to mis-specification and omitted variables
    - in both, the PE and the GE, the bias is small for the exchange rate elasticity and large for demand elasticity
- We quantify price and welfare implications based on real exchange rate shocks based on 2 experiments:
    - Implied changes in the Real Exchange Rate to close current account imbalances within the Euro Area
    - 20 appreciation of the Euro, French franc and US dollar.

Future

- Currently, complete pass-through
  - introduce distribution costs to allow for incomplete pass through
- Currently, deterministic model
  - introduce simulation errors in trade cost

Appendix

EER calculated by policy institutions (PI)

- Effective Exchange Rate (EER) based on McGuirk (1986)

$$\triangle \ln REER_i = \sum_{k \neq i} \sum_{n \neq i} \omega_{ni} \pi_{nk} \triangle \ln \left(\frac{P_i}{P_k} \right)$$

- PI calculate weights for the effect on production (not exports)

$$TW_{ik} = \sum_{n=1}^{N} \psi_{ni} \pi_{nk}$$

  - where $\psi_{ni} = \frac{X_{ni}}{\sum_{k=1}^{N} X_{ki}}$ includes the home market share

- These weights are normalized to 1

$$W_{ik} = \frac{\sum_{n=1}^{N} \psi_{ni} \pi_{nk}}{\sum_{n=1}^{N} \psi_{ni} (1 - \pi_{ni})}$$

  - which leads to a bias in export equations. Back

Results: Partial Equilibrium counter factual

	Hat algebra			d ln version	
	Baseline	GM mistake	REER	REER	IMF
Exchange Rate	4	-3.854	-3.626	-4.052	-3.971
	(0)	(.022)	(.048)	(.009)	(.006)
Foreign demand	-1	2.564	4.57	.558	1.325
	(0)	(.04)	(.146)	(.027)	(.018)

- Biases are more pronounced compared to General Equilibrium ones

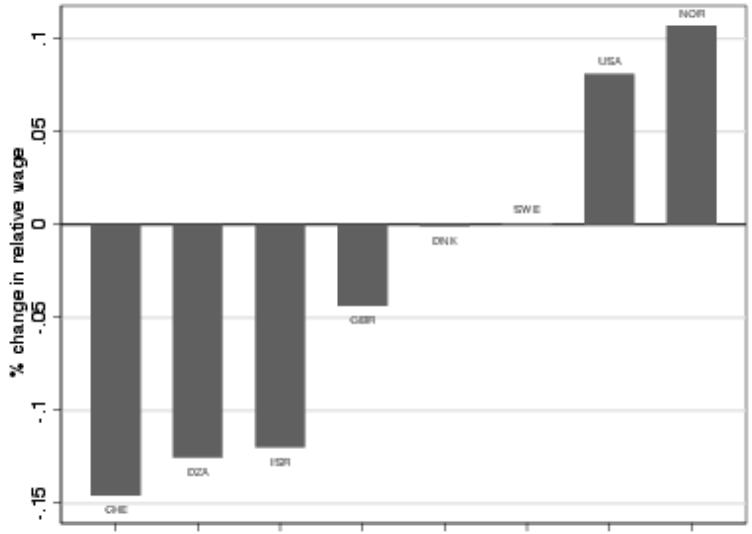
Monte Carlo Results: Partial Equilibrium counter factual

	Hat algebra			d ln version	
	Baseline	GM mistake	REER	REER	IMF
Exchange Rate	4	-3.523	-2.751	-4.025	-3.585
	(0)	(.091)	(.147)	(.029)	(.076)
Foreign demand	-1	1.436	1.843	1.009	1.262
	(0)	(.106)	(.206)	(.033)	(.092)

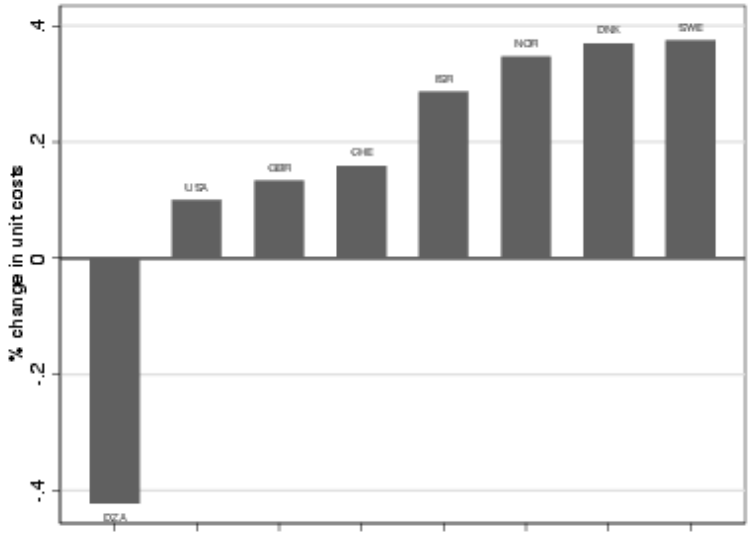
- Induce random error in trade shares and conduct 1000 replications
- Monte Carlo reduces bias in demand and increases bias in exchange rate elasticity.

Back

Spillover effects on wages and unit costs

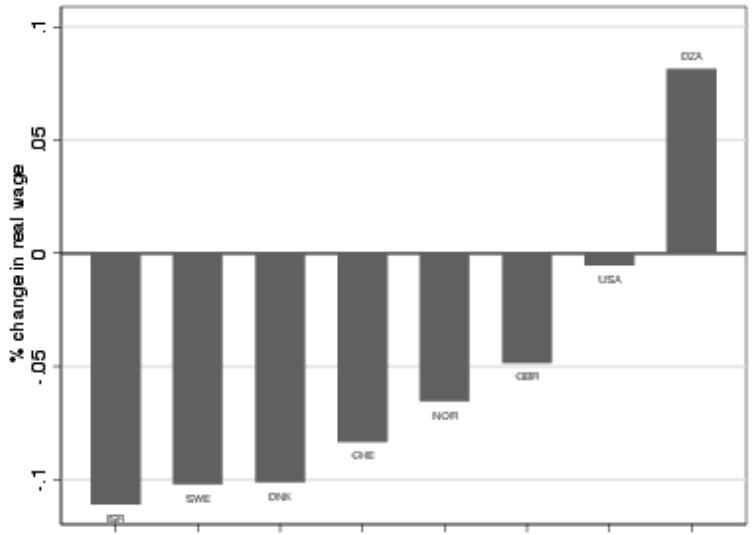


(e) Change in real wage

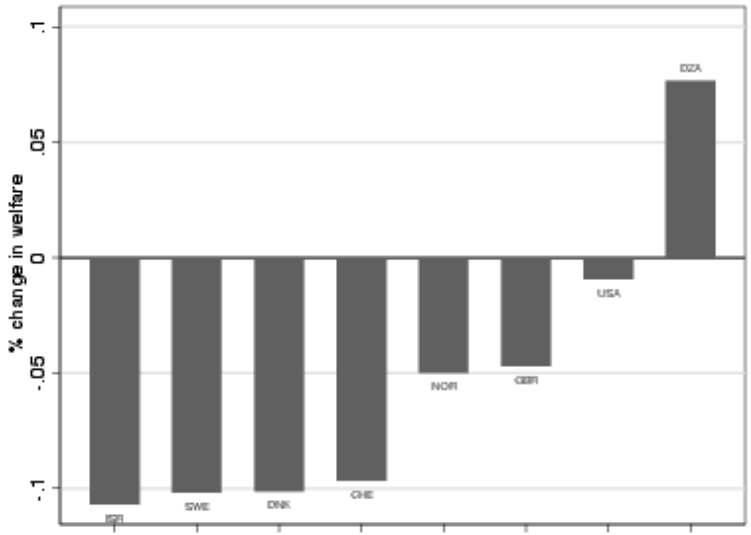


(f) Change in welfare

Spillover effects on real wages and welfare



(g) Change in real wage



(h) Change in welfare

Back

Results: Partial Equilibrium counter factual

- We consider 3 exchange rate policy experiments.
  1. Appreciation of 20% of the Euro.
  2. Appreciation of 20% of the French nominal exchange rate.
  3. Appreciation of 20% of the US dollar.

Results: Appreciation of 20% of the Euro.

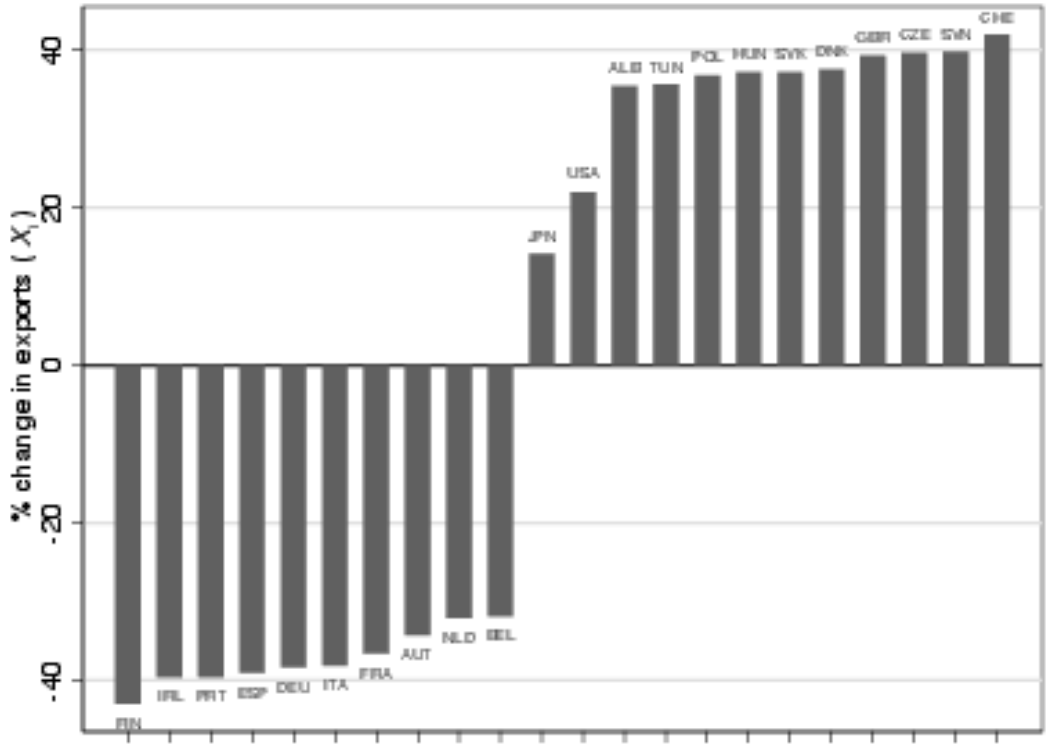


Figure: Cross-country changes in exports

Results: Appreciation of 20% of the Euro.

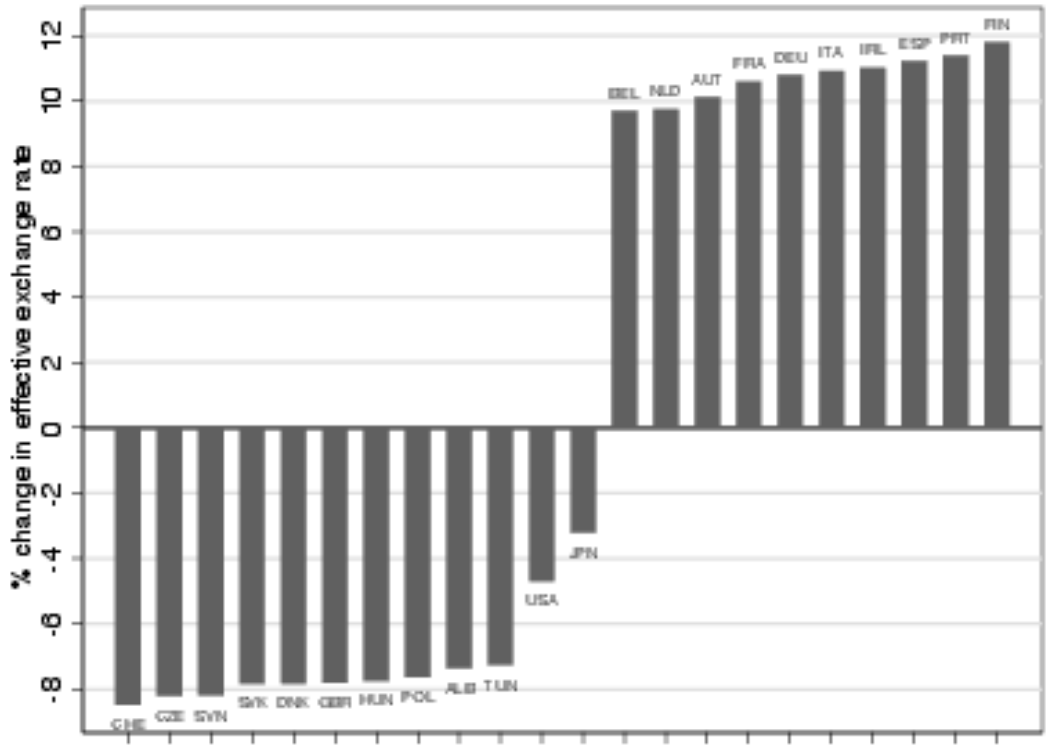


Figure: Cross-country changes in competitiveness (REER)

Back

Results: Appreciation of 20% of the French franc.

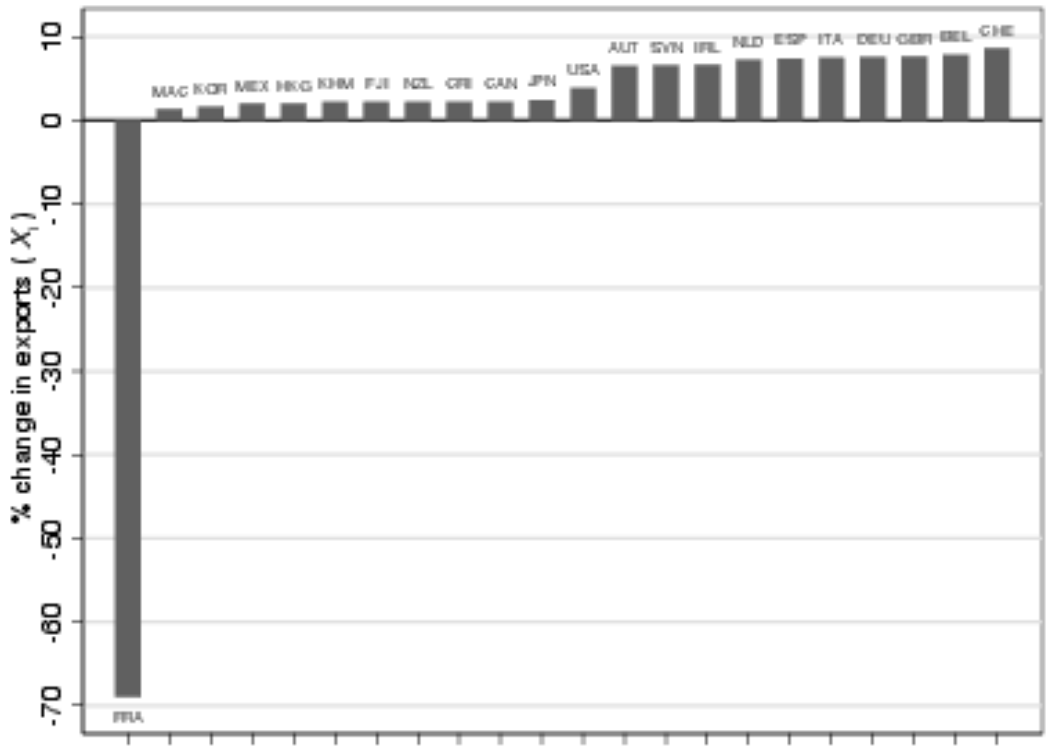


Figure: Cross-country changes in exports

Results: Appreciation of 20% of the French franc.

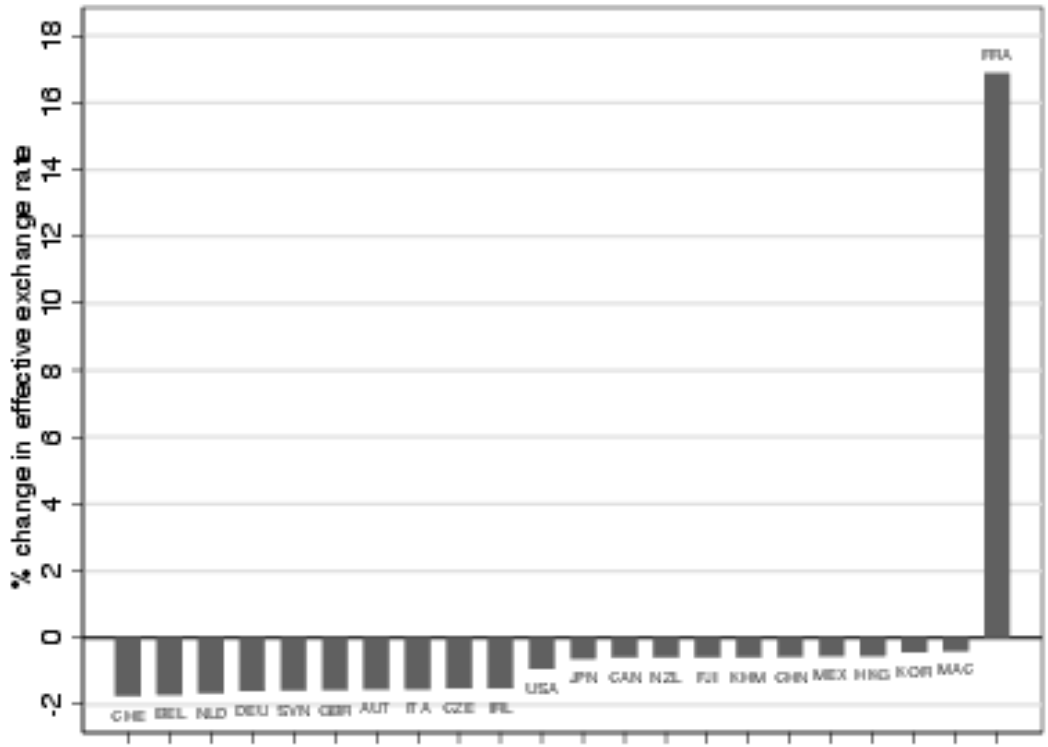


Figure: Cross-country changes in competitiveness (REER)

Back

Results: Appreciation of 20% of the US dollar.

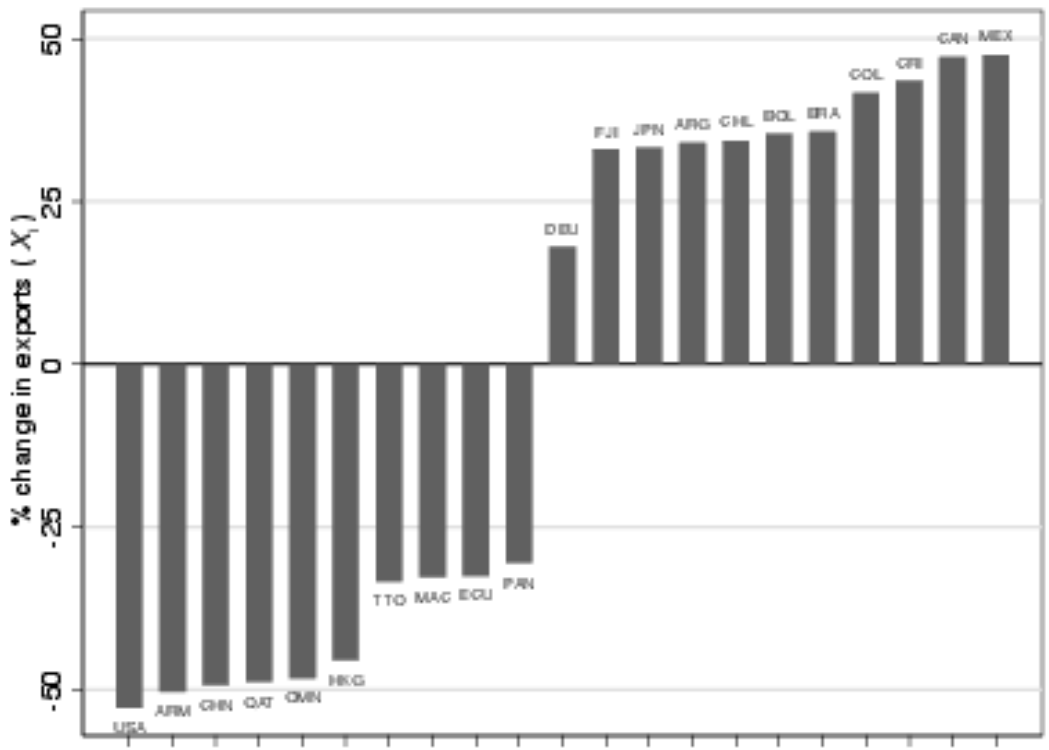


Figure: Cross-country changes in exports

- effects include countries that pegged their currencies to the US dollar.

Results: Appreciation of 20% of the US dollar.

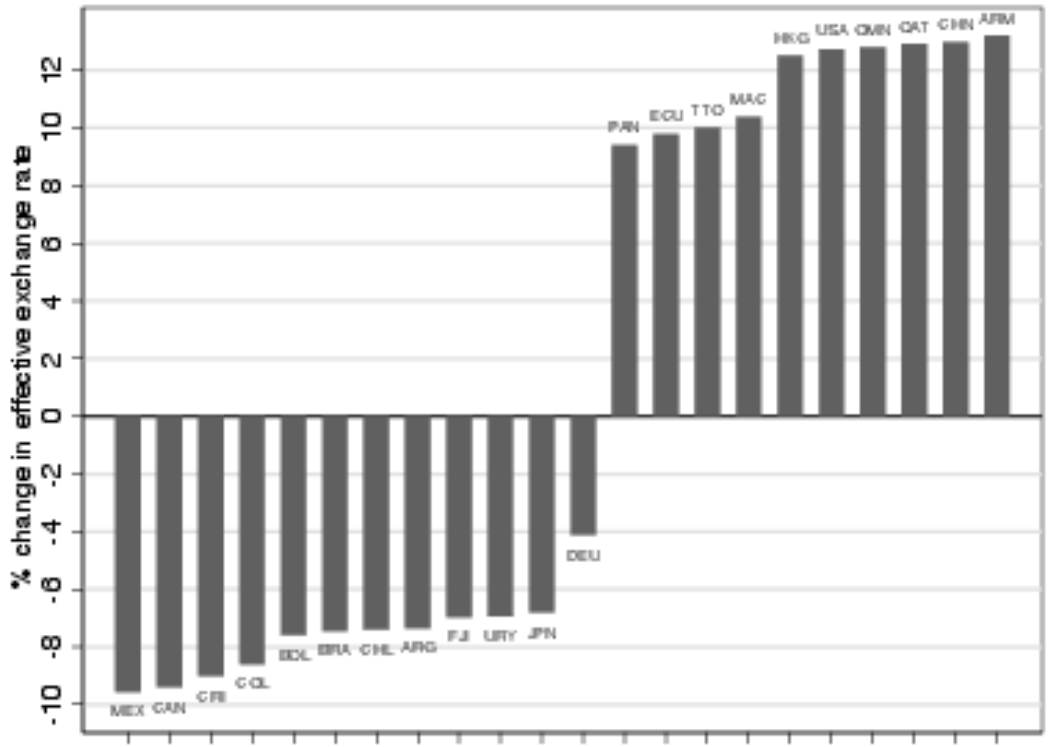


Figure: Cross-country changes in competitiveness (REER)

- effects include countries that pegged their currencies to the US dollar. Back