Department of Economics
Working Paper No. 256

Trade Balance Dynamics and Exchange Rates: In Search of the J-Curve Using a Structural Gravity Approach

Harald Badinger
Aurélien Fichet de Clairfontaine

January 2018

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Harald Badinger[†] and Aurélien Fichet de Clairfontaine[‡]

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Abstract

This paper uses a structural gravity approach, specifying currency movements as trade cost component to derive an empirical trade balance model, which incorporates multilateral resistance terms and accounts for the cross-country variation in the exchange rate pass-through into import and export prices. The model is estimated using quarterly bilateral trade flows between 47 countries over the period 2010Q1-2017Q2, disaggregated into 97 commodity groups. Our results support the existence of an "aggregate" J-curve, pooled over commodity groups; at the same time they point to considerable heterogeneity in the trade balance dynamics across industries below the surface of aggregate data.

Keywords: Exchange Rate Variations · Gravity · J-curve · Trade Balance

JEL Classification: F12 · F31 · F32

*The authors wish to thank the participants at the ISWG-Workshop (WIFO, Vienna, Austria), XX Encuentro de Economía Aplicada (Valencia, Spain) and at the GfR Winter Seminar (Spital am Pyhrn, Austria) for their helpful comments.

† *Affiliation:* WU Vienna, Department of Economics, Austrian Institute of Economic Research (WIFO), and CESifo. *Address:* Welthandelsplatz 1, A-1020 Vienna, Austria. E-mail: harald.badinger@wu.ac.at.

‡ *Affiliation:* WU Vienna, Department of Economics, *Address:* Welthandelsplatz 1, A-1020 Vienna, Austria. E-mail: afichet@wu.ac.at.

1 Introduction

The prevalence of large and persistent global imbalances is seen as a major threat to the stability of the world economic system. Hence, identifying and quantifying the effects of the main determinants of the current (and financial) account is an issue that is repeatedly raised to the fore in both academic and public debates. The exchange rate, as most important single price of an economy and crucial determinant of relative prices between domestic and foreign goods, is one key factor influencing global imbalances. In policy discussions of bilateral imbalances, the allegation of exchange rate manipulation and demands for realignments can be observed quite frequently.

From a theoretical perspective, the standard Marshall-Lerner condition specifies when a depreciation leads to an improvement of the trade balance, assuming perfect competition, rigid prices, complete exchange rate pass-through and infinite export supply elasticities. It reveals that a depreciation has three effects: a price effect, since imports become more expensive, and quantity responses of exports and imports due to changes in their relative prices. This basic insight also holds true under more general assumptions.

The price effect typically materializes more quickly than the quantity effects. As a consequence, a depreciation may lead to an incipient deterioration of the trade balance, which subsequently turns into a positive effect after the quantity effects have worked themselves out. This gives rise to a J-curve effect of a depreciation on the trade balance (or an inverted J-curve effect of an appreciation on the trade balance).

The J-curve phenomenon and the "sluggishness of quantity" was first considered in detail by Magee (1973). Till the late 1980s, the J-curve hypothesis has then been repeatedly tested using aggregate trade data, investigating the link between a country's real effective exchange rate and its trade balance vis-à-vis its most important trading partners using time-series techniques (e.g., Bahmani-Oskooee, 1985; Himarios, 1985). These type of studies, which show mixed results on the presence of J-curves, were criticized for being potentially subject to an aggregation bias that conceals effects taking place at the bilateral level (Bahmani-Oskooee and Brooks, 1999).

Rose and Yellen (1989) were the first to use bilateral trade data and test the J-curve hypothesis for country pairs, utilizing cointegration techniques proposed by Engle and Granger (1987), but they find no support for the presence of a J-curve. More recent studies make use of an error-correction version of an autoregressive distributed lag (ARDL) model, suggested by Pesaran et al. (2001). Overall, as suggested by the comprehensive survey by Bahmani-Oskooee and Ratha (2004), the empirical evidence on the existence of a J-curve is rather mixed.

The most widely used models for the analysis of trade balance dynamics strongly resemble early empirical gravity equations by relating the export-import ratio to relative economic size (proxied by GDP) and the (real) exchange rate. Additional (ad-hoc) variables included in previous studies are GDP growth, government consumption or the level of high-powered money (see Bahmani-Oskooee and Ratha, 2004).

A shortcoming even of recent studies on trade balance dynamics is that they do not reflect the considerable progress that has been made in the gravity literature, which emphasizes the importance of multilateral resistance terms (Anderson and Van Wincoop, 2003) and incorporates the exchange rate (and its pass-through) as trade cost component (Anderson et al., 2016). This widespread lack of a rigorous theoretical foundation may be an explanation for the mixed or negative results about the presence of a J-curve in the vast majority of previous studies.

The present paper addresses these shortcomings by setting up a trade balance model that builds on a structural gravity model, shifting the focus from a bilateral to a multilateral analysis, accounting for third-country effects and incorporating cross-country differences in the exchange rate pass-through. The empirical model is tested for a comprehensive and recent dataset over the period 2010-2017, including quarterly observations on bilateral trade flows between 47 (mainly OECD) countries, disaggregated into 97 commodity groups, with a total of up to $64,860$ observations per commodity group.

We find that, when pooling across commodity groups, the trade balance deteriorates over the first two quarters following a depreciation. This effect persists for four quarters and is then followed by a trade balance improvement in the long-run, thus providing evidence for an "aggregate" J-curve. The results of the estimates for the 97 commodity groups are less clear-cut and show considerable heterogeneity, though their average closely resembles the results from the pooled estimation.

The remainder of the paper is structured as follows: Section 2 reviews a theoretically founded gravity model with exchange rate effects. Section 3 sets up a closely related, gravity based short- and long-run trade balance model. Section 4 presents the results from testing the J-curve hypothesis based on the corresponding empirical model, both pooled across and disaggregated for 97 commodity groups. Section 5 concludes.

2 Gravity and Exchange Rates as Determinants of Trade Costs

In this section we consider a structural gravity model including the exchange rate, which builds the backbone of our empirical analysis.

The Basic Gravity Model

Specifically, our analysis builds on Anderson and Van Wincoop (2003). They use a multi-country monopolistic competition model to derive a gravity equation, which implies that the export shipment from country i to country j for commodity k at time t ($\bar{X}^k_{ijt}$) is given by

$$\bar{X}^k_{ijt} = Y^k_t s^k_{it} b^k_{jt} \left(\frac{t^k_{ijt}}{\Pi^k_{it} P^k_{jt}} \right)^{1-\sigma_k}, \tag{1}$$

where the bar over the dependent variable is meant to indicate that Eq. (1) describes an equilibrium outcome for period t; Y^k_t is world exports of commodity (group) k, s^k_{it} and b^k_{jt} are the shares of countries i and j in world output of commodity k (corresponding to their predicted trade shares in a frictionless world economy), the variable t_{ijt}^k depicts iceberg-type bilateral trade costs (equal to one under frictionless trade), and σ_k is the elasticity of substitution parameter. Finally, Π_{it}^k and P_{jt}^k are the exporter (outward) and importer (inward) multilateral trade resistance terms (henceforth MRT), respectively, defined as

$$(\Pi_{it}^k)^{1-\sigma_k} = \sum_j \left(\frac{t_{ijt}^k}{P_{jt}^k} \right)^{1-\sigma_k} b_{jt}^k \quad \text{and} \quad (P_{jt}^k)^{1-\sigma_k} = \sum_i \left(\frac{t_{ijt}^k}{\Pi_{it}^k} \right)^{1-\sigma_k} s_{it}^k, \tag{2}$$

i.e., they can be regarded as income-share weighted average of the exporter's and importer's bilateral resistances (trade costs) with all trading partners. In the case of zero trade costs, Eq. (1) simplifies to $X_{ijt}^k = Y_t^k s_{it}^k b_{jt}^k$, where trade flows solely depend on world output (income) and the exporter's and importer's share therein.

Exchange Rate Effects in the Gravity Model

Following Anderson et al. (2016), the exchange rate is modeled as a time-variant per unit trade cost, where a depreciation could be equivalently interpreted as a tax on imports or subsidy on exports. Accordingly, bilateral trade costs in period t are defined as

$$t_{ijt}^k = \frac{\tau_{ij}^k}{E_{ijt}^{\rho_j^k}}, \tag{3}$$

where τ_{ij}^k is the (bilateral) commodity-specific, time-invariant trade cost component, related to distance and contiguity and de facto time-invariant variables such as, e.g., language, cultural or institutional differences or transport technology.

In Eq. (3), the variable E_{ijt} reflects the bilateral exchange rate between countries i and j; it is time-specific and hence introduces time-variation into (total) bilateral trade costs t_{ijt}^k. It is defined such that an increase in the exchange rate is associated with a depreciation of country i's currency vis-à-vis country j's currency (price notation).

Of course, whether the decomposition of trade costs into a time-invariant component and the exchange rate as only time-variant component is appropriate, depends on the time period considered. For our empirical analysis with a time span of seven years, we argue that this approach can be reasonably justified.

Exchange rate changes matter for country i's exports only, if they translate into consumer prices of country j (i.e., country j's imports in domestic currency). Hence, another crucial determinant of trade costs is the variable ρ_j^k, reflecting the exchange rate pass-through (ERPT) to country j's import prices.[1] According to Eq. (3), a 1% depreciation of the exporter's currency relative to the importer decreases trade costs by $(100 \times \rho_j^k)$ % in industry k. I.e., if ERPT is complete, then $\rho_j^k = 1$; on the other extreme, if exporters fully (have to) "absorb" the depreciation, import prices do not respond at all, $\rho_j^k = 0$, and trade is invariant to exchange rate changes.

Substituting Eq. (3) into Eq. (1) yields the following augmented gravity equation:

$$\bar{X}_{ijt}^k = Y_t^k \frac{s_{it}^k}{(\Pi_{it}^k)^{1-\sigma_k}} \frac{b_{jt}^k}{(P_{jt}^k)^{1-\sigma_k}} \left(\frac{\tau_{ij}^k}{E_{ijt}^{\rho_{jt}^k}} \right)^{1-\sigma_k}. \tag{4}$$

According to Eq. (4), a country with higher ERPT of the importer country will experience a larger export effects of exchange rate changes.

Note that with homogeneous ERPT, i.e, $\rho_j^k = \rho_i^k = \rho^k$, the effects of exchange rate shocks on trade costs are fully symmetric, since $E_{jit} = E_{ijt}^{-1}$:

$$\left| \frac{\Delta t_{ijt}^k}{\Delta E_{ijt}} \right| = \left| \frac{\Delta t_{jit}^k}{\Delta E_{jit}} \right| = \rho^k \frac{\tau_{ij}^k}{E_{ijt}^{\rho^k - 1}}, \tag{5}$$

i.e., the effects of exchange rate changes on the exporter's and importer's trade costs are mirror images.

A limitation of Eq. (4) for our empirical analysis is its implicit assumption that the elasticity of exports with respect to prices (triggered by exchange rate changes) is the same for all destination countries, i.e., that all countries j respond in the same way to changes in the (domestic) price of foreign products from country (i). To put it differently, in Eq. (4), the variation in export responses to exchange rate changes across destination countries comes only from differences in the ERPT, i.e., the variable ρ_j^k.

We relax this assumption by redefining ρ_j^k as $\rho_j^k \Phi_j^k$, where ρ_j^k still reflects the

[1] In line with Anderson et al. (2016), the ERPT is assumed to be time-invariant.

ERPT and Φ_j^k (together with σ_k) reflects variations in the price elasticity with respect to foreign products (from country i) across destination countries j (which are assumed to be invariant w.r.t. the country of origin i). As a result, trade costs are redefined as

$$t_{ijt}^k = \frac{\tau_{ij}^k}{E_{ijt}^{\rho_j^k \Phi_j^k}}, \tag{6}$$

and the augmented gravity model is given by

$$\bar{X}_{ijt}^k = Y_t^k \frac{s_{it}^k}{(\Pi_{it}^k)^{1-\sigma_k}} \frac{b_{jt}^k}{(P_{jt}^k)^{1-\sigma_k}} \left(\frac{\tau_{ij}^k}{E_{ijt}^{\rho_j^k \Phi_j^k}} \right)^{1-\sigma_k}. \tag{7}$$

Eq. (7) shows that bilateral export flows depend positively on the exchange rate (increase with a depreciation) and that this relationship is stronger, when the ERPT (ρ_j^k) is large and when the price elasticity (related to exchange rate changes) w.r.t. foreign products is large, i.e., when Φ_j^k and σ_k are large in magnitude.

3 Trade Balance Gravity, Exchange Rates, and the J-Curve

In the following, we translate the export gravity equation (7) into a trade balance gravity equation, which will be used to test the J-curve hypothesis, according to which a depreciation is instantly followed by a deterioration of the trade balance (price effect) and a consecutive improvement (quantity effect) that is large enough make up for the incipient negative short-run effect.

In order to test the J-curve hypothesis, two modifications of the structural gravity equation defined in Eq. (7) are required: First, the dependent variable of interest is the trade balance (TB) rather than exports. Second, Eq. (7) does not distinguish between and allow the direction of the short-run and long-run effects of the exchange rate on the trade balance to differ, which is at the heart of the J-curve hypothesis.

Trade Balance Gravity

Addressing the first issue, we define the bilateral trade balance TB_{ij}^k as ratio of (commodity k) exports of country i to country j relative to the exports of country j to country i, i.e., $\overline{TB}_{ijt}^k = \bar{X}_{ijt}^k / \bar{X}_{jit}^k$. Making use of Eq. (7), this yields the following trade balance version of the gravity model

$$\overline{TB}_{ijt}^k = \frac{\bar{X}_{ijt}^k}{\bar{X}_{jit}^k} = \frac{Y_t^k}{Y_t^k} \frac{s_{it}^k b_{jt}^k}{s_{jt}^k b_{it}^k} \left(\frac{\tau_{ij}^k}{E_{ijt}^{\rho_j^k \Phi_j^k} \Pi_{it}^k P_{jt}^k} \right)^{1-\sigma_k} \left(\frac{\tau_{ji}^k}{E_{jit}^{\rho_i^k \Phi_i^k} \Pi_{jt}^k P_{it}^k} \right)^{\sigma_k - 1}, \tag{8}$$

which specifies net exports as function of relative income shares and relative (time-invariant and time-varying) trade costs, adjusted by the ratio of countries' MRTs.

By definition, $Y_t^k s_{it}^k b_{jt}^k = Y_t^k b_{it}^k s_{jt}^k$, such that the first and second term in Eq. (8) cancel out. We obtain

$$\overline{TB}_{ijt}^k = E_{ijt}^{(\rho_j^k \Phi_j^k + \rho_i^k \Phi_i^k)(\sigma_k - 1)} \left(\frac{\tau_{ji}^k}{\tau_{ij}^k} \right)^{\sigma_k - 1} \left(\frac{\Pi_{it}^k}{P_{it}^k} \right)^{\sigma_k - 1} \left(\frac{P_{jt}^k}{\Pi_{jt}^k} \right)^{\sigma_k - 1}, \tag{9}$$

where we have made use of the fact that $E_{jit} = E_{ijt}^{-1}$.

Hence, an increase in the exchange rate E (depreciation) leads to an improvement of the trade balance, and the effect is larger, the greater the increase in exports and the decrease in imports. As can be seen from Eq. (9), the effect on exports is larger, the larger (in magnitude) the price elasticity of country j w.r.t. to foreign goods, i.e., $\Phi_j^k(\sigma_k - 1)$, and the more exchange rate changes pass through to country j's consumer prices of country i's exports (ρ_j^k).

The effect on imports is larger, the larger (in magnitude) the price elasticity of country i w.r.t. to foreign goods, i.e., $\Phi_{it}^k(\sigma_k - 1)$ and the more exchange rate changes pass through to consumer prices of country i's imports from country j (ρ_i^k).

Taking logs we obtain the following empirical model:

$$\ln \overline{TB}_{ijt}^{k} = \Phi_j^k(\sigma_k - 1)(\rho_j^k \times \ln E_{ijt}) + \Phi_i^k(\sigma_k - 1)(\rho_i^k \times \ln E_{ijt})$$
$$+(\sigma_k - 1)\ln\left(\frac{\tau_{ji}^k}{\tau_{ij}^k}\right) + (\sigma_k - 1)\ln\left(\frac{\Pi_{it}^k}{P_{it}^k}\right) + (\sigma_k - 1)\ln\left(\frac{P_{jt}^k}{\Pi_{jt}^k}\right) + \varepsilon_{ijt}^k, \quad (10)$$

which relates the trade balance (TB) to the exchange rate (E), interacted with importer ERPT (ρ_j) and exporter ERPT (ρ_i), relative trade costs ($\frac{\tau_{ji}^k}{\tau_{ij}^k}$) and the ratios of countries' MRTs; finally, ε_{ijt}^k is an idiosyncratic error term.

The Short- and the Long-Run

We next turn to a dynamic version of Eq. (10) that is able to distinguish short- and long-run effects with potentially different signs. A preliminary inspection of the time series properties of our key variables – the trade balance and the exchange rate – indicates that around 88% of the 1,908 series contain a unit root for TB and 95% for E, when four lags are considered (the same applies when controlling for a time trend). This share drops with a shorter lag-length (particularly for TB), such that we conclude that most of our series are integrated of order one, with a small subset of stationary series .

Against this background, we opt for the dynamic fixed-effect estimator for non-stationary heterogeneous panels by Pesaran and Smith (1995).[2] Specifically, we set up an error-correction model (ECM) of Eq. (10), which we estimate in unrestricted form:

$$\begin{aligned}\Delta \ln TB_{ijt} = {} & \delta_1 \ln TB_{ijt-1} + \delta_2(\rho_j \times \ln E_{ijt-1}) + \delta_3(\rho_i \times \ln E_{jit-1}) + \\ & \sum_{q=1}^{Q} \psi_q \Delta \ln TB_{ijt-q} + \sum_{p=0}^{P} \eta_p \Delta(\rho_j \times \ln E_{ijt-p}) + \\ & \sum_{p=0}^{P} \omega_p \Delta(\rho_i \times \ln E_{ijt-p}) + \alpha_{it} + \gamma_{jt} + \mu_{ij} + \varepsilon_{ijt}.\end{aligned} \quad (11)$$

[2]The use of alternative cointegration techniques for panel data, such as the mean-group and pooled mean estimators proposed by Pesaran et al. (1999), is infeasible due to the presence of gaps in the data.

Notice that the commodity superscript k has been dropped in Eq. (11), which should hence be regarded as panel for a specific commodity (with the indicator k suppressed) or as panel pooled over all commodities. Both variants will be considered in the empirical analysis.

In Eq. (11), multilateral resistance terms ratios (Π_{it}/P_{it} and P_{jt}/Π_{jt} respectively) are controlled for by time-varying exporter-commodity (α_{it}) and importer-commodity fixed effects (γ_{jt}). The time-invariant trade cost component is accounted for by the use of cross-section (exporter-importer-commodity) fixed effects (μ_{ij}). This leaves the exchange rate (E_{ijt}), interacted with importer ERPT (ρ_j) and exporter ERPT (ρ_i), as key explanatory variable in our model. Ideally, ERPT would be measured at the commodity group level; unfortunately, for our sample, ERPT measures are only available at the country-level. Hence, the ERPT variables ρ_j and ρ_i are time-invariant and country-specific, both in the pooled estimation and in the estimation by commodity group. Provided there is cointegration (and the coefficients are significant), the long-run effect of a change in the exchange rate on the trade balance implied by Eq. (11) is given by $-(\delta_2 + \delta_3)/\delta_1$.

Short-run impacts are traced out by cumulatively summing up over time the estimates of the parameters associated with the lagged first-differences of the exchange rate ($\eta_p + \omega_p$). An advantage of the ECM approach is that it gives us a direct estimate of long-run effects, allowing us to choose a parsimonious specification of Eq. (11) for the short-run. If prices were completely flexible, the (negative) price effect would materialize immediately to its full extent; if for part of the exports, the exchange rate is contractually fixed for a certain period of time, the short-run effect will materialize with a delay. We opt for a maximum lag-length of eight quarters for the first differences of both the trade balance and the exchange rate, after which we assume the short-run price effect to have fully materialized. The total short-run effect is then obtained by summing over all short-run parameters ($\sum_{p=0}^{8}(\eta_p + \omega_p)$).

We define our results to be indicative of a J-curve, if the cumulative short-run effect of a depreciation is significant and negative for any of the lag-lengths considered and the (cointegrating) long-run effect given by $-(\delta_2+\delta_3)/\delta_1$ is significant and positive.

4 Estimation Results

In order to trace out the trade balance dynamics in response to exchange rate changes and to test for J-curve effects, we use quarterly data over the period 2010-2017. The use of high frequency data is important, since with yearly data, offsetting effects might occur within the same time period, potentially giving a distorted picture of the shape of the reaction function.[3]

Bilateral trade flows are extracted from the UN Comtrade database, quarterly exchange rates are taken from the European Central Bank data warehouse and defined as quarterly average of units of foreign currency in domestic currency. Country-specific data for the exchange rate pass-through (ERPT) is taken from Bussiere et al. (2016), who provide estimates of the exchange rate pass-through to import prices for 51 economies. Unfortunately their ERPT-estimates are time-invariant and not disaggregated into commodity groups.

We end up with an unbalanced panel of 47 advanced and emerging economies and a total of 97 commodity groups, following the 2-digit Harmonized System (HS) classification (2012 revision).[4] This yields an average of $24,944$ observations (of potentially $64,860$) per commodity group and $2,419,613$ observations in total.

To test for a long-run (cointegrating) relationship between TB and E (interacted with importer and exporter ERPT), we carry out Pedroni (1999) panel cointegration tests for each of the 97 commodity groups. The testing procedure consists of seven statistics, four based on a pooled panel (the "within dimension"), three based on a group-mean approach, allowing parameter heterogeneity over cross-sectional units (the "between dimension").[5]

[3]Our initial approach to use monthly data was given up due to the huge number of missing observations at the commodity level used, which would have forced us to drop a significant amount of observations from the analysis.

[4]Approximately 6% of the country-pairs (accounting for 21% of total exports in our dataset) are characterized by a common currency ($\ln E = 0$). We also estimated our models excluding these observations and obtained virtually identical results.

[5]The "within-dimension" test statistics are obtained from pooled unit root tests on the residuals estimated from a pooled regression of $\ln TB$ on $\rho_j \times \ln E$ and $\rho_i \times \ln E$ (by commodity group), while the "between-dimension" test statistics are obtained by averaging cross-section specific statistics calculated from the residuals of a panel with heterogeneous slope parameters (again by commodity group). Both set of testing regressions contain cross-section specific fixed effects as well as importer- and exporter-time fixed effects.

Detailed results are reported in Table B in the Appendix. All of the 679 tests (seven tests, 97 commodity groups) reject the null hypothesis of no cointegration. This is strong evidence for the existence of a long-run cointegrating relationship between the trade balance and the exchange rate for all 97 commodity groups (and thereby indirectly also for an overall long-run relationship in the "average" panel that is pooled across commodity groups.) Of course, sign and significance of the link between TB and E remain to be determined in the estimation of the error-correction model (11).

Results for Pooled Panel

To illustrate our empirical approach, Eq. (11) is first estimated as a panel, which is pooled for all 97 commodity groups and can hence be considered as analysis of the aggregate trade balance.

Cross-section (exporter-importer-commodity) fixed effects and exporter-commodity-time and importer-commodity-time are included in the estimation. The cross-sectional dimension comprises $92,816$ exporter-importer-commodity combinations and the time dimension ranges from 2010Q1 to 2017Q2 (30 quarters). As outlined above, the maximum number of lags of the first-differences of TB and E, i.e., the short-run terms, is set equal to eight quarters in line with earlier studies typically using up to six or eight quarterly lags (see, for instance, Bahmani-Oskooee and Kanitpong, 2017).

The lag length is then determined by minimizing the joint F-test on the short-run coefficients of E and minimizing the mean-squared prediction error (MSE). In case of conflicting outcomes of these two approaches, we select the smaller number of lags for the sake of parsimony.[6] For the pooled estimation of Eq. (11), the number of lags obtained is one for ΔTB and four for ΔE (interacted with both ERPT), yielding an $ECM(1,4)$.

Table 1 shows the estimation results for Eq. (11). The first panel reports the long-run coefficients, related to the lagged level of the TB (δ_1) and E, interacted

[6] Choosing the lag-length according to the Akaike or Schwartz information criterion turned out infeasible, since their values keep falling with the number of lags included, therefore inevitably reaching the maximum number of lags.

with importer ERPT (δ_2) and exporter ERPT (δ_3). The second panel reports the (short-run) coefficients of the lagged first difference of TB and of four lags of the first difference of E (along with the contemporaneous difference), interacted with importer ERPT (η_p) and exporter ERPT (ω_p). Additionally, the third and fourth panels report the short-run quarterly aggregate effects of E, defined as $(\eta_p + \omega_p)$, and the cumulative effect of E, obtained by summing up the aggregate effects of E over time.

Considering specification tests of our model, note that a panel Breusch-Pagan test rejects the null hypothesis of homoskedasticity. Heteroskedasticity has been a main issue in the OLS estimation of gravity equations and our application does not make an exception.[7]

In the pooled regression, the Wooldridge (2010) test for serial autocorrelation turns out significant at the 1%-level. With a view to our (preferred) estimates by commodity group, we repeated the test for subsets of our sample, namely importer-exporter by commodity, importer-commodity by exporter, and exporter-commodity by importer. The corresponding results indicate that the null hypothesis of uncorrelated disturbances cannot be rejected for 79.2%, 76.6%, and 78.4% of the estimates, respectively. These results, pointing to a lack of serial correlation for the large majority of our residual series, will be enforced by our serial correlation tests of the estimates by commodity group.

To address both the presence of heteroskedasticity and serial correlation (in a subset of our series), we follow the approach suggested by Baltagi (2001) and Wooldridge (2010) and use cross-section clustered standard errors for inference.

Turning to the results, the estimate of the speed of adjustment parameter (δ_1), i.e., the coefficient related to level TB, is equal to -0.706 and significantly different from zero, thus indicating a relatively quick return to equilibrium following a shock on the trade balance. The long-run effect of a depreciation passed through to export prices amounts to $-(0.376/-0.706) = 0.532$, since demand for exports goes up as

[7] The approach by Silva and Tenreyro (2006), who recommend the use of quasi-Poisson maximum likelihood estimation, is not applicable in the present context, where a dynamic gravity equation is estimated in first-differences as an unrestricted ECM with negative observations on the dependent variable.

Table 1: Estimates of Pooled Trade Balance Model, Eq. (11)

Quarterly lags	t	$t-1$	$t-2$	$t-3$	$t-4$
Long-run (LR)					
TB		-0.706^{***}			
		(0.002)			
$(\rho_j \times E)$		0.376^{***}			
		(0.125)			
$(\rho_i \times E)$		0.341^{***}			
		(0.129)			
Joint F-Test on E	8.14^{***}				
Short-run (SR)					
ΔTB		-0.101^{***}			
		(0.001)			
$\Delta(\rho_j \times E)$	-0.097	-0.404^{**}	-0.337^{*}	-0.160	-0.122
	(0.179)	(0.196)	(0.190)	(0.195)	(0.188)
$\Delta(\rho_i \times E)$	-0.250	-0.427^{**}	-0.181	0.038	-0.064
	(0.184)	(0.199)	(0.191)	(0.195)	(0.187)
Aggregate SR effect					
$\Delta E \times (\rho_j + \rho_i)$	-0.348	-0.764^{***}	-0.518^{**}	-0.198	-0.187
	(0.241)	(0.281)	(0.256)	(0.261)	(0.247)
Cumulative SR effect					
$\sum \Delta E \times (\rho_j + \rho_i)$	-0.348	-1.112^{***}	-1.631^{***}	-1.829^{***}	-2.017^{***}
	(0.241)	(0.369)	(0.522)	(0.647)	(0.754)
Observations	1,592,930				
Exporter-importer-commodity	92,816				
Adj. R^2	0.420				
Within R^2	0.397				

Notes: Cross-section clustered standard errors in parentheses. The model includes exporter-commodity-time (85,065), importer-commodity-time (85,272) and exporter-importer-commodity fixed effects. ***,**,* denote significance at 1, 5, and 10 percent.

a result of a decrease in prices (which in turn depends on the importer ERPT (ρ_j)). The long-run effect materializing through increased import prices of the exporting country ($\rho_i \times E$) is given by $-(0.341/-0.706) = 0.483$. Interestingly, we find that the responses to the price effects passed through to exports and imports are equal in size, i.e., the hypothesis that $\delta_2/\delta_1 = \delta_3/\delta_1$ cannot be rejected.

Summing up, our results for the long-run suggest a positive (cointegrating) relationship between the trade balance and the exchange rate (indicating that the Marshall-Lerner condition is fulfilled for aggregate trade on average), and that the import and export channels are quantitatively of equal importance, conditional on the exchange rate pass-through.

Regarding the short-run, the coefficients of the lagged differences $\Delta(\rho_j \times \ln E)$ and $\Delta(\rho_i \times \ln E)$ are negative and significant at lag zero for the former and at the first quarter lag for the latter. The significant negative effect of $\Delta(\rho_i \times \ln E)$ is consistent with an immediate price effect on country $i's$ imports from country j, which increase in value and hence deteriorate the trade balance. The significant negative effect of $\Delta(\rho_j \times \ln E)$ is consistent with the immediate price effect on the exporter's side, which is due to the decrease of exports' trade value that deteriorates the trade balance; this suggests that part of exports is contracted in foreign currency and that part of the depreciation is borne by the exporter.[8] By symmetry, from the importing country $j's$ perspective, the change in the exchange rate would be associated with an appreciation and a positive price effect through a larger value of exports to country i and a smaller value of imports from country i.

Furthermore, it is worth noting that ignoring the importer and exporter ERPT by setting $\rho_i = \rho_j = 1$ yields a positive long-run coefficient of E equal to 0.733 (not reported in the table), which is close to the sum of both estimates from the first panel of Table 1 but turns out insignificant. Moreover, in this specification, none of short-run coefficients of the lagged differences of the (interacted) exchange rate are significant, such that the existence of a negative short-run (price) effect would be concealed. We conclude that accounting for the ERPT is important in the

[8]This effect does not show up in the standard Marshall-Lerner condition, which assumes that all exports are contracted in the exporter's currency.

analysis of trade balance dynamics and that its omission from the analysis (as in most previous studies) may yield misleading estimates.

Remaining short-run coefficients are also negative until the last lag considered though they turn out statistically insignificant. However, if we restrict the parameters of $\Delta(\rho_i \times E)$ and $\Delta(\rho_j \times E)$ to equality and consider the combined effect of a change in the exchange rate (which can be justified by F-tests statistically), the effects reported in the third panel, i.e., the overall short-run effect of change in exchange rate through both the export and import channel, show a longer lasting (negative) short-run effect up to the fourth quarter lag. The persistence of this short-run TB deterioration, measured by the cumulative sum of short-run coefficients in the fourth panel, lasts up to four quarters following the depreciation with a total sum equal to -2.017. There is therefore no evidence of a strong short-run recovery (or quantity effect) already in the first year after the shock. However, in light of the large standard error (0.754) and the fact that several coefficients turned out insignificant when considered separately, the magnitude of the negative cumulative short-run effect should not be overstressed.

Overall, with aggregate trade data, the J-curve hypothesis receives support by negative short-run (price) effects (reflected in negative single, aggregated and cumulative sums of short-run coefficients), which are followed by long-run quantity adjustments leading to an overall improvement of the trade balance (reflected in the positive cointegration relationship between the exchange rate and the trade balance).

Results by Commodity Group

Having obtain results from a bird eye's perspective on the aggregate trade balance dynamics, we next estimate Eq. (11) using disaggregated data for 97 two-digit HS commodity groups, using the same time period and following the same approach as for the pooled estimation described above.[9] At this level of aggregation, the number

[9] The two-digit HS classification (Version 2012) comprises about 5,300 commodity descriptions arranged in 97 groups or 15 sections: 01-05 Animal & Animal Products, 06-15 Vegetable Products, 16-24 Foodstuffs, 25-27 Mineral Products, 28-38 Chemicals & Allied Industries, 39-40 Plastics / Rubbers, 41-43 Raw Hides, Skins, Leather, & Furs, 44-49 Wood & Wood Products, 50-63 Textiles, 64-67 Footwear / Headgear, 68-71 Stone / Glass, 72-83 Metals, 84-85 Machinery / Electrical, 86-89 Transportation, and finally 90-97 Miscellaneous.

of observations varies considerably across commodity groups, with a maximum of $33,256$ observations for "Iron and steel", and a minimum of $3,456$ observations for "Vegetable plaiting materials".

Optimal lag structures for the 97 estimations are again determined by minimized joint F-test on short-run exchange rate coefficients and MSE criterion as defined above. There is substantial variation in the short-run dynamics across commodity groups: 14 groups include only the contemporaneous change in exchange rate (period t) while 14 others include the maximum number of lags (from period t to $t-8$). The average number of first-differenced lags of E is four, which corresponds to the number of quarterly lags used in the pooled regression, and two for the first-differenced lags of TB.

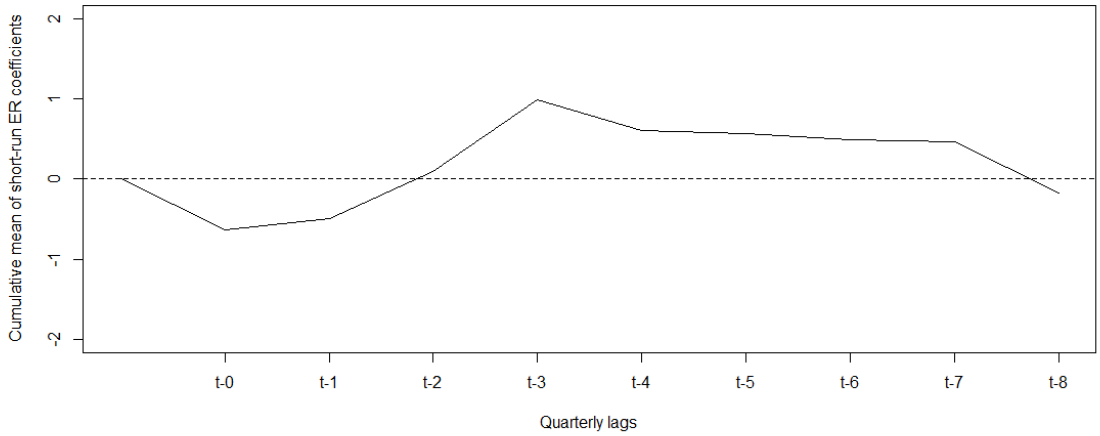
Table 2 summarizes the parameter estimates of the long-run and of the short-run effect of an exchange rate depreciation, with each line representing the results for a specific commodity group. To improve readability, Table 2 shows only the short-run coefficients significant at least at the 10% level.

Overall, the fit of the models is satisfactory with an average adjusted R-squared of 0.533. Residual diagnosis indicate that heteroskedasticity remains an issue in 58 commodity groups and serial correlation in 35 commodity groups. As in the pooled estimation, we use cross-section clustered standard errors to take these issues into account.

Before turning to detailed results, we take a look at the mean effects of the exchange rate on the trade balance, obtained by averaging the coefficients across the 97 commodity groups. The overall mean long-run depreciation effect of the exchange rate on the trade balance amounts to 0.852 (and 1.457 when taking only coefficients significant at 10% into account). Hence, the magnitude of the estimated average long-run effect is well in line with the results from the pooled estimation (1.015).

The estimated mean short-run effects of the exchange rate and their cumulative sum reveal interesting aspects of the short-run trade balance dynamics.The cumulative sum of the mean values of the short-run coefficients is illustrated in Fig. 1. The contemporaneous and first lags are characterized by a deterioration of the trade bal-

Figure 1: Mean of Cumulative Short-Run Reaction of TB to E



Notes: Mean (over all 97 commodity groups) of cumulative values of the sum of the coefficients of $(\rho_i \times \Delta \ln E)$ and $(\rho_j \times \Delta \ln E)$ for all eight quarterly lags. All insignificant coefficients have been set equal to zero.

ance and are then followed by consecutive quarters of short-run TB improvements before this effect vanishes in the last quarter $(t-8)$. Combined with a mean long-run effect of E amounting to 0.852, this pattern is indicative of the presence of an average J-curve. Moreover, the implied inter-temporal shape of the TB dynamics is in line with the pooled estimation, though the latter suggests that the improvement of the trade balance starts after lag four (rather than after lag two).

We next take a closer look at the commodity-specific estimates. Summarizing the key long-run results, a depreciation is linked to an improvement of the trade balance in 26 commodity groups, as reflected in significant and positive sum of long-run coefficients for the exchange rate interacted with importer and exporter ERPT $(\delta_2 + \delta_3)$. In twelve groups, a depreciation is associated with a long-run deterioration of the trade balance, for the remaining 59 commodity groups, the long-run effect of the exchange rate on the trade balance is insignificant.

Significant short-run effects, as measured by the sum of the short-run coefficients for the difference of the interacted exchange rate $(\eta + \omega)$ show up primarily within the first four quarters (including the contemporaneous quarter), following the change in the exchange rate. The peak in the number of significant short-run coefficients appears in the second-quarter lag with a total of 20 commodity groups.

The number then falls throughout the remaining four quarters with a maximum of eleven coefficients at the fifth-quarter lag and a minimum of three coefficients at the eighth-quarter lag. This suggests that short-run trade balance deviations from the equilibrium caused by a change in the exchange rate occur mainly within a year. In total, 42 significant negative short-run coefficients and 33 significant positive short-run coefficients are obtained for our sample in the first year following the depreciation. The highest frequency of negative short-run effects, 13, occurs contemporaneously (t), while the highest frequency of positive short-run effects (twelve) is observed for the third quarter ($t-2$).

Turning to significant cumulative short-run effects (not reported in the table), 77 of them are negative and 49 positive. Alike the significant single short-run coefficients, they are mainly observed within the first year following the depreciation. Also worth noting, with the exception of two commodity groups, no significant cumulative effects are found within the last three quarters of the second year. It is an indication that, in our sample, short-run trade balance dynamics triggered by exchange rate changes fade out after five quarters.

Overall, out of the subset of 26 commodity groups with positive long-run effects of the exchange rate, eleven J-curves are found with solely negative short-run coefficients.[10] Furthermore, for eight commodity groups[11] the long-run effects are positive with no short-run trade balance deterioration after the change in the exchange rate.[12]

A total of six commodity groups are characterized by both a significant short-run and long-run deterioration of the trade balance, where quantity adjustments seem absent[13]

A total of 59 commodity groups with no long-run depreciation effect are iden-

[10] Apparel and clothing accessories; Beverages, spirits and vinegar; Fruit and nuts, edible; Meat and edible meat offal; Miscellaneous manufactured articles; Natural, cultured pearls; Nuclear reactors, boilers, machinery and mechanical appliances; Organic chemicals; Plastics and articles thereof; Printed books, newspapers, pictures and other products of the printing industry; Umbrellas, sun umbrellas, walking-sticks, seat sticks, whips, riding crops.

[11] Animal originated products; Inorganic chemicals; Wadding, felt and non-wovens, special yarns; Fabrics; Metal; Ceramic products; Musical instruments; Toys, games and sports requisites"

[12] This complies with the definition of J-curve by Rose and Yellen (1989), where insignificant short-run and positive long-run effects represent a sufficient condition for the existence of a J-curve.

[13] Coffee, tea, mate and spices; Dairy produce; Feathers and down, prepared; Man-made staple fibers; Textiles, made up articles; Tools, implements, cutlery, spoons and forks, of base metal.

Table 2: Estimates of Trade Balance Model for 97 Commodity Groups, Eq. (11)

Industry		Long-run coefficients TB	E	Short-run ΔE coefficients t	$t-1$	$t-2$	$t-3$	$t-4$	$t-5$	$t-6$	$t-7$	$t-8$	Obs.	CPFE	Adj.R^2
Live animals	ECM(6,5)	-0.81 (-17.07)	5.05 (1.08)		−15.87								6,000	420	0.65
Meat and edible meat offal	ECM(3,8)	-0.52 (-12.1)	6.88 (2.17)			−9.08	−8.60					−5.29	7,497	508	0.56
Fish and crustaceans, mollusks and other aquatic invertebrates	ECM(1,2)	-0.69 (-28.34)	-6.48 (-3.89)	−4.94									16,128	1056	0.50
Dairy produce	ECM(2,6)	-0.62 (-20.03)	-4.67 (-2)	−5.72			9.37	14.30	7.17				11,167	721	0.54
Animal originated products	ECM(1,8)	-0.67 (-23.70)	3.96 (1.67)										9,402	760	0.53
Trees and other plants, live	ECM(1,6)	-1.04 (-22.49)	-0.01 (0.00)	13.86	12.74								7,875	620	0.65
Vegetables and certain roots and tubers	ECM(8,0)	-0.98 (-25.75)	3.28 (1.52)										10,104	660	0.69
Fruit and nuts, edible	ECM(1,7)	-0.97 (-37.33)	5.6 (2.66)		−8.23								12,329	957	0.59
Coffee, tea, mate and spices	ECM(4,0)	-0.54 (-15.44)	-1.97 (-1.97)	−6.18									14,376	852	0.52
Cereals	ECM(2,1)	-0.82 (-23.41)	7.93 (2.73)		14.37								9,000	564	0.61
Products of the milling industry	ECM(2,8)	-0.68 (-22.64)	-1.84 (-0.54)			7.97						13.78	8,888	697	0.52
Oil seeds and oleaginous fruits	ECM(1,4)	-0.99 (-40.01)	1.45 (1.06)				6.37						17,792	1142	0.57
Lac	ECM(3,0)	-0.71 (-24.91)	-1.47 (-0.66)										11,182	726	0.57
Vegetable plaiting materials	ECM(4,0)	-0.64 (-11.47)	1.94 (0.13)	−38.99									3,426	250	0.61
Animal or vegetable fats and oils and their cleavage products	ECM(3,0)	-0.63 (-33.43)	-1.62 (-1.15)										16,778	1000	0.49
Meat, fish or crustaceans, mollusks or other aquatic invertebrates	ECM(1,8)	-0.84 (-33.65)	-0.23 (-0.08)			−21.36							10,301	770	0.57
Sugars and sugar confectionery	ECM(3,2)	-0.63 (-27.91)	1.70 (1.41)			−9.7							17,402	984	0.50
Cocoa and cocoa preparations	ECM(6,8)	-0.70 (-18.22)	5.35 (1.52)										9,592	638	0.56
Preparations of cereals, flour, starch or milk	ECM(1,3)	-0.64 (-27.21)	-0.11 (-0.10)										20,016	1173	0.47
Preparations of vegetables, fruit, nuts or other parts of plants	ECM(2,5)	-0.6 (-26.40)	-2.14 (-1.95)						3.33				18,736	1142	0.47
Miscellaneous edible preparations	ECM(1,8)	-0.74 (-34.14)	-1.85 (-1.21)	−3.74					4.87				18,690	1313	0.51
Beverages, spirits and vinegar	ECM(1,4)	-0.68 (-33.92)	3.47 (2.78)		−5.44	−4.32	−5.56						23,781	1421	0.50
Food industries, residues and wastes thereof	ECM(8,6)	-0.62 (-13.48)	-0.84 (-0.35)				12.29						9,396	650	0.54
Tobacco and manufactured tobacco substitutes	ECM(7,5)	-0.57 (-11.23)	2.68 (0.44)						14.09				5,706	422	0.59
Salt	ECM(1,7)	-0.73 (-25.36)	3.61 (1.64)	6.99									16,945	1208	0.49
Ores, slag and ash	ECM(1,7)	-0.73 (-25.10)	1.51 (0.17)				24.85						6,241	554	0.58
Mineral fuels, mineral oils and products of their distillation	ECM(1,1)	-0.65 (-32.12)	-0.91 (-0.37)	−7.84									20,730	1188	0.46
Inorganic chemicals	ECM(1,0)	-0.59 (-36.48)	2.06 (1.88)										25,474	1424	0.46
Organic chemicals	ECM(1,2)	-0.65 (-31.33)	4.41 (3.68)	−2.83									24,925	1450	0.46
Pharmaceutical products	ECM(1,6)	-0.72 (-29.62)	-0.42 (-0.31)	−3.86									23,131	1445	0.47
Fertilizers	ECM(2,1)	-0.93 (-31.79)	-1.09 (-0.37)										9,114	592	0.64
Tanning or dyeing extracts	ECM(2,6)	-0.63 (-23.69)	0.58 (0.41)				3.54						20,838	1360	0.48
Essential oils and resinoids	ECM(1,7)	-0.71 (-31.63)	2.42 (2.09)							4.04			21,739	1431	0.48
Soap, organic surface-active agents	ECM(3,6)	-0.62 (-27.06)	-2.04 (-1.33)							3.95			18,781	1167	0.50
Albuminoidal substances	ECM(2,7)	-0.63 (-22.16)	-1.02 (-0.78)										15,668	1098	0.50
Explosives	ECM(3,6)	-0.75 (-14.34)	-0.27 (-0.04)		−13.84								5,886	399	0.61
Photographic or cinematographic goods	ECM(3,3)	-0.55 (-19.52)	4.11 (1.63)	9.13									9,712	600	0.56
Chemical products n.e.s.	ECM(1,7)	-0.73 (-34.45)	1.91 (1.33)	2.94									22,268	1495	0.48
Plastics and articles thereof	ECM(2,4)	-0.57 (-30.68)	1.78 (1.80)			−4.76							31,815	1702	0.43
Rubber and articles thereof	ECM(3,3)	-0.58 (-29.78)	1.15 (1.15)	3.74									27,664	1516	0.46
Raw hides and skins (other than furskins) and leather	ECM(1,2)	-0.64 (-34.97)	-0.05 (-0.03)										15,427	1018	0.49
Articles of leather	ECM(2,7)	-0.64 (-23.55)	3.97 (1.68)		−11.25	5.87			−6.89				20,310	1355	0.50
Furskins and artificial fur	ECM(2,3)	-0.87 (-24.02)	1.73 (0.40)										9,250	615	0.62
Wood and articles of wood	ECM(1,3)	-0.72 (-37.19)	1.44 (1.11)		3.20								25,806	1518	0.46
Cork and articles of cork	ECM(4,8)	-0.70 (-12.25)	17.22 (1.29)								−34.01	−44.32	3,911	304	0.67
Manufactures of straw, esparto or other plaiting materials	ECM(1,8)	-0.93 (-27.90)	-14.48 (-1.44)								−29.81		4,642	409	0.67
Pulp of wood or other fibrous cellulosic material	ECM(1,0)	-0.47 (-14.77)	-5.98 (-1.48)										8,476	574	0.51
Paper and paperboard	ECM(1,3)	-0.64 (-35.35)	1.32 (1.13)		−2.95								29,130	1619	0.42
Printed books, newspapers, pictures and other products of the printing industry	ECM(6,6)	-0.72 (-28.00)	2.44 (1.93)	−5.23		−6.11	−7.91	−7.36	−6.65	−5.79			22,189	1308	0.50

Notes: t-values in parentheses. ECM(q,p) indicates the number of lag q for ΔTB and p for ΔE. Only significant short-run ΔE coefficients are reported and standard errors are country-pair clustered. All models include exporter-year, importer-year and bilateral country-pair fixed effects. CPFE denotes the number of bilateral country-pairs

Table 2: Estimates of Eq. (11) for 97 commodity groups (continued)

Industry		Long-run coefficients TB	E	Short-run ΔE coefficients t	$t-1$	$t-2$	$t-3$	$t-4$	$t-5$	$t-6$	$t-7$	$t-8$	Obs.	CPFE	Adj.R^2
Silk	ECM(2,5)	-0.81 (-17.94)	-8.12 (-1.42)										4,550	345	0.63
Wool, fine or coarse animal hair	ECM(5,5)	-0.68 (-16.51)	-0.25 (-0.08)		10.37				7.19				8,640	562	0.60
Cotton	ECM(2,8)	-0.81 (-26.11)	-5.24 (-2.18)		6.48	5.83			11.86	9.00			12,402	892	0.55
Vegetable textile fibers	ECM(8,8)	-0.72 (-9.97)	4.25 (0.76)			13.68	−19.09		−13.79		15.38	−20.05	5,528	392	0.63
Man-made filaments	ECM(2,3)	-0.62 (-26.97)	-0.79 (-0.54)			6.49							16,685	1037	0.50
Man-made staple fibers	ECM(5,3)	-0.59 (-21.16)	-4.42 (-1.95)	−4.82		7.11							12,840	824	0.50
Wadding, felt and nonwovens, special yarns	ECM(2,0)	-0.54 (-24.81)	3.14 (2.12)										19,798	1148	0.48
Carpets and other textile floor coverings	ECM(3,5)	-0.69 (-22.39)	0.95 (0.45)										11,740	744	0.56
Fabrics	ECM(3,0)	-0.60 (-20.98)	3.47 (1.79)										16,098	978	0.51
Textile fabrics	ECM(1,8)	-0.73 (-27.95)	0.61 (0.29)				−7.06	−8.73				−5.29	14,881	1061	0.51
Fabrics	ECM(6,3)	-0.60 (-18.37)	-1.54 (-0.49)				12.49						9,717	644	0.59
Tin	ECM(7,8)	-0.60 (-16.12)	2.29 (1.30)	−6.42	−5.72			−4.67	−7.31				18,017	1164	0.53
Metals	ECM(2,7)	-0.70 (-30.23)	-1.66 (-1.01)	−3.99		6.43		−4.4		3.88			20,989	1386	0.51
Apparel and clothing accessories	ECM(1,3)	-0.71 (-36.38)	2.94 (2.46)	−3.37	−3.52	−3.32							25,878	1499	0.48
Apparel and clothing accessories	ECM(1,6)	-0.68 (-32.32)	-1.33 (-0.65)		−12.69	−6.96							17,596	1246	0.53
Tools, implements, cutlery, spoons and forks, of base metal	ECM(3,3)	-0.73 (-22.91)	-5.54 (-3.26)	−4.98			7.17						16,590	976	0.58
Metal	ECM(6,0)	-0.82 (-17.46)	8.6 (1.84)										6,422	392	0.66
Textiles, made up articles	ECM(6,5)	-0.63 (-16.45)	-7.81 (-1.87)	−11.92		30.67							5,372	360	0.66
Footwear	ECM(3,7)	-0.64 (-21.92)	0.78 (0.47)		−3.74					5.87			18,810	1236	0.51
Nuclear reactors, boilers, machinery and mechanical appliances	ECM(3,4)	-0.66 (-27.43)	3.15 (2.28)			−3.73	−3.78						19,232	1140	0.52
Headgear and parts thereof	ECM(1,1)	-0.65 (-35.98)	-0.51 (-0.45)										27,572	1524	0.46
Umbrellas, sun umbrellas, walking-sticks, seat sticks, whips, riding crops	ECM(6,6)	-0.64 (-24.76)	3.00 (1.68)			−6.87				−4.81			18,988	1146	0.48
Feathers and down, prepared	ECM(7,4)	-0.66 (-19.03)	-3.57 (-2.06)					−4.71					16,194	1030	0.48
Electrical machinery and equipment and parts thereof	ECM(3,5)	-0.64 (-30.80)	-0.42 (-0.42)					3.87					28,101	1597	0.47
Railway, tramway locomotives, rolling-stock and parts thereof	ECM(1,6)	-0.67 (-32.9)	5.25 (2.20)				5.78	−7.15	−7.30				19,566	1283	0.46
Stone, plaster, cement, asbestos, mica or similar materials	ECM(7,6)	-0.80 (-14.74)	2.08 (0.38)			13.08							6,494	458	0.54
Ceramic products	ECM(1,0)	-0.57 (-30.84)	2.30 (2.00)										28,128	1516	0.41
Vehicles	ECM(1,4)	-0.56 (-20.31)	-15.41 (-2.08)		30.52	16.64	42.65						5,537	415	0.58
Aircraft, spacecraft and parts thereof	ECM(1,7)	-0.58 (-19.27)	6.39 (0.73)						−14.49				8,570	640	0.52
Ships, boats and floating structures	ECM(1,7)	-0.62 (-17.38)	1.26 (0.12)							−20.74			4,903	385	0.60
Glass and glassware	ECM(6,7)	-0.77 (-22.46)	8.87 (2.15)				−10.77				12.51		8,147	562	0.55
Natural, cultured pearls	ECM(1,4)	-0.75 (-35.18)	3.81 (4.08)		−4.95	−5.87	−3.01	−4.01					26,618	1532	0.48
Optical, photographic, cinematographic, measuring, checking, medical or surgical instruments and apparatus	ECM(1,8)	-0.72 (-30.09)	-1.44 (-0.89)					−4.09					20,022	1342	0.48
Iron and steel	ECM(1,4)	-0.79 (-50.20)	-0.41 (-0.68)										33,256	1806	0.49
Clocks and watches and parts thereof	ECM(3,6)	-0.68 (-34.60)	0.39 (0.54)					2.65		−3.63			28,650	1696	0.45
Iron or steel articles	ECM(3,1)	-0.60 (-22.22)	5.22 (2.26)	17.08									9,872	604	0.52
Musical instruments	ECM(3,0)	-0.49 (-28.11)	1.38 (2.09)										27,898	1480	0.50
Arms and ammunition	ECM(3,2)	-0.72 (-34.73)	-2.24 (-1.00)										16,166	912	0.52
Copper and articles thereof	ECM(1,8)	-1.05 (-39.25)	-12.76 (-1.71)		32.78	20.56	30.93				33.65		7,012	611	0.62
Nickel and articles thereof	ECM(3,2)	-0.60 (-29.31)	0.42 (0.81)										32,200	1652	0.46
Furniture	ECM(1,2)	-0.65 (-35.09)	5.30 (3.25)			4.85							17,865	1009	0.49
Aluminum and articles thereof	ECM(3,0)	-0.70 (-23.02)	-1.16 (-0.87)										11,668	700	0.58
Toys, games and sports requisites	ECM(6,1)	-0.72 (-17.77)	6.78 (3.77)										7,154	426	0.59
Lead and articles thereof	ECM(1,3)	-0.74 (-39.89)	0.13 (0.11)		−2.98								29,331	1630	0.50
Zinc and articles thereof	ECM(3,0)	-0.73 (-30.53)	-3.42 (-3.31)										23,955	1334	0.52
Miscellaneous manufactured articles	ECM(3,5)	-0.59 (-32.19)	2.31 (1.83)		−5.77		−3.46		−4.92				21,340	1335	0.48
Works of art	ECM(2,7)	-1.09 (-38.31)	-6.03 (-1.51)					−13.06	9.66				10,152	769	0.61
Commodities not specified according to kind	ECM(2,3)	-0.58 (-22.87)	-0.85 (-0.83)										15,232	843	0.57

Notes: t-values between brackets. ECM(q,p) indicates the number of lag q for ΔTB and p for ΔE. Only significant short-run ΔE coefficients are reported. The parameter estimates are obtained by OLS and standard errors are country-pair clustered. All the 97 models include exporter-year, importer-year and bilateral country-pair fixed effects. CPFE: Number of bilateral country-pairs tified, where 17 solely exhibit negative short-run effects (thus no sign of quantity adjustment in the short-run) and 18 positive effects (thus no sign of a price effect in the short-run). Out of this subset of 59 commodity groups without long-run depreciation effect, 20 are characterized by "short-run J-curve" dynamics, where negative short-run coefficients are followed by positive ones. For these commodities the depreciation effect seems to be only temporary and vanishes after two years.

5 Concluding Remarks

The literature on the J-curve hypothesis has offered a variety of approaches on how to estimate inter-temporal responses of the trade balance to exchange rate shocks. While most studies focus on the investigation of bilateral relationships, the present study provides a multilateral and sectoral perspective in a gravity framework for a sample of 47 countries and 97 commodity groups over the period 2010Q1-2017Q2.

We build on Anderson et al. (2016) and derive a structural trade balance gravity equation that includes the exchange rate and its pass-through to prices as a component of trade costs. The inter-temporal aspects of the empirical relationship between the trade balance and the exchange rate are investigated with an error-correction model, modeling the long-run cointegrating relationship between the trade balance and the exchange rate as well as short-run effects.

A test of the J-curve hypothesis for the 47 countries ($2,162$ country-pairs, pooled across all 97 commodity groups) reveals that on average, there is a negative short-run (price) effect materializing "immediately" within the first two quarters and significantly deteriorating the trade balance. The negative effect persists throughout the entire short-run period of eight quarters considered. A long-run improvement of the trade balance is indicated by the existence of a long-run cointegrating relationship, suggesting that a 1% depreciation is associated with a 1.04% improvement of the trade balance. Hence, for our country and commodity sample and period of investigation, the trade balance dynamics seems to follow a J-curve pattern on average.

The analysis at the commodity level yields a much more diverse picture. A positive long-run effect is obtained only for a subset of 26 of the 97 commodity groups (of which eleven show a J-curve pattern), for 59 groups there is no significant long-run effect (20 of which show a short-run J-curve pattern).

Overall, in light of the anything but clear-cut long-run relationship between the exchange rate and the trade balance at the sectoral level and the anything but uniform short- and long-run patterns of trade balance responses, exchange rate policy does not appear to be a suitable instrument to influence and steer a country's trade balance dynamics.

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Appendix

Table A: List of the 47 Countries and their 37 Currencies

Country	Currency	Country	Currency
Argentina	Argentine peso	Rep. of Korea	South Korean won
Australia	Australian dollar	Mexico	Mexican peso
Austria	Euro	Morocco	Moroccan dirham
Belgium	Euro	Netherlands	Euro
Brazil	Brazilian real	New Zealand	New Zealand dollar
Canada	Canadian dollar	Norway	Norwegian krone
Sri Lanka	Sri Lankan rupee	Pakistan	Pakistani rupee
Chile	Chilean peso	Peru	Peruvian sol
China	Chinese yuan renminbi	Philippines	Philippine peso
Colombia	Colombian peso	Poland	Polish zloty
Czech Rep.	Czech koruna	Portugal	Euro
Denmark	Danish krone	Russian Federation	Russian ruble
Finland	Euro	Singapore	Singapore dollar
France	Euro	South Africa	South African rand
Germany	Euro	Spain	Euro
Greece	Euro	Sweden	Swedish krona
Guatemala	Guatemalan quetzal	Thailand	Thai baht
Hong Kong SAR	Hong Kong dollar	Turkey	Turkish lira
Hungary	Hungarian forint	Egypt	Egyptian pound
Indonesia	Indonesian rupiah	United Kingdom	Pound sterling
Ireland	Euro	United States of America	US dollar
Israel	Israeli new shekel	Uruguay	Uruguayan peso
Italy	Euro	Switzerland	Swiss franc
Japan	Japanese yen		

Table B: Results from Pedroni Panel Cointegration Tests

Name	Obs.	ν	Pooled ρ	Pooled t (PP)	Pooled t (ADF)	Group-mean ρ	Group-mean t (PP)	Group-mean t (ADF)
Animals	5,648	6.44	−27.74	−39.08	−27.64	−23.56	−46.55	−25.90
Meat and edible meat offal	7,702	3.00	−21.43	−32.04	−18.66	−18.27	−39.09	−18.41
Fish and crustaceans, molluscs and other aquatic invertebrates	11,896	5.34	−29.1	−43.28	−28.52	−22.27	−49.85	−28.00
Dairy produce	11,058	7.64	−27.83	−38.72	−28.5	−21.84	−44.34	−29.11
Animal originated products	8,154	5.79	−23.43	−31.31	−21.13	−19.51	−36.85	−22.04
Trees and other plants, live	6,200	1.99	−29.78	−48.93	−20.76	−26.24	−61.87	−16.85
Vegetables and certain roots and tubers	12,172	2.35	−34.39	−59.90	−40.67	−28.46	−73.67	−37.73
Fruit and nuts, edible	10,642	3.76	−33.76	−54.26	−35.35	−27.82	−65.30	−31.64
Coffee, tea, mate and spices	12,866	8.16	−33.35	−48.46	−31.26	−28.12	−59.31	−33.31
Cereals	6,390	5.34	−27.49	−41.82	−31.19	−22.90	−49.27	−31.21
Products of the milling industry	8,240	6.70	−25.45	−34.40	−24.74	−21.37	−41.02	−24.90
Oil seeds and oleaginous fruits	14,892	5.76	−46.45	−73.98	−46.12	−39.32	−89.40	−45.83
Lac	8,354	9.07	−35.98	−48.33	−37.32	−31.12	−57.88	−38.76
Vegetable plaiting materials	2,256	4.09	−15.93	−21.34	−13.52	−13.24	−25.12	−14.51
Animal or vegetable fats and oils and their cleavage products	14,618	9.05	−34.27	−48.04	−35.51	−28.13	−55.86	−36.81
Meat, fish or crustaceans, molluscs or other aquatic invertebrates	10,494	4.30	−27.58	−40.27	−28.76	−22.50	−47.61	−30.65
Sugars and sugar confectionery	15,350	9.64	−36.03	−50.42	−36.79	−29.48	−59.31	−38.25
Cocoa and cocoa preparations	11,516	6.93	−35.20	−50.85	−33.52	−28.06	−58.31	−33.21
Preparations of cereals, flour, starch or milk	17,444	6.66	−33.96	−48.13	−31.23	−27.95	−57.14	−30.26
Preparations of vegetables, fruit, nuts or other parts of plants	18,552	8.10	−38.66	−55.57	−38.24	−31.54	−66.29	−37.73
Miscellaneous edible preparations	21,328	9.89	−40.77	−57.79	−45.08	−34.46	−68.87	−48.62
Beverages, spirits and vinegar	20,894	8.82	−44.68	−63.02	−42.76	−37.81	−76.50	−43.24
Food industries, residues and wastes thereof	11,168	7.82	−31.81	−44.59	−33.51	−25.33	−51.01	−33.16
Tobacco and manufactured tobacco substitutes	5,738	6.11	−21.97	−32.92	−23.27	−17.12	−39.40	−23.85
Salt	16,724	10.71	−46.22	−62.11	−43.15	−39.29	−72.76	−43.65
Ores, slag and ash	4,758	6.68	−22.57	−32.25	−23.29	−18.66	−38.78	−25.10
Mineral fuels, mineral oils and products of their distillation	15,322	9.42	−38.39	−53.52	−40.86	−32.92	−63.99	−42.65
Inorganic chemicals	19,108	9.99	−42.45	−58.62	−42.06	−35.06	−68.19	−43.90
Organic chemicals	20,420	12.83	−47.59	−64.66	−49.44	−39.88	−76.11	−51.02
Pharmaceutical products	23,514	12.33	−44.84	−61.99	−46.31	−37.81	−74.13	−49.33
Fertilizers	5,920	5.794	−27.18	−40.38	−31.41	−22.51	−47.02	−32.25
Tanning or dyeing extracts	21,292	10.63	−44.66	−60.92	−43.18	−36.68	−70.68	−43.45
Essential oils and resinoids	22,652	11.14	−48.51	−67.00	−47.83	−40.26	−79.15	−48.33
Soap, organic surface-active agents	19,566	9.64	−41.98	−57.90	−38.52	−35.32	−69.65	−38.88
Albuminoidal substances	14,468	9.64	−38.73	−50.95	−35.59	−32.68	−59.28	−36.66
Explosives	5,138	6.34	−25.33	−35.40	−25.76	−21.91	−43.10	−28.36
Photographic or cinematographic goods	8,020	7.83	−21.43	−29.08	−17.66	−17.98	−34.23	−19.19
Chemical products n.e.s.	22,980	10.66	−46.30	−66.91	−50.79	−37.96	−78.58	−52.72
Plastics and articles thereof	22,026	8.00	−39.10	−56.40	−35.80	−31.90	−66.10	−35.5
Rubber and articles thereof	25,402	12.20	−46.26	−64.69	−47.92	−37.78	−76.68	−50.10
Raw hides and skins (other than furskins) and leather	10,232	7.13	−28.21	−40.22	−27.09	−23.61	−49.18	−29.11
Articles of leather	21,680	9.33	−49.89	−68.63	−46.71	−44.05	−83.44	−48.32
Furskins and artificial fur	6,492	2.88	−29.53	−45.66	−29.13	−24.74	−53.90	−29.81
Wood and articles of wood	22,126	11.27	−45.41	−63.53	−47.08	−37.88	−75.05	−47.08
Cork and articles of cork	3,106	4.72	−17.99	−23.74	−18.93	−16.21	−29.80	−20.17
Manufactures of straw, esparto or other plaiting materials	3,714	4.88	−20.73	−29.52	−21.49	−17.70	−35.37	−22.44
Pulp of wood or other fibrous cellulosic material	5,442	4.39	−15.82	−22.02	−14.58	−12.74	−25.94	−15.77
Paper and paperboard	26,432	11.23	−43.48	−61.03	−44.66	−36.81	−73.77	−48.4
Printed books, newspapers, pictures and other products of the printing industry	24.812	11.42	−53.54	−75.34	−51.46	−45.60	−90.42	−53.04
Silk	3.228	5.31	−20.74	−27.03	−20.14	−17.32	−31.33	−22.16
Wool, fine or coarse animal hair	7,944	−5.15	−30.35	−42.78	−29.24	−26.50	−50.99	−30.70
Cotton	14,110	7.59	−40.91	−55.79	−38.02	−34.69	−65.29	−37.59
Vegetable textile fibres	6,142	5.59	−27.36	−36.65	−26.58	−23.53	−43.38	−26.13
Man-made filaments	14,074	9.27	−34.95	−47.13	−34.29	−28.35	−54.53	−35.21
Man-made staple fibres	12,450	6.86	−31.52	−44.10	−33.68	−27.13	−52.36	−35.03
Wadding, felt and nonwovens, special yarns	16,764	9.13	−35.75	−49.78	−35.27	−29.64	−59.15	−36.57
Carpets and other textile floor coverings	11,374	8.73	−36.95	−51.67	−38.39	−32.07	−62.83	−39.45
Fabrics	13,832	8.45	−36.79	−50.91	−36.78	−61.66	−60.85	−39.32
Textile fabrics	15,926	10.97	−39.50	−52.72	−35.23	−34.71	−64.12	−36.42
Fabrics	9,812	5.98	−30.01	−41.71	−30.59	−24.02	−48.72	−31.07
Tin	22,482	8.17	−54.34	−74.20	−44.77	−48.58	−90.33	−45.19
Metals	22,154	8.20	−52.20	−71.24	−42.40	−46.06	−86.65	−43.10
Apparel and clothing accessories	22,560	11.15	−46.20	−64.11	−43.85	−39.33	−76.47	−46.23
Apparel and clothing accessories	16,508	7.34	−49.86	−67.13	−37.25	−42.41	−79.49	−34.89
Tools, implements, cutlery, spoons and forks, of base metal	14,490	8.02	−45.66	−64.26	−48.58	−29.83	−82.13	−48.53
Metal	6,880	5.80	−30.59	−44.80	−31.93	−26.57	−55.70	−31.86
Textiles, made up articles	4,896	4.34	−25.31	−34.02	−24.74	−22.17	−42.14	−26.95
Footwear	21,092	10.22	−42.03	−59.06	−45.84	−34.81	−69.87	−48.57
Nuclear reactors, boilers, machinery and mechanical appliances	18,190	12.74	−45.33	−61.94	−45.94	−39.39	−74.51	−49.53
Headgear and parts thereof	21,872	11.35	−41.02	−56.24	−42.21	−34.41	−67.2	−45.13
Umbrellas, sun umbrellas, walking-sticks, seat sticks, whips, riding crops	20,898	9.60	−44.95	−62.01	−42.24	−37.28	−73.39	−43.43
Feathers and down, prepared	19,172	12.40	−42.54	−57.66	−44.67	−35.09	−66.88	−45.64
Electrical machinery and equipment and parts thereof	16,178	8.00	−29.20	−42.80	−29.20	−23.60	−51.10	−31.60
Railway, tramway locomotives, rolling-stock and parts thereof	19,546	10.65	−35.95	−50.05	−34.86	−30.14	−59.20	−37.45
Stone, plaster, cement, asbestos, mica or similar materials	6,752	9.15	−27.49	−36.83	−24.64	−23.03	−43.06	−25.76
Ceramic products	22,656	11.50	−41.30	−56.25	−40.47	−33.81	−65.29	−42.31
Vehicles	3,458	5.93	−16.96	−21.42	−15.13	−14.64	−24.75	−16.52
Aircraft, spacecraft and parts thereof	7,496	7.48	−24.07	−32.05	−22.92	−19.40	−36.85	−23.99
Ships, boats and floating structures	3,944	5.24	−19.51	−25.51	−20.46	−16.33	−29.58	−19.72
Glass and glassware	7,976	8.88	−28.00	−37.55	−28.47	−23.43	−44.13	−29.45
Natural, cultured pearls	24,742	14.24	−50.99	−70.56	−50.79	−43.09	−83.68	−52.55
Optical, photographic, cinematographic instruments and apparatus	22,856	11.39	−41.30	−57.67	−40.43	−34.79	−68.95	−43.19
Iron and steel	29,094	9.20	−44.00	−64.40	−46.10	−37.50	−78.00	−49.20
Clocks and watches and parts thereof	6,960	10.40	−26.50	−33.90	−27.60	−22.60	−39.80	−29.90
Iron or steel articles	7,638	8.56	−22.15	−29.31	−23.04	−17.72	−33.74	−27.33
Musical instruments	26,400	12.03	−45.05	−62.72	−47.88	−36.38	−73.66	−50.21
Arms and ammunition	13,408	10.76	−42.55	−57.89	−43.71	−36.23	−68.41	−44.64
Copper and articles thereof	6,102	7.88	−34.38	−49.96	−35.21	−29.74	−61.75	−36.50
Nickel and articles thereof	27,658	8.80	−37.70	−56.20	−37.30	−35.00	−71.20	−43.10
Furniture	13,882	7.90	−31.89	−44.90	−35.08	−27.15	−53.58	−37.76
Aluminium and articles thereof	9,724	10.19	−36.65	−50.09	−38.99	−32.10	−60.87	−41.34
Toys, games and sports requisites	6,798	7.71	−29.37	−39.23	−28.70	−24.99	−46.37	−29.85
Lead and articles thereof	25,074	11.53	−49.54	−68.72	−50.97	−41.51	−81.95	−53.45
Zinc and articles thereof	21,606	9.22	−49.03	−71.35	−48.69	−41.82	−86.81	−48.88
Miscellaneous manufactured articles	21,314	7.71	−37.31	−53.00	−37.70	−31.42	−62.68	−36.88
Works of art	8,558	10.16	−41.91	−60.52	−44.97	−36.73	−73.29	−47.73
Commodities not specified according to kind	12,546	9.59	−37.21	−51.96	−37.12	−31.71	−62.71	−39.41

Note: Pedroni (1999)' test for cointegration between TB, $\rho_j \times \ln E$ and $\rho_i \times \ln E$ by commodity group. ν: Variance-ratio test, ρ and t: Unit root test (PP: Philip-Perron test, ADF: Augmented Dickey-Fuller test).