What Explains Trade Persistence?
A Theory of Habits in the Supply Chains

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Outline

Marketing

Supply chains and trade flows volatility in the face of global shocks

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International trade flows are volatile, imbalanced, and fragmented across offshored supply chains. But there is still a lack of understanding about why global trade shocks, such as the Covid-19 pandemic, result in synchronised, but remarkably unequal trade flow responses across countries. This column argues that less-integrated countries focusing on arm's-length trade experience the greatest trade flow disruptions in response to global trade shocks, while trade flows between more integrated countries relying on intermediate imports tend to dip less and bounce back more rapidly.

The outbreak of the Covid-19 pandemic has caused a worldwide disruption in trade flows. According to the WTO, a 9.2% decline in the volume of world merchandise trade for 2020 is expected, with a rebound of 7.2% in 2021. The drop in trade is around two to three times larger than the drop predicted for world GDP (a drop of 3.5% is most recently forecasted by the IMF, in the updates to the *World Economic Outlook* released in January 2021). The adjustment is very heterogeneous – the WTO calculates 14.7% and 11.7% declines in export volumes in the US and Europe, respectively, and a mere 4.5% drop in Asia. These developments resemble what has been known as the Great Trade Collapse of 2008-09 (Baldwin 2009, 2020) during which the world GDP shrank by 1%, while the value of global trade flows slumped by some 10% in a remarkably synchronised fashion across the world (Alessandria et al. 2010).

These international trade patterns before, during, and after the Great Recession, can be seen in Figure 1, which encapsulates three empirical facts. First, independently of the country group, there

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ECONOMICS, SHAPING THE POST-COVID WORLD

Helping to predict trade flows at a time of global crisis

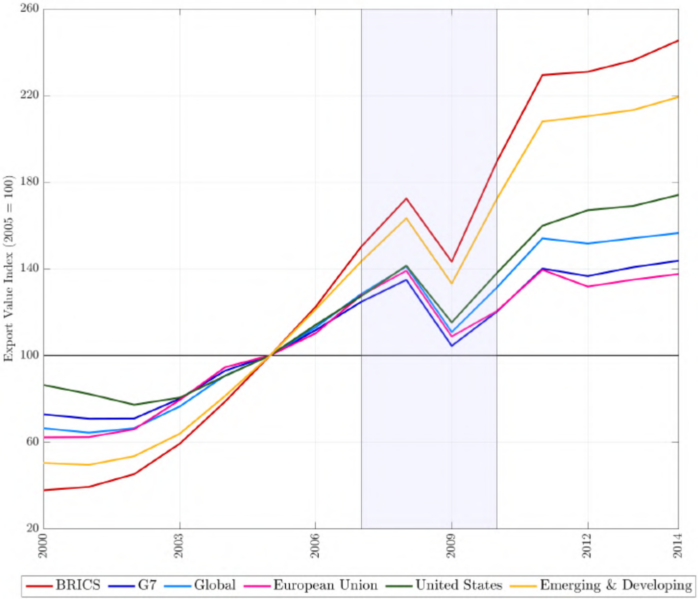
In today's globalised world, the ramifications of a global shock can be significant, disrupting trade flows between countries in ways that have been hard to predict. Research by Mariarosaria Comunale, Justas Dainauskas and Povilas Lastauskas sheds new light on how countries can seek to minimise disruption.

Motivation

- Implementing changes in trade policy takes time and resources.
  - Patterns of "who trades with whom" are regionally-biased and slow to adjust (Eichengreen and Irwin (1998)).
- But the value of "how much is traded" is volatile, especially when countries are hit by large shocks.
- In the face of large and particularly common shocks, the observed value of trade flows adjust **by more and more rapidly** than predicted by the **neo-classical gravity equation**, but **somewhat less rapidly** than the **static gravity equation**.
- We call this discrepancy the "*trade persistence*" puzzle.
- In general, both static and neo-classical gravity models cannot explain:
  - Why trade flow adjustments are **sharp, synchronized, yet heterogeneous** in response to common trade shocks?
  - Why trade flow values adjust to (common) shocks **neither instantaneously nor very sluggishly**?

Dynamics of Global Trade and GDP Growth Rates

Trade Flows in Major Country Groups



Existing Theoretical Puzzles

- Standard gravity models are **static** models (Anderson (1979) and Anderson and van Wincoop (2003)), as they are silent about the transitional dynamics of global trade flows.
- Eaton and Kortum (2002) derive observationally equivalent gravity model, driven by the supply-side considerations. Similarly, a heterogeneous firm model due to Melitz (2003) also delivers multiplicative gravity model. As demonstrated by Arkolakis et al. (2012), these equivalent representations generalize to a wider class of trade models, leaving us wonder about the neglected forces that are behind the empirically relevant dynamics of trade flows.
- Neo-classical gravity model extensions rely on **capital accumulation** (Yotov and Olivero (2012) and Anderson et al. (2020)). But they struggle to predict large, sharp, and heterogeneous trade flow adjustments to common trade shocks we observed in the data.
    - Capital stock depreciates at rate $\delta \in [0, 1]$. Predicted trade persistence coefficient of $1 - \delta$ comes from Cobb-Douglas production function. But IMF (2015) estimates of δ are [0.04, 0.1], such that trade persistence coefficient is [0.9, 0.96].
- Most theoretical gravity models assume **zero or exogenous trade balance** (Arkolakis et al. (2012)). This is at odds with the observed **persistence of current account imbalances**, especially before GTC.

Existing Empirical Puzzles

- Estimation of gravity equations using a panel dataset of countries mainly rely on **"direction" and "time" fixed effects** as well as **pooled coefficient estimators** (Helpman et al. (2008); Feenstra (2016)).
    - Absence of **unobservable common factors** implies shocks originating from third countries are not fully reflected in bilateral trade flow adjustments between source or and destination economies.
    - Pooled coefficient estimators ignore the fact that trade flows between some country pairs are significantly more persistent than others due to inherent **structural differences** across countries, i.e. this heterogeneity is not taken into account.
- Empirical gravity models typically omit **country-specific trade imbalances**, despite their prominence as conduits for local and global trade tensions (IMF (2019); Beirne et al. (2020)).

What We Do: Theory

- We argue that countries develop "*supply-side habits*" in their technology when they continuously trade with one another.
    - Production habits may develop due to **shared history, institutions, values, or colonial ties** (Eichengreen and Irwin (1998)).
    - At the firm level, multi-nationals do business with offshore suppliers that are reliable, since assembling, disbanding, or swapping foreign suppliers in response to shocks is costly.
    - Indeed **contractual obligations** closely tie companies and suppliers over time and create momentum for **trade flows to persist**.
    - **Differences in supply habits** across countries then generate differences in the trade momentum, which explains **country-specific trade imbalances**.
- The empirical model of the supply-habit-augmented gravity equation offers several advantages:
    - Nests the static and neo-classical gravity models in special cases.
    - Predicts **autocorrelated and heterogeneous** trade flows across countries and **endogenous country-specific trade imbalances**.
    - Creates "inward" and "outward" **time-varying multilateral trade resistance (w/ and w/o lags)**, which fundamentally changes the **transmission** of local and common trade shocks.

What We Do: Empirics

- We find **two empirical causes** of the trade persistence puzzle: (i) inference based on **pooled coefficient estimators (PE)**; and (ii) ill-suited modelling of time-varying **unobservable common factors (UCF)**.
    - w/o UCF and w/ PE (i.e., FE), gives trade persistence coefficient equal to 0.91.
    - w/ UCF and w/o PE (i.e., CCEMG), it is 0.35.
    - w/o UCF and w/o PE (i.e., MG), it is 0.55.
    - w/ UCF and w/ PE (i.e., CCEP), it is 0.37.
- Based on RMSE of in-sample prediction for global trade flows, CCEMG generally out-performs FE, MG, CCEP, and other approaches, throughout the entire data sample, but also during solely "good times" or "bad times".
- **Trade persistence** is positively related to model-implied **supply habits** and colonial ties, but negatively to geographic distance.
- Evidence favors our framework that explains heterogeneous trade persistence and predicts **heterogeneous response** to local and common trade shocks (e.g. supply habits in supply chains).

Outline

Gravity and Habits

- The workhorse framework for trade policy analysis in the context of permanent, unilateral, and exogenous trade shocks remains the **static gravity model** (Anderson (1979), Anderson and van Wincoop (2003), Helpman et al. (2008), and Feenstra (2016)).
- The **neo-classical gravity equation** based on capital accumulation is advocated by Yotov and Olivero (2012), Alvarez (2017), and Anderson et al. (2020), but predicts virtually homogeneous and persistent trade flows across countries.
- **Habits** are not rooted in first principles as strongly as capital accumulation, but they are a widely-established in the macro-finance literature (e.g., Abel (1990); Campbell and Cochrane (1999); Ravn et al. (2006, 2007); and Herbst and Schorfheide (2016)).
- Analyzing **historical dependence** of trade flows in the data goes back to Eichengreen and Irwin (1998), yet lacks theoretical grounding.
- **Trade elasticity heterogeneity** usually stems from the **demand side** by allowing homothetic translog preferences as in Novy (2013), additively separable preferences, giving rise to "subconvexity" (Carrere et al. (2020)) or a combination of heterogeneous income elasticity of demand and technologies (Fieler (2011)).

Trade and International Macroeconomics

- Persistence of **trade costs** in hyper-globalisation (e.g. Anderson and van Wincoop (2004); Disdier and Head (2008); Zwinkels and Beugelsdijk (2010); Head and Mayer (2014)) is related to the dynamic properties of the multilateral trade resistance in our model and aligns with Baldwin and Taglioni (2006).
- Some static gravity models also incorporate **multilateral trade imbalances** as a weakly exogenous regressor (e.g. Davis and Weinstein (2002), Dekle et al. (2007), and Dekle et al. (2008)).
- We contribute to the literature looking at the **causes and consequences of the GTC**, such as Alessandria et al. (2010); Bems et al. (2010); Altomonte et al. (2012); Antonakakis (2012); Levchenko et al. (2010); Eaton et al. (2016); Novy and Taylor (2020) and others.
- Empirically, Serlenga and Shin (2007) were the first to explore the role of **unobservable common factors** using gravity equations. But our approach is distinct from theirs as we introduce theoretically-consistent empirical modelling of both the contemporaneous and lagged unobservable common factors.

Outline

Basic Setup

- World economy evolves over discrete time $t = 0, 1, 2, \ldots$ and consists of a finite number of countries indexed by $n = \{1, 2, \ldots, N\}$.
- Each country is populated by consumers and producers.
- Production is split into two sectors: **wholesale and distribution**.
- Wholesale varieties are imperfectly substitutable.
- There is a unit mass of wholesale firms indexed by $\omega \in [0, 1]$.
- Distributor merges imported and domestically-produced wholesale varieties into a composite good.
- Consumers purchase the composite good and supply labour to the wholesale firms inelastically.
- Delivering one unit of wholesale variety from source country i to destination j costs $d_{ij} > 1$ relative to the unit costs (i.e., iceberg cost).
- **Distributor technology is subject to supply habits**: time-dependent and country-specific bias in production when sourcing wholesale varieties from different trade partner countries.

Supply Habits in Production

- Wholesale technology: $m_{ij,t}(\omega) = z_{i,t} h_{ij,t}(\omega)$, where $i, j \in n$, $h_{ij,t}(\omega) > 0$ are hours of labor, and $z_{i,t}$ is stationary and exogenous.
- Distributor aggregates wholesale varieties into a composite good according to CES production technology with multiplicative supply or production habits:

$$x_{ij,t} = \left[\int_0^1 \left(m_{ij,t}(\omega) x_{ij,t-1}^{\chi_{ij}} \right)^{1-1/\eta} d\omega \right]^{1/(1-1/\eta)}, \qquad (1)$$

  where $\eta > 1$ is the elasticity of substitution, $\chi_{ij} > 0$ denotes the habit intensity, and $x_{ij,t-1}$ is the stock of habit.
- Cost-minimizing demand for wholesale varieties:

$$m_{ij,t}(\omega) = x_{ij,t} x_{ij,t-1}^{\chi_{ij}(\eta-1)} \left[\frac{P_{ij,t}(\omega)}{\tilde{P}_{ij,t}} \right]^{-\eta}. \qquad (2)$$

  NB: $m_{ij,t}(\omega)$ increases in current and lagged trade flows $x_{ij,t}$ and $x_{ij,t-1}$, since $\chi_{ij} > 0$, but decreasing in the relative price $P_{ij,t}(\omega)/\tilde{P}_{ij,t}$, where $P_{ij,t}(\omega)$ is wholesale variety price and $\tilde{P}_{ij,t}$ is competitive distributor PPI.

Supply Habits in Production (cont'd.)

- **What are technology or supply habits?**
- Grossman and Helpman (1995): learning-by-doing is an important source of technical change where trade plays a key role. The idea is that accumulated knowledge to manufacture the product makes firms more productive. More recently, Keller (2004) concludes that "importing is associated with technology spillovers."
- A more recent revival of the learning-by-doing technology and trade is sometimes referred to as the "learning-by-importing" hypothesis or embodied technology in imports, and it has received substantial empirical support in Acharya and Keller (2009); Amiti and Konings (2007); Elliott et al. (2016); Halpern et al. (2015); Zhang (2017), among many others.
- The term $x_{ij,t-1}^{\chi_{ij}}$ can be seen as a technology parameter that affects the relative demand for imported imports $m_{ij,t}$, parameterized as the (indexed by χ_{ij}) past production level, embodying accumulated knowledge to combine inputs. The larger the past aggregate production level, the better is a firm at using inputs (internal returns).

Trade Imbalance

- Foreign and domestic composite goods are imperfect substitutes and consumer preferences are CES.
- Consumption $C_{j,t}$ is smoothed over time by trading Arrow-Debreu bonds with other countries (Obstfeld and Rogoff (1996)), which leads to short-run multilateral trade imbalances.
- Income-expenditure identity determines output $C_{j,t} = Y_{j,t}\Xi_{j,t}$, where the trade imbalance term is given by

$$\Xi_{j,t} = \frac{1}{1 + \sum_{i=1}^{N} q_{ij,t}\pi_{ji,t} - \sum_{i=1}^{N} \pi_{ij,t}}, \tag{3}$$

  $\pi_{ij,t} = X_{ij,t}/C_{j,t}$ measures the import penetration ratio (IPR), and $q_{ij,t}$ is the real bilateral exchange rate (RBER).
- Long-run trade imbalance is equal to the present discounted value of the short-run trade imbalances and its value is finite under the standard transversality condition.
- **General Equlibrium:**
  - Consumers maximize present discounted value of utility;
  - Distributors break-even;
  - Wholesale firms maximize profits;
  - Exogenous shocks to $z_{i,t}$ drive economic fluctuations over time.

Supply-Habit-Augmented Gravity Equation: Non-Linear

Proposition

The gravity equation is dynamic when supply habits are non-zero, such that $\chi_{ij} > 0$ *for all* $i \in n \setminus j$*. And when supply habits are asymmetric across countries, such that* $\chi_{ij} \neq \chi_{ji}$ *for all* $i \in n \setminus j$*, and/or the inward and outward the bilateral iceberg costs are non-identical, such that* $d_{ij} \neq d_{ji} > 1$ *for all* $i \in n \setminus j$*, the gravity equation is subject to the multilateral trade imbalance:*

$$A_{ij,t} = X_{ij,t} \times \frac{Y_t}{Y_{i,t} Y_{j,t}} = \Xi_{j,t} \left[\frac{d_{ij}^{1+\chi_{ij}}}{\Phi_{i,t} \Phi_{i,t-1}^{\chi_{ij}} P_{j,t}} \right]^{1-\eta} \left[\frac{\theta_{i,t-1}^{-\eta}}{A_{ij,t-1}^{1-\eta} Y_{j,t-1}^{1-\eta}} \right]^{\chi_{ij}}, \quad (4)$$

where Y_t *is world income,* $\theta_{i,t} = Y_{i,t}/Y_t$*, while* $P_{j,t}$ *and* $\Phi_{i,t}$ *are the "inward" and "outward" multilateral trade resistance terms, respectively.*

Supply-Habit-Augmented Gravity Equation: Log-Linear

- Taking the natural logs on both sides of (4) gives the theoretically motivated regression model for the dynamic gravity equation:

$$
\begin{aligned}
\ln A_{ij,t} = {} & \underbrace{\chi_{ij}(\eta-1)\ln A_{ij,t-1}}_{\text{size-adjusted bilateral trade flow persistence}} \\
& + \underbrace{\ln(\Xi_{j,t})}_{\text{multilateral trade imbalance}} \\
& + \underbrace{\chi_{ij}\eta\ln Y_{t-1} - \chi_{ij}\eta\ln Y_{i,t-1} + \chi_{ij}(\eta-1)\ln Y_{j,t-1}}_{\text{aggregate income}}, \\
& - \underbrace{(1+\chi_{ij})(\eta-1)\ln d_{ij} + (\eta-1)\ln P_{j,t} + (\eta-1)\ln\Phi_{i,t} + \chi_{ij}(\eta-1)\ln\Phi_{i,t-1}}_{\text{bilateral and multilateral trade resistance}}.
\end{aligned}
$$

- The persistence of the size-adjusted bilateral trade flows $A_{ij,t}$ is increasing in the intensity of supply habits specific to that country-pair $\chi_{ij} > 0$.
- "Outward" multilateral resistance, capturing j's propensity to trade with ROW, is contemporaneous and lagged (i.e., $\Phi_{i,t}$ and $\Phi_{i,t-1}$).
- Size-adjusted bilateral trade flows $A_{ij,t}$ are increasing in destination-specific multilateral trade imbalance $\Xi_{j,t}$.

Nesting "Neo-Classical" Gravity Equation

Corollary

When supply habits are non-zero, but iceberg costs and supply habits are symmetrical across countries, such that $d_{ij} = d_{ji}$ *and* $\chi_{ij} \to \chi > 0$ *for all* $i \in n \setminus j$*, the gravity equation is dynamic, but all global trade flows are balanced, such that:*

$$\begin{aligned}
\lim_{\chi_{ij} \to \chi \, \forall \, i \in n \setminus j} \ln A_{ij,t} = & \chi(\eta - 1) \ln A_{ij,t-1} \\
& - (1 + \chi)(\eta - 1) \ln d_{ij} + (\eta - 1) \ln P_{j,t} \\
& + (\eta - 1) \ln \Phi_{i,t} + \chi(\eta - 1) \ln \Phi_{i,t-1} \\
& + \chi\eta \ln Y_{t-1} - \chi\eta \ln Y_{i,t-1} + \chi(\eta - 1) \ln Y_{j,t-1},
\end{aligned}$$

since $\lim_{\chi_{ij} \to \chi \, \forall \, i \in n \setminus j} \Xi_{j,t} = 1$ *under the assumption that* $d_{ij} = d_{ji}$*.*

Nesting "Static" Gravity Equation

Corollary

When supply habits are infinitesimally weak, such that $\chi_{ij} \rightarrow 0$ *for all* $i \in n \setminus j$*, the gravity equation is static á la Anderson and van Wincoop (2003):*

$$\lim_{\chi_{ij} \rightarrow 0 \, \forall \, i \in n \setminus j} \ln A_{ij,t} = (1-\eta)\left[\ln d_{ij} - \ln \Phi_{i,t} - \ln P_{j,t}\right], \tag{5}$$

since $\lim_{\chi_{ij} \rightarrow 0 \, \forall \, i \in n \setminus j} \Xi_{j,t} = 1$ *assuming that iceberg costs are symmetrical, such that* $d_{ij} = d_{ji}$*, which implies that* $\lim_{\chi_{ij} \rightarrow 0 \, \forall \, i \in n \setminus j} \Phi_{i,t} = P_{i,t}$.

Outline

Unobservable Trade Resistance

- Standard gravity model predicts **time-invariant bilateral trade resistance** (d_{ij}) and **static** "inward" and "outward" **multilateral trade resistance** ($P_{i,t}$ and $P_{j,t}$, respectively).
- Following Feenstra (2016), "FE" panel regression models use **country fixed effects**, **time fixed effects**, and a **pooled coefficient estimator**.
    - If gravity model is dynamic and heterogeneous, pooled coefficient estimates can be biased and inconsistent (Pesaran and Smith (1995)).
    - Time fixed effects ignore likely correlation between unobservable multilateral trade resistance and observable regressors (Anderson and Yotov (2010); Anderson (2011); Kapetanios et al. (2017)).
- Antitheses to FE are the "Mean Group" (MG) and "Common Correlated Pooled" (CCEP) approaches.
    - MG ignores unobservable trade resistance, but **retains parameter heterogeneity** (Pesaran and Smith (1995)).
    - CCEP uses **cross-sectionally averaged observable factors** to proxy unobservable multilateral trade resistance, but applies pooled coefficient estimator (Pesaran (2006)).
- **Our preferred estimator is the "Common Correlated Mean Group" (CCEMG)** (Chudik and Pesaran (2015)), which proxies unobservable multilateral trade resistance like the CCEP and retains parameter heterogeneity like the MG.

Methodology

- The supply-habit-augmented gravity equation (4) is a large N (39) and large T (65 years: 1950-2014) panel regression model. It extends the interactive fixed effects of Bai (2009) into a three-dimensional data structure.
- Our model captures variation over $t = 1, 2, ..., T$ and also spatial variation across the source country $i = 1, 2, ..., N$ and the destination country $j = 1, 2, ..., N - 1$, such that for all $j \neq i$:

$$y_{ij,t} = \mathbf{x}'_{ij,t}\beta_{ij} + u_{ij,t}, \tag{6}$$

$$u_{ij,t} = \boldsymbol{\lambda}'_{ij}\phi_t + \varepsilon_{ij,t}, \tag{7}$$

$$\mathbf{x}_{ij,t} = \gamma'_{ij}\phi_t + \boldsymbol{\nu}_{ij,t}, \tag{8}$$

where $\mathbf{x}_{ij,t} = [\mathrm{FLOW}_{ij,t-1}, \mathrm{TB}_{j,t}, \mathrm{GDP}_{i,t-1}, \mathrm{GDP}_{j,t-1}, \mathrm{GDP}_{t-1}]'$ is a $j \times 1$ vector of all common and country-specific observable factors, $y_{ij,t} := \mathrm{FLOW}_{ij,t}$ are the trade flows, $\beta_{ij} = [\beta_{1ij}, \beta_{2ij}, ..., \beta_{kij}]'$ is a $k \times 1$ vector of coefficients, while ϕ_t and $\boldsymbol{\lambda}_{ij}$, γ_{ij} represent some configuration of the unobservable vector of common factors and country-pair-specific vectors of factor loadings, respectively.

- Note that ϕ_t and $\boldsymbol{\lambda}_{ij}$ encompass time fixed effects, country fixed effects, and country-time fixed effects as **special cases**.

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Appendix

Results: Coefficient Estimates (Baseline)

VARIABLES	**CCEMG** $\text{FLOW}_{ij,t}$	**FE** $\text{FLOW}_{ij,t}$	**MG** $\text{FLOW}_{ij,t}$	**CCEP** $\text{FLOW}_{ij,t}$
$\text{FLOW}_{ij,t-1}$	0.347*** (0.00825)	0.907*** (0.00451)	0.548*** (0.00643)	0.374*** (0.0161)
$\text{TB}_{j,t}$	0.975*** (0.126)	0.219*** (0.0279)	0.803*** (0.0714)	0.612*** (0.0801)
$\text{GDP}_{i,t-1}$	-0.312*** (0.0778)	-0.00174 (0.00749)	-0.183*** (0.0149)	-0.296*** (0.0338)
$\text{GDP}_{j,t-1}$	-0.117 (0.0954)	-0.0239*** (0.00714)	-0.132*** (0.0150)	-0.195 (0.0271)
GDP_{t-1}	0.228 (0.201)	-0.0419 (0.0258)	0.322*** (0.0397)	
Time Fixed Effects	N	Y	N	N
Country/Pair Fixed Effects	Y	Y	N	N
Unobservable Common Factors	Y	N	N	Y

Note: Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Results: Coefficient Estimates

- Trade persistence coefficient decreases nearly three-fold after incorporating **unobservable common factors (UCF)** and departing from pooled coefficient estimators (PE), i.e. **taking fully into account parameter heterogeneity across all country pairs**.
- Trade persistence coefficients in different cases:
  - w/o UCF and w/ PE (i.e., FE): 0.91.
  - **w/ UCF and w/o PE (i.e., CCEMG): 0.35**.
  - w/o UCF and w/o PE (i.e., MG): 0.55.
  - w/ UCF and w/ PE (i.e., CCEP): 0.37.
- **CCEMG predicts unitary trade flow elasticity to multilateral trade imbalance** (i.e., if multilateral trade deficit of the destination country increases, then bilateral trade flows to that destination also increase). The closest alternative is the MG (0.80) while pooled estimators, especially when UCF are not included, shows a very minor role.
- The signs and magnitudes of the theoretical coefficients predicted by the supply-habit-augmented dynamic gravity equation are broadly consistent with the CCEMG coefficient estimates.
- We also conduct a number of checks by e.g. excluding the multilateral trade imbalance (vs. our theoretical model), running a restricted version, re-parameterized version, using different estimnators (e.g. augmented mean group, PPML, hybrid fixed effects) and our main conclusions remain broadly unchanged.

Outline

Horse Race

- Why does trade persistence puzzle matter?
  - Static and neo-classical gravity equations cannot explain **sharp, synchronized, and heterogeneous** trade flow adjustments in response to common shocks (e.g., GTC 2008-09; COVID-19 etc.).
  - But **CCEMG** estimates of supply-habit-augmented gravity equation predict relatively **low trade persistence** compared to the neo-classical gravity model estimated using the FE approach.
- To validate CCEMG approach, for instance over FE, MG, and CCEP strategies, we conduct a predictive performance as a "horse race". Specifically, **we perform three checks based on Root Mean Square Errors (RMSE) by using different possible estimators**:
  1. Calculating RMSE for the full sample.
  2. Calculating RMSE for "good times" and "bad times" based on the full sample estimates.
  3. Re-estimating the coefficients for the sub-samples of "good times" and "bad times" separately, and then calculating RMSE for "good times" and "bad times".
- We find that CCEMG delivers most accurate data fit not only for the entire sample, but also during solely "good times" or "bad times", when compared to the main alternatives.

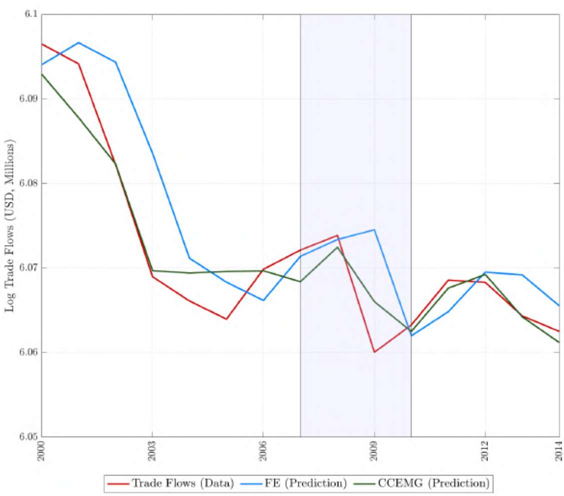
Results: RMSE

Table: Root Mean Square Error

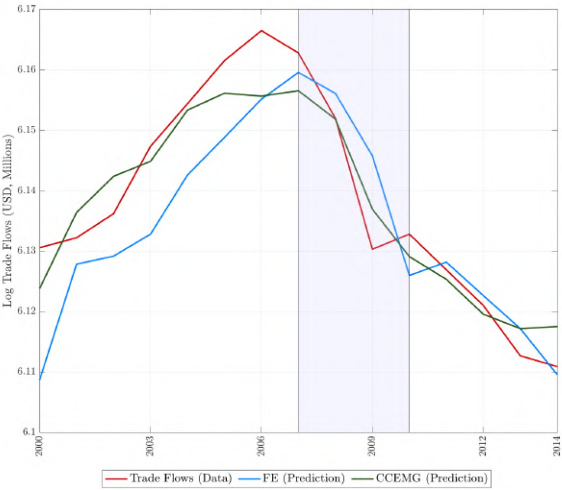
	Full Sample	"Bad Times"			"Good Times"		
Method		$w = 0$	$w = 1$	$w = 3$	$w = 0$	$w = 1$	$w = 3$
CCEMG	**0.38**	**0.41**	**0.41**	**0.41**	**0.38**	**0.37**	**0.35**
MG	0.44	0.50	0.49	0.48	0.44	0.43	0.40
CCEP	0.47	0.47	0.47	0.47	0.43	0.42	0.39
FE	0.55	0.65	0.63	0.59	0.54	0.52	0.49

Note: This figure presents the Root Mean Square Errors (RMSE) calculated using different methods of estimating the coefficients in a dynamic gravity equation. The in-sample RMSEs are presented for the full data sample, the observed "good times", and the observed "bad times" in order to compare different model performance inside and outside of time periods characterized by common (global) trade shocks. Consistent with Kose et al. (2020), the "bad times" represent the global recession years, namely 1975, 1982, 1991, and 2009, while the "good times" are all of the remaining years in our data sample that spans 1950-2014. The term $w = \{0, 1, 2, 3\}$ further indicates the length of the windows surrounding the recession years (i.e., number of years before and after common (global) trade shocks that are included in "bad times" in addition to the recession years). The values in bold indicate the smallest RMSE.

Predicted Size-Adjusted Trade Flows Between USA and China (Log Scale)



Predicted Size-Adjusted Trade Flows Between China and USA (Log Scale)



Outline

Quantifying Supply Habits

- How to measure supply habit parameter χ_{ij}?
  - Trade persistence coefficient $\beta_{1ij} = \chi_{ij}(\eta - 1)$ identifies parameters χ_{ij} and η **jointly**.
  - But the elasticity of substitution $\eta > 0$ is likely to be **country-specific**, since $\chi_{ij} > 0$, yet some β_{1ij} are **negative** (e.g. South Africa).
- Theory of habits in supply chains suggests that χ_{ij} can be mapped to global value chain (GVC) indicators compiled by Casella et al. (2019).
  - Specifically, domestic value-added (DVA) and foreign value-added (FVA) shares of domestic exports, such that DVA + FVA = 1.
  - Distributor technology then implies

$$\mathrm{FVA}_{ij,t} = \frac{X_{ij,t} - M_{ij,t}}{X_{ij,t}} \equiv 1 - x_{ij,t-1}^{-\chi_{ij}} \in [0,1] \bigg|_{\chi_{ij}>0}, \qquad (9)$$

where $X_{ij,t}$ ($M_{ij,t}$) are the nominal trade flows of final (intermediate) goods from origin i to destination j, while $x_{ij,t-1}$ are the analogous lagged real trade flows of final goods.

  - $\mathrm{FVA}_{ij,t}$ ($\mathrm{DVA}_{ij,t}$) is increasing (decreasing) in habit parameter χ_{ij}.

Quantifying Supply Habits (cont'd.)

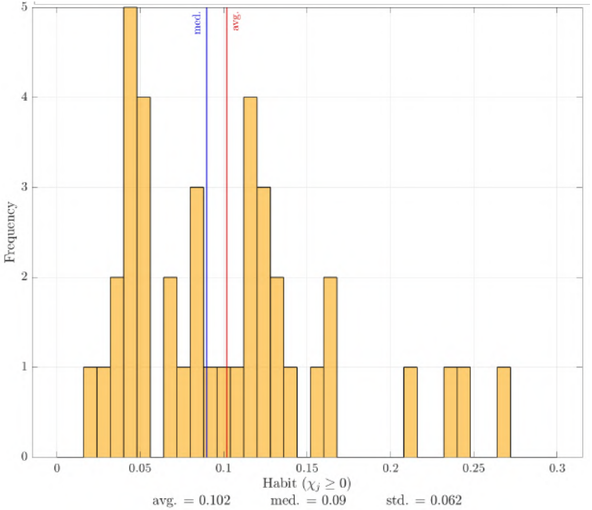
- **How to cross-validate theory of habits in supply chains?**
  1. Constructing χ_{ij} from time-averaged $\text{FVA}_{ij,t}$:

     $$\chi_{ij} = -\frac{\ln\left(1 - \text{FVA}_{ij}\right)}{\ln\left(x_{ij}\right)}, \tag{10}$$

     such that $\lim_{\text{FVA}_{ij,t} \to 0} \chi_{ij} = 0$ (i.e. "made here, sold there" static gravity equation).

  2. Projecting trade persistence coefficient estimates ($\ln \beta_{1ij}$) on model-implied habits ($\ln \chi_{ij}$), country-specific fixed effects, and other control variables, such as geographic distance, shared history, institutions, values, or colonial ties to control for x_{ij} (Eichengreen and Irwin (1998); Mayer and Zignago (2011)).
- We find that trade persistence is positively related to **model-implied supply habits** and **colonial ties**, but negatively to **geographic distance**.

Model-Implied Supply Habits: Country-Specific Averages



Notes: The figure depicts habits derived from averaged domestic value added and trade flows data, as suggested in equation (10). We have used data from 39 countries over the period of 1990-2014.

Results: What Drives Trade Persistence?

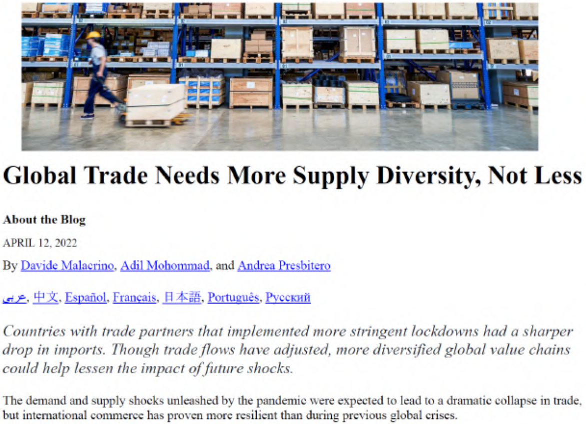
Table: What Drives Bilateral Trade Persistence?

	All	$t_{\beta_{1ij}} > 1.64$	$t_{\beta_{1ij}} > 1.96$	$t_{\beta_{1ij}} > 2.575$
	(1)	(2)	(3)	(4)
VARIABLES	$\ln \beta_{1ij}$	$\ln \beta_{1ij}$	$\ln \beta_{1ij}$	$\ln \beta_{1ij}$
$\ln \chi_{ij}$	-0.0536	0.0242	0.0304	0.0407**
	(0.0463)	(0.0202)	(0.0194)	(0.0202)
Colony	0.568**	0.198	0.122	0.214*
	(0.225)	(0.180)	(0.191)	(0.122)
Common language	0.115*	0.0205	0.0421	0.0134
	(0.0688)	(0.0388)	(0.0357)	(0.0335)
ln(Distance)	-0.101***	-0.0707***	-0.0489***	-0.0490***
	(0.0323)	(0.0174)	(0.0163)	(0.0147)
Constant	-0.404	0.208	0.0557	0.376
	(0.684)	(0.321)	(0.306)	(0.290)
Observations	1,302	923	864	725
R-squared	0.174	0.220	0.234	0.253

Notes: Robust standard errors associated with the Huber/White/sandwich coefficient estimates are displayed in parentheses. All regression models incorporate source- and destination-country-specific fixed effects.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Policy Implications



Global Trade Needs More Supply Diversity, Not Less

About the Blog

APRIL 12, 2022

By Davide Malacrino, Adil Mohommad, and Andrea Presbitero

عربي, 中文, Español, Français, 日本語, Português, Русский

Countries with trade partners that implemented more stringent lockdowns had a sharper drop in imports. Though trade flows have adjusted, more diversified global value chains could help lessen the impact of future shocks.

The demand and supply shocks unleashed by the pandemic were expected to lead to a dramatic collapse in trade, but international commerce has proven more resilient than during previous global crises.

Outline

Introduction

Overview of Literature

Theory

Empirical Analysis

Prediction Performance

Cross Validation

Summary

Future research

Bibliography

Appendix

Summary

- We propose a **theory of habits in supply chains** to explain why common trade shocks cause **sharp, synchronized, but heterogeneous** trade flow adjustments across countries.
- Our theory predicts **heterogeneous bilateral trade persistence**; it nests the static and neo-classical gravity equations as special cases.
- We demonstrate that cross-country **supply habit asymmetry** creates differences in home-bias and generates **multilateral trade imbalances**.
- **Multilateral trade imbalances** in turn explain variation in bilateral trade flows in addition to other standard regressors (e.g., geographic distance, size of economic activity, lagged trade flows etc.).
- Empirical results show two causes of trade persistence predicted by the neo-classical gravity equation:
    1. Ill-suited modelling of **unobservable common factors**;
    2. Inference based on **pooled coefficient estimators**.
- We show that by retaining parameter heterogeneity and approximating unobservable common factors by cross-sectional averages of observable regressors, we obtain the **most accurate prediction** of variation in global trade flows during "good times" and "bad times" alike.

Outline

A few directions of future research

- We document pervasive heterogeneity of the trade persistence coefficients across countries. However, the question of what drives the cross-country differences in the empirical estimates of the trade persistence coefficients remains an open discussion.
- In the end, we call for a more structural approach to tackle the dynamics of the global trade network and heterogeneity in trade elasticities. In particular, we encourage **more research aimed at separating the short- and the long-run run effects in trade elasticities**, which may portray substantial structural heterogeneity, in addition to trade pairs, as is recently illustrated by Boehm et al. (2020)).
- An extension to **functional elasticities**, varying by the GVC participation as well as more elaborate technology to account for the GVC complexity are worth pursuing further.
- Another area that we forfeit to future research is **dynamic non-linear panel regression models**, which would be able to appropriately account for the "zero trade problem", but simultaneously retain parameter heterogeneity and enrich the model specification with unobservable common shocks.

Outline

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Outline

Annex (1)

VARIABLES	**CCEMG** $\widetilde{\text{FLOW}}_{ij,t}$	**FE** $\widetilde{\text{FLOW}}_{ij,t}$	**MG** $\widetilde{\text{FLOW}}_{ij,t}$	**CCEP** $\widetilde{\text{FLOW}}_{ij,t}$
$\widetilde{\text{FLOW}}_{ij,t-1}$	0.447*** (0.00816)	0.908*** (0.00444)	0.528*** (0.00701)	0.451*** (0.0162)
$\text{GDP}_{i,t-1}$	-0.276*** (0.0639)	-0.00189 (0.00753)	-0.211*** (0.0314)	-0.259*** (0.0319)
$\text{GDP}_{j,t-1}$	-0.129 (0.0836)	-0.0354*** (0.00711)	-0.0873*** (0.0267)	-0.145*** (0.0236)
GDP_{t-1}	0.112 (0.112)	-0.0143 (0.0258)	0.397*** (0.0906)	
Time Fixed Effects	N	Y	N	N
Country/Pair Fixed Effects	Y	Y	N	N
Unobservable Common Factors	Y	N	N	Y

Note: Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Annex (2)

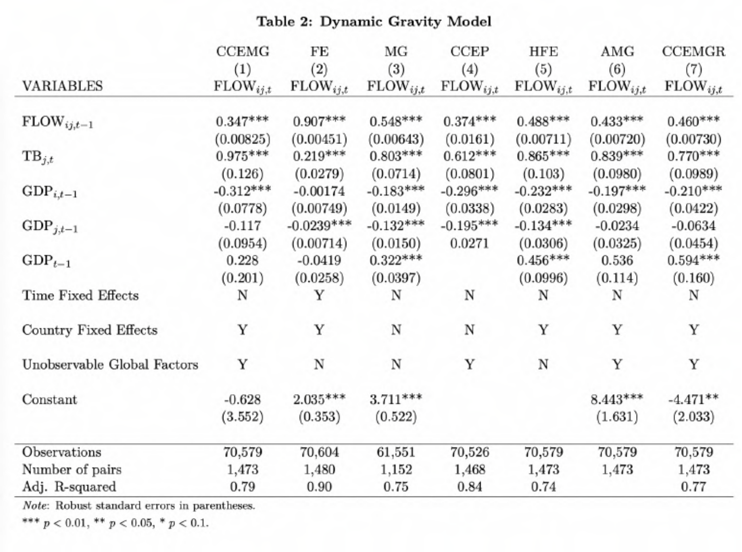

Table 2: Dynamic Gravity Model

	CCEMG	FE	MG	CCEP	HFE	AMG	CCEMGR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	$FLOW_{ij,t}$	$FLOW_{ij,t}$	$FLOW_{ij,t}$	$FLOW_{ij,t}$	$FLOW_{ij,t}$	$FLOW_{ij,t}$	$FLOW_{ij,t}$
$FLOW_{ij,t-1}$	0.347***	0.907***	0.548***	0.374***	0.488***	0.433***	0.460***
	(0.00825)	(0.00451)	(0.00643)	(0.0161)	(0.00711)	(0.00720)	(0.00730)
$TB_{j,t}$	0.975***	0.219***	0.803***	0.612***	0.865***	0.839***	0.770***
	(0.126)	(0.0279)	(0.0714)	(0.0801)	(0.103)	(0.0980)	(0.0989)
$GDP_{i,t-1}$	-0.312***	-0.00174	-0.183***	-0.296***	-0.232***	-0.197***	-0.210***
	(0.0778)	(0.00749)	(0.0149)	(0.0338)	(0.0283)	(0.0298)	(0.0422)
$GDP_{j,t-1}$	-0.117	-0.0239***	-0.132***	-0.195***	-0.134***	-0.0234	-0.0634
	(0.0954)	(0.00714)	(0.0150)	0.0271	(0.0306)	(0.0325)	(0.0454)
GDP_{t-1}	0.228	-0.0419	0.322***		0.456***	0.536	0.594***
	(0.201)	(0.0258)	(0.0397)		(0.0996)	(0.114)	(0.160)
Time Fixed Effects	N	Y	N	N	N	N	N
Country Fixed Effects	Y	Y	N	N	Y	Y	Y
Unobservable Global Factors	Y	N	N	Y	N	Y	Y
Constant	-0.628	2.035***	3.711***			8.443***	-4.471**
	(3.552)	(0.353)	(0.522)			(1.631)	(2.033)
Observations	70,579	70,604	61,551	70,526	70,579	70,579	70,579
Number of pairs	1,473	1,480	1,152	1,468	1,473	1,473	1,473
Adj. R-squared	0.79	0.90	0.75	0.84	0.74		0.77

Note: Robust standard errors in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Annex (3)

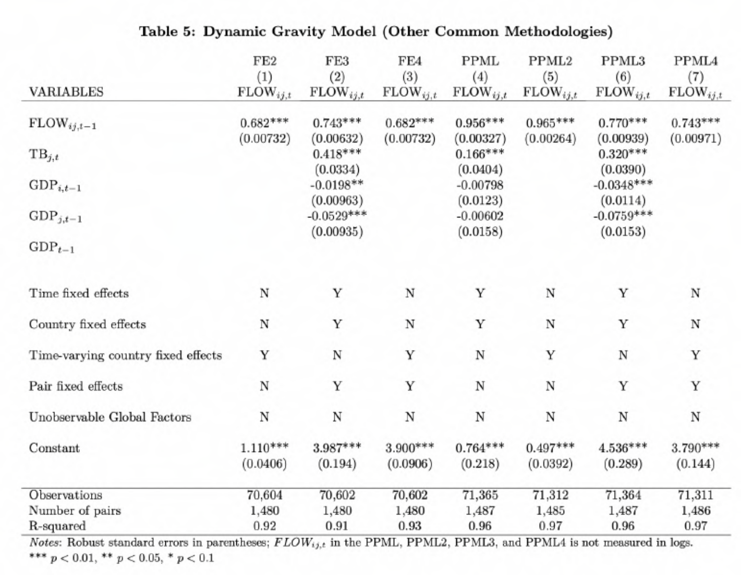

Table 5: Dynamic Gravity Model (Other Common Methodologies)

	FE2	FE3	FE4	PPML	PPML2	PPML3	PPML4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	$\text{FLOW}_{ij,t}$	$\text{FLOW}_{ij,t}$	$\text{FLOW}_{ij,t}$	$\text{FLOW}_{ij,t}$	$\text{FLOW}_{ij,t}$	$\text{FLOW}_{ij,t}$	$\text{FLOW}_{ij,t}$
$\text{FLOW}_{ij,t-1}$	0.682***	0.743***	0.682***	0.956***	0.965***	0.770***	0.743***
	(0.00732)	(0.00632)	(0.00732)	(0.00327)	(0.00264)	(0.00939)	(0.00971)
$\text{TB}_{j,t}$		0.418***		0.166***		0.320***	
		(0.0334)		(0.0404)		(0.0390)	
$\text{GDP}_{i,t-1}$		-0.0198**		-0.00798		-0.0348***	
		(0.00963)		(0.0123)		(0.0114)	
$\text{GDP}_{j,t-1}$		-0.0529***		-0.00602		-0.0759***	
		(0.00935)		(0.0158)		(0.0153)	
GDP_{t-1}							
Time fixed effects	N	Y	N	Y	N	Y	N
Country fixed effects	N	Y	N	Y	N	Y	N
Time-varying country fixed effects	Y	N	Y	N	Y	N	Y
Pair fixed effects	N	Y	Y	N	N	Y	Y
Unobservable Global Factors	N	N	N	N	N	N	N
Constant	1.110***	3.987***	3.900***	0.764***	0.497***	4.536***	3.790***
	(0.0406)	(0.194)	(0.0906)	(0.218)	(0.0392)	(0.289)	(0.144)
Observations	70,604	70,602	70,602	71,365	71,312	71,364	71,311
Number of pairs	1,480	1,480	1,480	1,487	1,485	1,487	1,486
R-squared	0.92	0.91	0.93	0.96	0.97	0.96	0.97

Notes: Robust standard errors in parentheses; $FLOW_{ij,t}$ in the PPML, PPML2, PPML3, and PPML4 is not measured in logs.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Annex (4)

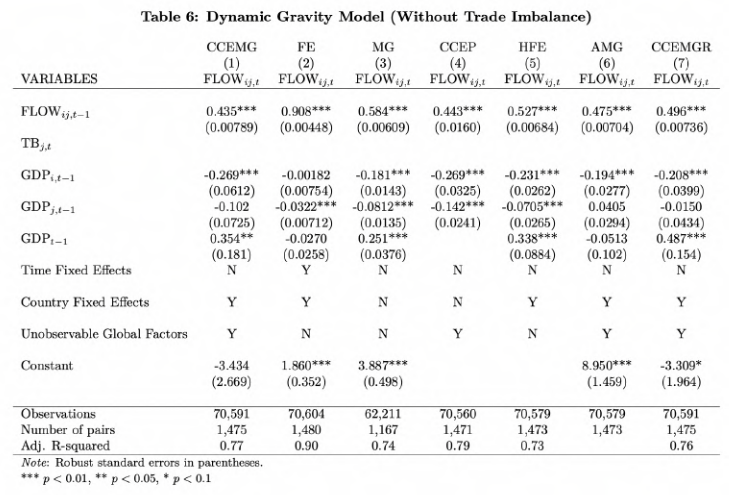

Table 6: Dynamic Gravity Model (Without Trade Imbalance)

VARIABLES	CCEMG (1) $\text{FLOW}_{ij,t}$	FE (2) $\text{FLOW}_{ij,t}$	MG (3) $\text{FLOW}_{ij,t}$	CCEP (4) $\text{FLOW}_{ij,t}$	HFE (5) $\text{FLOW}_{ij,t}$	AMG (6) $\text{FLOW}_{ij,t}$	CCEMGR (7) $\text{FLOW}_{ij,t}$
$\text{FLOW}_{ij,t-1}$	0.435***	0.908***	0.584***	0.443***	0.527***	0.475***	0.496***
	(0.00789)	(0.00448)	(0.00609)	(0.0160)	(0.00684)	(0.00704)	(0.00736)
$\text{TB}_{j,t}$							
$\text{GDP}_{i,t-1}$	-0.269***	-0.00182	-0.181***	-0.269***	-0.231***	-0.194***	-0.208***
	(0.0612)	(0.00754)	(0.0143)	(0.0325)	(0.0262)	(0.0277)	(0.0399)
$\text{GDP}_{j,t-1}$	-0.102	-0.0322***	-0.0812***	-0.142***	-0.0705***	0.0405	-0.0150
	(0.0725)	(0.00712)	(0.0135)	(0.0241)	(0.0265)	(0.0294)	(0.0434)
GDP_{t-1}	0.354**	-0.0270	0.251***		0.338***	-0.0513	0.487***
	(0.181)	(0.0258)	(0.0376)		(0.0884)	(0.102)	(0.154)
Time Fixed Effects	N	Y	N	N	N	N	N
Country Fixed Effects	Y	Y	N	N	Y	Y	Y
Unobservable Global Factors	Y	N	N	Y	N	Y	Y
Constant	-3.434	1.860***	3.887***			8.950***	-3.309*
	(2.669)	(0.352)	(0.498)			(1.459)	(1.964)
Observations	70,591	70,604	62,211	70,560	70,579	70,579	70,591
Number of pairs	1,475	1,480	1,167	1,471	1,473	1,473	1,475
Adj. R-squared	0.77	0.90	0.74	0.79	0.73		0.76

Note: Robust standard errors in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Annex (5)

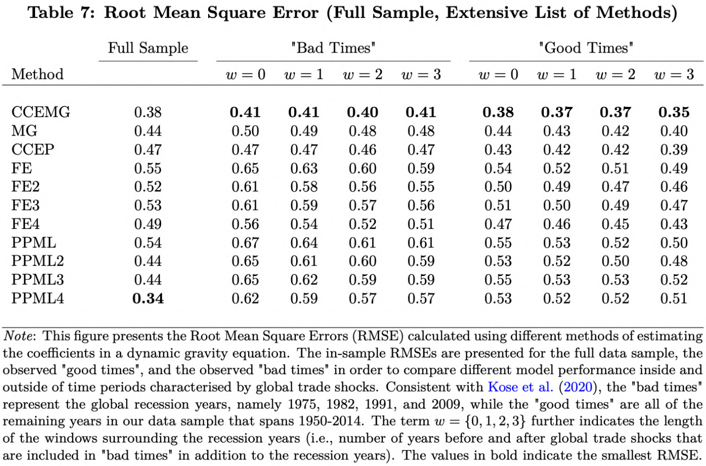

Table 7: Root Mean Square Error (Full Sample, Extensive List of Methods)

Method	Full Sample	"Bad Times" $w=0$	"Bad Times" $w=1$	"Bad Times" $w=2$	"Bad Times" $w=3$	"Good Times" $w=0$	"Good Times" $w=1$	"Good Times" $w=2$	"Good Times" $w=3$
CCEMG	0.38	**0.41**	**0.41**	**0.40**	**0.41**	**0.38**	**0.37**	**0.37**	**0.35**
MG	0.44	0.50	0.49	0.48	0.48	0.44	0.43	0.42	0.40
CCEP	0.47	0.47	0.47	0.46	0.47	0.43	0.42	0.42	0.39
FE	0.55	0.65	0.63	0.60	0.59	0.54	0.52	0.51	0.49
FE2	0.52	0.61	0.58	0.56	0.55	0.50	0.49	0.47	0.46
FE3	0.53	0.61	0.59	0.57	0.56	0.51	0.50	0.49	0.47
FE4	0.49	0.56	0.54	0.52	0.51	0.47	0.46	0.45	0.43
PPML	0.54	0.67	0.64	0.61	0.61	0.55	0.53	0.52	0.50
PPML2	0.44	0.65	0.61	0.60	0.59	0.53	0.52	0.50	0.48
PPML3	0.44	0.65	0.62	0.59	0.59	0.55	0.53	0.53	0.52
PPML4	**0.34**	0.62	0.59	0.57	0.57	0.53	0.52	0.52	0.51

Note: This figure presents the Root Mean Square Errors (RMSE) calculated using different methods of estimating the coefficients in a dynamic gravity equation. The in-sample RMSEs are presented for the full data sample, the observed "good times", and the observed "bad times" in order to compare different model performance inside and outside of time periods characterised by global trade shocks. Consistent with Kose et al. (2020), the "bad times" represent the global recession years, namely 1975, 1982, 1991, and 2009, while the "good times" are all of the remaining years in our data sample that spans 1950-2014. The term $w = \{0, 1, 2, 3\}$ further indicates the length of the windows surrounding the recession years (i.e., number of years before and after global trade shocks that are included in "bad times" in addition to the recession years). The values in bold indicate the smallest RMSE.

Annex (6)

Table 8: Root Mean Square Error (Sub-Samples, Extensive List of Methods)

	Full Sample	"Bad Times"				"Good Times"			
Method		$w = 0$	$w = 1$	$w = 2$	$w = 3$	$w = 0$	$w = 1$	$w = 2$	$w = 3$
CCEMG	0.38	-	**0.09**	**0.26**	**0.32**	0.37	0.34	**0.30**	**0.25**
MG	0.44	-	0.32	0.39	0.42	0.43	0.41	0.39	0.33
CCEP	0.47	-	-	0.44	0.47	0.46	0.44	0.42	0.38
FE	0.55	0.65	0.62	0.60	0.59	0.54	0.52	0.51	0.49
FE2	0.52	0.62	0.60	0.58	0.57	0.52	0.50	0.49	0.47
FE3	0.53	0.60	0.60	0.57	0.57	0.52	0.50	0.49	0.47
FE4	0.49	0.57	0.56	0.54	0.53	0.49	0.47	0.46	0.44
PPML	0.54	0.53	0.70	0.64	0.60	0.54	0.49	0.49	0.49
PPML2	0.44	0.50	0.60	0.54	0.51	0.44	0.40	0.40	0.39
PPML3	0.44	0.37	0.44	0.44	0.43	0.43	0.40	0.39	0.47
PPML4	**0.34**	**0.35**	0.35	0.35	0.34	**0.34**	**0.32**	0.31	0.44

Note: This figure presents the Root Mean Square Errors (RMSE) calculated using different methods of estimating the coefficients in a dynamic gravity equation. The in-sample RMSEs are presented for the full data sample, the observed "good times", and the observed "bad times" in order to compare different model performance inside and outside of time periods characterised by global trade shocks. Consistent with Kose et al. (2020), the "bad times" represent the global recession years, namely 1975, 1982, 1991, and 2009, while the "good times" are all of the remaining years in our data sample that spans 1950-2014. The term $w = \{0, 1, 2, 3\}$ further indicates the length of the windows surrounding the recession years (i.e., number of years before and after global trade shocks that are included in "bad times" in addition to the recession years). The values in bold indicate the smallest RMSE.

Annex (7)

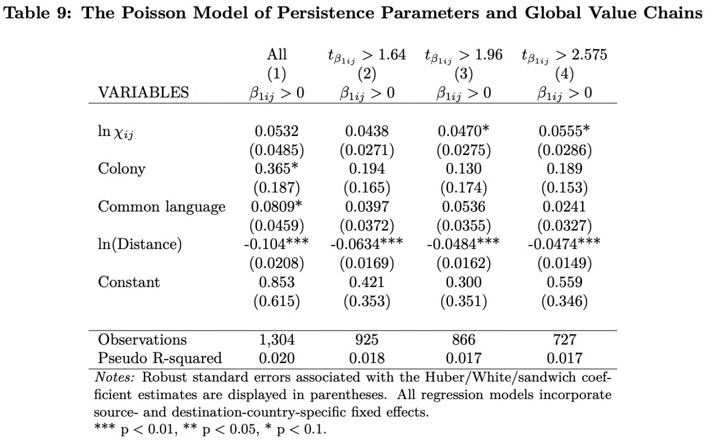

Table 9: The Poisson Model of Persistence Parameters and Global Value Chains

	All	$t_{\beta_{1ij}} > 1.64$	$t_{\beta_{1ij}} > 1.96$	$t_{\beta_{1ij}} > 2.575$
	(1)	(2)	(3)	(4)
VARIABLES	$\beta_{1ij} > 0$	$\beta_{1ij} > 0$	$\beta_{1ij} > 0$	$\beta_{1ij} > 0$
$\ln \chi_{ij}$	0.0532	0.0438	0.0470*	0.0555*
	(0.0485)	(0.0271)	(0.0275)	(0.0286)
Colony	0.365*	0.194	0.130	0.189
	(0.187)	(0.165)	(0.174)	(0.153)
Common language	0.0809*	0.0397	0.0536	0.0241
	(0.0459)	(0.0372)	(0.0355)	(0.0327)
ln(Distance)	-0.104***	-0.0634***	-0.0484***	-0.0474***
	(0.0208)	(0.0169)	(0.0162)	(0.0149)
Constant	0.853	0.421	0.300	0.559
	(0.615)	(0.353)	(0.351)	(0.346)
Observations	1,304	925	866	727
Pseudo R-squared	0.020	0.018	0.017	0.017

Notes: Robust standard errors associated with the Huber/White/sandwich coefficient estimates are displayed in parentheses. All regression models incorporate source- and destination-country-specific fixed effects.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.