Appendix

Both Experience Measures

Table A1 presents OLS estimates with both experience measures, with and without the pair-specific trends. When the two are used in conjunction, the coefficient estimates become unstable and very dependent upon whether or not we use pair-specific trends. The coefficient on experience measured as past trade flips signs from positive to negative (compare Column 2 to Column 1 and Column 4 to Column 3). While the coefficient on experience measured as number of years of positive trade is always positive and significant, we see a 5-fold increase in the presence of pair-specific trends. Given that the correlation between the two experience measures is 0.93, such unstable estimates are consistent with multicollinearity. Therefore, it is better to use the experience measures in lieu of each other (as we do in the main paper) and not in conjunction.

Table A1: Experience and Bilateral Exports: Both Experience Measures

	(1) OLS No trend	(2) OLS Trend	(3) OLS No trend	(4) OLS Trend
Experience (time)	0.100***	0.498***	0.078***	0.355***
	(0.017)	(0.021)	(0.014)	(0.025)
Experience (value)	0.053***	-0.014***	0.007***	-0.022***
	(0.002)	(0.002)	(0.002)	(0.002)
Both in GATT/WTO	0.123***	0.008	0.049***	0.004
	(0.030)	(0.029)	(0.017)	(0.021)
PTA	0.538***	0.125***	0.282***	0.111***
	(0.029)	(0.027)	(0.015)	(0.018)
GSP	0.158***	0.239***	0.010	0.121***
	(0.041)	(0.041)	(0.021)	(0.028)
Currency Union	0.218***	0.251***	0.166***	0.188***
	(0.069)	(0.064)	(0.034)	(0.041)
$\ln X_{od,t-1}$			0.522***	0.368***
			(0.003)	(0.003)
Exporter-year fixed effects	Yes	Yes	Yes	Yes
Importer-year fixed effects	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes
Pair specific trends	No	Yes	No	Yes
Observations	642,993	642,993	568,562	568,562
R-squared	0.852	0.891	0.900	0.916

Standard errors clustered on country-pair; *** p<0.01, ** p<0.05, * p<0.1; Experience (time) measures experience as the number of years of strictly positive bilateral exports; Experience (value) measures experience as cumulated past value of bilateral exports

Estimates With Lagged Dependent Variable and Without Pair-Specific Fixed Effects

The Least Squares Dummy Variables estimator is inconsistent in the presence of lagged dependent variables. However, when the number of time periods is large, as is the case here, this bias goes to zero. For the dynamic panel estimator if $\hat{a}$ is the estimate of the coefficient on the lagged dependent variable, then from Nickell (1981) $\lim_{N\to\infty}(\hat{a}-a) = -\frac{(1+a)}{(T-1)}$ where *N* is the number of country-pairs and *T* is the number of time periods. Since we have an unbalanced panel, we can calculate this at the

median value of T = 39 across country-pairs. Using the formula, the bias is quite minimal. For instance, if a = 0.7 then the bias is -0.04.

As a robustness check, we also estimate specifications that include the lagged dependent variable but without any pair-specific fixed effects. These are shown in Table A2 below where Columns 3 and 4 add pair-specific trends to Columns 1 and 2. The coefficient on both experience measures are positive and significant, and the coefficient on experience measured in years are comparable to the estimates in Table 1.

Table A2: Experience and Bilateral Exports (Without Pair-Specific Fixed Effects)

	(1) OLS No trend	(2) OLS No Trend	(3) OLS Trend	(4) OLS Trend
Experience (time)	0.315***		0.121***	
	(0.005)		(0.011)	
Experience (value)		0.246***		0.066***
		(0.003)		(0.005)
Both in GATT/WTO	0.093***	0.069***	0.049***	0.049***
	(0.011)	(0.010)	(0.017)	(0.017)
PTA	0.474***	0.381***	0.278***	0.269***
	(0.011)	(0.010)	(0.015)	(0.015)
GSP	-0.058***	-0.029***	0.012	0.011
	(0.011)	(0.011)	(0.022)	(0.022)
Currency Union	0.355***	0.232***	0.172***	0.159***
	(0.021)	(0.018)	(0.035)	(0.033)
$\ln X_{od,t-1}$	0.781***	0.640***	0.522***	0.505***
	(0.002)	(0.003)	(0.003)	(0.003)
Exporter-year fixed effects	Yes	Yes	Yes	Yes
Importer-year fixed effects	Yes	Yes	Yes	Yes
Pair fixed effects	No	No	No	No
Pair specific trends	No	No	Yes	Yes
Observations	568,562	568,562	568,562	568,562
R-squared	0.88	0.88	0.90	0.90

Standard errors clustered on country-pair; *** p<0.01, ** p<0.05, * p<0.1; Experience (time) measures experience as the number of years of strictly positive bilateral exports; Experience (value) measures experience as cumulated past value of bilateral exports

PPML Estimates With Lagged Dependent Variable

Introducing dynamics into a standard Poisson model is non-trivial since the conditional mean is required to remain positive. The results, as Blundell et al. (2002) point out, hinge critically on the functional form of the lagged dependent variable in the exponential function for the conditional mean. We experimented with three specifications of the lagged dependent variable shown in Table A3 (with experience measured as years of positive trade) and Table A4 with (experience measured as past cumulated trade).

Columns 1 and 1' in Tables A3 and A4 present PPML estimates with the lagged levels of bilateral trade as an additional explanatory variable. As highlighted in Blundell et al. (2002), using levels of the lagged dependent variable can potentially lead to an explosive series and issues of convergence. We do encounter this issue. We fail to obtain convergence with experience is measured as past trade, when we include pair-specific trends (Column 1' in Table A4).

Columns 2 and 2' in Tables A3 and A4 use a log-transformation of the lagged dependent variable. However, the use of the lagged log-transformation will continue to drop a substantial fraction of zeros (though not all) in the trade matrix. For instance, in an OLS specification with logged trade that simply drops zeros, the number of observations equals 568,562 (Column 2 of Table 1 in the main paper). In the Poisson specification with lagged log of the dependent variable, the number of observations equals 616,524. In both cases, we fail to account for zeros in the trade matrix.

A third alternative is to use the inverse hyperbolic transformation, but this again creates convergence issues in some specifications. These results are shown in Columns 3 and 3' of Tables A3 and A4 below. In specifications with pair-specific trends---in both Tables A3 and A4---PPML does not converge.[1]

Table A3: Experience (Years) and Bilateral Exports: PPML with lagged dependent variable

	(1) Lagged level	(1') Lagged level	(2) Lagged log	(2') Lagged log	(3) Inverse hyperbolic	(3') Inverse hyperbolic
Experience as years ($E_{od,t}^{time}$)	0.527***	0.691***	-0.091***	-0.047	-0.236***	No
	(0.071)	(0.076)	(0.022)	(0.044)	(0.050)	Convergence
WTO	-0.125	-0.240***	0.010	-0.080***	-0.014	
	(0.080)	(0.075)	(0.019)	(0.029)	(0.030)	
PTA	0.261***	0.084***	0.088***	0.050***	0.123***	
	(0.036)	(0.026)	(0.010)	(0.012)	(0.015)	
GSP	-0.119*	-0.296***	-0.042***	-0.103***	-0.062**	
	(0.063)	(0.051)	(0.016)	(0.024)	(0.025)	
Currency Union	-0.007	0.038	0.010	0.025*	0.009	
	(0.039)	(0.031)	(0.010)	(0.014)	(0.015)	
$X_{od,t-1}$	1.35E-12***	1.10E-12				
	(3.50E-13)	(8.58E-13)				
$\ln X_{od,t-1}$			0.726***	0.568		
			(0.006)	(0.007)		
Inverse hyperbolic transformed $X_{od,t-1}$					0.567***	
					(0.020)	
Exporter-year fixed effects	Yes	Yes	Yes	Yes	Yes	
Importer-year fixed effects	Yes	Yes	Yes	Yes	Yes	
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Pair specific trends	No	Yes	No	Yes	No	Yes
Observations	1,061,011	1,061,278	616,524	616,364	1,063,214	
R-squared	0.99	0.99	0.99	0.99	0.99	

Standard errors clustered on country-pair; *** p<0.01, ** p<0.05, * p<0.1; Experience (time) measures experience as number of years of strictly positive bilateral exports.

We obtain similar unreliable estimates if we measure experience in terms of cumulated past trade (see Table A3 below). Two of the specifications fail to converge. Additionally, the PPML

[1] We also encounter non-convergence in a specification without pair-specific fixed effects (not shown).

specifications with the lagged log of the dependent variable have almost the same number of observations as the OLS specification.

Table A4: Experience (Past Trade) and Bilateral Exports: PPML with lagged dependent variable

	(1) Lagged level	(1') Lagged level	(2) Lagged log	(2') Lagged log	(3) Inverse hyperbolic	(3') Inverse hyperbolic
Experience as past trade ($E_{od,t}^{value}$)	0.597***	No	-0.005	-0.209***	-0.022	No
	(0.041)	Convergence	(0.009)	(0.013)	(0.044)	Convergence
WTO	-0.005		0.013	-0.113***	-0.008	
	(0.051)		(0.019)	(0.032)	(0.032)	
PTA	0.210***		0.091***	0.041***	0.130***	
	(0.027)		(0.010)	(0.012)	(0.015)	
GSP	-0.120***		-0.041***	-0.109***	-0.060**	
	(0.043)		(0.016)	(0.023)	(0.025)	
Currency Union	-0.009		0.009	0.019	0.008	
	(0.027)		(0.010)	(0.014)	(0.016)	
$X_{od,t-1}$	3.31e-14					
	(3.07e-13)					
$\ln X_{od,t-1}$			0.728***	0.622***		
			(0.007)	(0.008)		
Inverse hyperbolic transformed $X_{od,t-1}$					0.574***	
					(0.019)	
Exporter-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Importer-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Pair specific trends	No	Yes	No	Yes	No	Yes
Observations	1,063,333		616,524	616,444	1,063,199	
R-squared	0.99		0.99	0.99	0.99	

Standard errors clustered on country-pair; *** p<0.01, ** p<0.05, * p<0.1; Experience (value) measures experience as cumulated past value of bilateral exports.

When both experience measures are used in conjunction, the coefficient estimates on experience measured in terms of number of years of positive trade is comparable to estimates in Table 2 of the main paper. However, we do not obtain convergence when we use the inverse hyperbolic transformation (Column 5 in Table A5).

Table A5: Both Experience Measures: PPML with lagged dependent variable

	(1) No lags	(2) Lagged level	(3) Lagged log	(4) Inverse hyperbolic
Experience as years ($E_{od,t}^{time}$)	0.414***	0.412***	0.148***	No convergence
	(0.093)	(0.092)	(0.056)	
Experience as past trade ($E_{od,t}^{value}$)	0.034***	0.034***	-0.022***	
	(0.008)	(0.008)	(0.003)	
WTO	-0.231***	-0.231***	-0.082***	
	(0.073)	(0.073)	(0.029)	
PTA	0.081***	0.083***	0.050***	
	(0.026)	(0.026)	(0.012)	
GSP	-0.292***	-0.296***	-0.100***	
	(0.051)	(0.051)	(0.024)	
Currency Union	0.041	0.039	0.025*	
	(0.031)	(0.031)	(0.014)	
$X_{od,t-1}$		1.10e-12		
		(8.47e-13)		
$\ln X_{od,t-1}$			0.570***	
			(0.007)	
Inverse hyperbolic transformed $X_{od,t-1}$				
Exporter-year fixed effects	Yes	Yes	Yes	Yes
Importer-year fixed effects	Yes	Yes	Yes	Yes
Pair fixed effects	Yes	Yes	Yes	Yes
Pair specific trends	Yes	Yes	Yes	Yes
Observations	1,060,492	1,060,493	616,358	
R-squared	0.99	0.99	0.99	

Standard errors clustered on country-pair; *** p<0.01, ** p<0.05, * p<0.1; Experience (time) measures experience as number of years of strictly positive bilateral exports; Experience (value) measures experience as cumulated past value of bilateral exports.

Dynamic panel models within a Poisson specification encounter an important issue highlighted by Wooldridge (2005) – the initial conditions problem. Dynamic panel models require additional assumptions about the relationship between the initial observations ("initial conditions") on trade in levels and the pair-specific fixed effects. Unlike linear models with lagged dependent variables where first-differencing (e.g., Arellano-Bond) eliminates these unobserved time-invariant terms, there are no known transformations in the Poisson model that eliminates the unobserved fixed effects. This is in addition to the standard Nickell bias problem.

Wooldridge (2005) specifies a conditional distribution for the unobserved heterogeneity and uses a random-effects model to accommodate the initial conditioning. But this does not resolve the heteroskedasticity bias, the key advantage of the PPML estimator. Moreover, Wooldridge warns that misspecification of this distribution generally results in inconsistent parameter estimates.

In the existing trade literature, a few papers estimate a dynamic gravity model. On example is Olivero and Yotov (2012). However, when including a lagged dependent variable, they only use OLS. They note that "Unfortunately, we cannot apply the PPML estimator directly, owing to the complex non-linear structure of our model." Anderson and Yotov (2020) estimate a short-run gravity model that allows for lags. They use exactly one specification (Column 2 of Table 2 in the paper) that has a lagged dependent variable (lagged log of bilateral trade) within a PPML specification without pair-fixed effects. In this specification, some coefficients have the wrong signs (e.g., tariffs have a positive sign). Others are insignificant (contiguity, common language) or implausibly small (the coefficient on PTA). When they deploy pair-fixed effects with the lagged dependent variable, they revert to the OLS formulation, where the results are more reasonable (tariffs become negative and significant; FTA coefficient increases). In their working paper version, they do not have any PPML specification with a lagged dependent variable.

Overall, a PPML specification with a lagged dependent variable within a gravity setting does not have a reliable solution yielding consistent estimates. Therefore, in our main paper, we choose to report the PPML specification without a lagged dependent variable.

References

Anderson, J.E. and Yotov, Y.V., 2020. Short run gravity. *Journal of International Economics*, 126.

Blundell, R., Griffith, R., & Windmeijer, F. (2002). Individual effects and dynamics in count data models. *Journal of Econometrics*, 108(1), 113-131.

Olivero, M.P. and Yotov, Y.V., 2012. Dynamic gravity: endogenous country size and asset accumulation. *Canadian Journal of Economics*, 45(1), pp.64-92.

Wooldridge, J. (2005). Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity. *Journal of Applied Econometrics*, 20, 39-54.