Trade and currency weapons

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Online Appendix

Contents

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A Country list

Country sample

Algeria	Dominican Rep.	Kenya	Portugal
Argentina	Egypt	Korea	Russian Federation
Australia	El Salvador	Kuwait	Saudi Arabia
Austria	Estonia	Kyrgyzstan	Senegal
Azerbaijan	Ethiopia	Laos	Sierra Leone
Bangladesh	Finland	Latvia	Singapore
	France	Lebanon	Slovakia
Belgium-Luxembourg	Gabon	Lithuania	Slovenia
Belize	Gambia	Madagascar	South Africa
Benin	Georgia	Malawi	Spain
Bolivia	Germany	Malaysia	Sri Lanka
Bosnia and Herzegovina	Ghana	Mali	Sweden
Brazil	Greece	Mexico	Switzerland
Bulgaria	Guatemala	Moldova	Syria
Burundi	Guinea	Mongolia	Tanzania
Cameroon	Guinea Bissau	Morocco	Tchad
Canada	Honduras	Mozambique	Thailand
Central Africa	Hong Kong	Netherlands	Togo
Chile	Hungary	New Zealand	Trinidad and Tobago
China	India	Nicaragua	Tunisia
Colombia	Indonesia	Nigeria	Turkey
Costa Rica	Ireland	Norway	Uganda
Côte d'Ivoire	Israel	Pakistan	Ukraine
Croatia	Italy	Panama	United Kingdom
Cyprus	Jamaica	Paraguay	United States
Czech Republic	Japan	Peru	Uruguay
Dem. Rep. of the Congo	Jordan	Philippines	Venezuela
Denmark	Kazakhstan	Poland	Zambia

B Additional regressions

In this appendix we study whether our results vary depending on the type of traded goods (B.1) or the type of exporting countries (B.2). We also study possible non-linearities in the impact of exchange rates or tariffs on exports (B.3).

B.1 Goods

The first two columns of Table B1 compare the estimation results for manufactured goods and for agricultural products, using the same specification as in the baseline. Manufactured products are more responsive to a change in the real exchange rate than agricultural products, while the opposite applies to tariffs: a 1% appreciation of the exporter's currency decreases manufactured (resp. agricultural) product exports by 0.48% (resp. 0.23%), while a 1% increase in the power of the tariff decreases manufactured (resp. agricultural) exports by 1.14% (resp. 1.67%). Unsurprisingly given the relative sample sizes, our baseline results are closer to those obtained on manufactured goods than to those based on agricultural goods.

We then use Rauch's classification (see **?**) to distinguish between homogeneous products (products whose prices are quoted on organized exchange or in trade publications) and differentiated products. Column (3) and (4) show that the impact of both real exchange rates and tariffs is slightly lower on differentiated products compared to homogeneous products. Our baseline results are close to those obtained with differentiated goods.

Restricting ourselves to manufactured goods, we find that tariffs are 2.3 times more powerful than exchange rates to move exports, as for differentiated products. In both cases, we are close to the baseline ratio of 2.9.

Table B1: Trade elasticities: different types of goods

	Dependent variable: $Exports_{ijkt}$			
			Rauch classification	
	(1)	(2)	(3)	(4)
	Manuf. products	Agri. products	Homogeneous products	Differentiated products
RER_{ijt}	-0.479***	-0.230***	-0.492***	-0.481***
	(-7.618)	(-6.58)	(-9.28)	(-7.629)
	[0.058]	[0.035]	[0.053]	[0.0631]
$Tariff_{ijkt}$	-1.139***	-1.670***	-1.688***	-1.054***
	(-10.55)	(-21.98)	(-23.55)	(-8.341)
	[0.166]	[0.076]	[0.0716]	[0.126]
GDP_{it}	0.723***	0.239***	0.612***	0.733***
	15.07	6.80	6.832	12.36
FE ik - jkt - ij	Yes	Yes	Yes	Yes
Observations	54,246,572	4,397,311	17,510,834	42,448,318
R-squared	0.647	0.622	0.611	0.652

Notes: t-stats are in parentheses. In brackets are the standard errors, clustered at the country-pair level. All variables are in logarithm. All nominal variables are expressed in US dollars. The level of significance is the following: *** p<0.01, ** p<0.05, * p<0.1.

B.2 Countries

Table B2 studies whether trade elasticities differ for several types of countries, using the same specification as for the baseline estimations. In Column (1), we test whether the elasticity of exports to the real exchange rate differs when both the exporting and the importing countries are members of the euro area, in which case their bilateral intra-zone real exchange rate only depends on inflation differentials. Specifically, we interact the real exchange rate with a dummy that is equal to unity when both i and j are members of the euro area. The resulting coefficient is significantly positive. Combining it with the non-interacted coefficient on the real exchange rate (which remains unaffected), we find that the reaction of exports to the bilateral real exchange rate is more than halved when the two countries are part of the euro area. This striking result does not arise from membership of the single market, as evidenced by Column (2) which interacts the real exchange rate with a dummy that is equal to unity when both i and j are members of the European union, and finds a coefficient that is not significant.[1] Hence the lower coefficient found on the real exchange rate for intra-European trade is related to the fixed nominal rate rather than to economic integration. The non-interacted coefficient stays unaffected, which confirms that it can be used to study the impact of exchange rate policies on exports.

In Column (3), we study whether trade elasticities differ for advanced economies. Specifically, we interact the real exchange rate and the tariff with a dummy that is equal to unity when both i and j are OECD members. The elasticity of exports to the real exchange rate is found to be reduced for OECD countries, whereas the elasticity to tariffs is magnified.

Finally, Column (4) reports the results obtained when interacting tariffs and real

[1] We do not repeat the same exercise for tariffs since they are equal to zero within the EU and within the euro area.

exchange rates with a dummy for large countries.[2] It may be argued that trade between large economies reacts more to the exchange rate or to tariffs because these countries are less likely to adjust their margins. We find a non-significant coefficient on the interacted dummy with the real exchange rate, but a highly significant, negative coefficient on the interacted dummy with the tariff. On the whole, restricting the analysis to large countries inflates the ratio between tariffs and exchange-rate elasticities from 2.9 in our baseline estimation to 4.2 here.

B.3 Non-linearities

As shown in Figure 2 in the data section of the paper, a tariff cut is more permanent on average than a tariff hike. Hence a cut may have more impact on trade than a hike. This possibility is explored in Table B3, Column (1), where the tariff is interacted with a dummy that is equal to unity when the tariff has increased relative to the previous year. The tariff in the destination country has significantly less negative impact on exports just after an increase than when it is either constant or declining: a 1% tariff increase in the destination country reduces exports by 1.14%, while a 1% tariff cut stimulates exports by 2%. Hence, the equivalence ratio between tariffs and the real exchange rate is 4.7 for a tariff cut but only 2.7 for a tariff increase.

Now, it may be argued that tariffs in the destination country have more impact on exports when the exporter's currency is overvalued or, symmetrically, that the overvaluation of the exporter's currency is more detrimental to exports when tariffs in the destination country are high. Column (2) shows that this is indeed the case: the coefficient on the real exchange rate interacted with the tariff is significantly negative. Trade and monetary barriers tend to reinforce each other.

[2] This country group comprises the United States, Canada, France, Germany, United Kingdom, Japan, Italy, Mexico, Turkey, South Korea and Spain.

Table B2: Trade elasticities: different types of countries

	Dependent variable : $Exports_{ijkt}$			
	(1) Euro area	(2) European Union	(3) OECD countries	(4) Large economies
RER_{ijt}	-0.477***	-0.475***	-0.491***	-0.480***
	(-8.072)	(-8.063)	(-8.323)	(-8.12)
$Tariff_{ijkt}$	-1.369***	-1.365***	-1.072***	-1.285***
	(-14.90)	(-14.88)	(-11.18)	(-14.00)
GDP_{it}	0.695***	0.694***	0.704***	0.696***
	(12.37)	(12.35)	(12.55)	(12.38)
$RER_{ijt} * EA_{ijt}$	0.262***			
	(2.653)			
$RER_{ijt} * EU_{ijt}$		-0.00551		
		(-0.633)		
$RER_{ijt} * OECD_{ijt}$			0.0257***	
			(3.900)	
$Tariff_{ijkt} * OECD_{ijt}$			-0.907***	
			(-6.722)	
$RER_{ijt} * Large_{ijt}$				0.063
				(-0.90)
$Tariff_{ijkt} * Large_{ijt}$				-0.737***
				(-3.24)
FE ik - jkt - ij	Yes	Yes	Yes	Yes
Observations	63,203,049	63,203,049	63,203,049	63,203,049
R-squared	0.640	0.640	0.640	0.640

Notes: standard errors are clustered at the country-pair level, t-stats are in parentheses. $Tariff_{ijkt}$ stands for $1 + \tau_{ijkt}$. All variables are in logarithm except for region dummies ; all nominal variables are expressed in US dollars. The level of significance is the following: *** p<0.01, ** p<0.05, * p<0.1

Next, we also test whether the real exchange rate has more impact on exports when it appreciates than when it depreciates by interacting the real exchange rate with a dummy equal to unity when the real exchange rate has depreciated relative to the previous year. The results reported in Column (3) show that, although significant, the interacted term bears a very small coefficient. The almost symmetric reaction of exports to exchange-rate appreciations or depreciations is consistent with the pattern shown in Figure 3 (contrasting with tariffs).

Column (4) explores whether the real exchange rate has more impact on exports when it is "misaligned", i.e. far away from its trend. For each bilateral real exchange rate, we calculate the deviation of the log-exchange rate from a linear trend. The real exchange is then interacted with the square of this deviation, called "misalignment". The interacted term has significant, negative effect on exports, confirming that large deviations have more impact than small ones. However the coefficient on the (non-interacted) real exchange rate remains close to its baseline value.[3]

[3] The same exercise is not possible for tariffs due to the limited number of tariff changes at the exporter-importer-product level.

Table B3: Non-linear estimations

	Dependent variable : $Exports_{ijkt}$			
	(1)	(2)	(3)	(4)
RER_{ijt}	-0.419***	-0.401***	-0.405***	-0.393***
	(-6.692)	(-7.333)	(-7.406)	(-7.204)
$Tariff_{ijkt}$	-1.998***	-1.743***	-1.680***	-1.677***
	(-10.15)	(-12.68)	(-12.18)	(-12.18)
$Tariff_{ijkt} * Increase$	0.861***			
	(5.685)			
$RER_{ijt} * Tariff_{ijkt}$		-0.150***		
		(5.366)		
$RER_{ijt} * Depreciation$			-0.00428**	
			(2.536)	
$RER_{ijt} * Misalignment$				-0.078***
				(3.866)
Controls	Yes	Yes	Yes	Yes
FE ik-jkt	Yes	Yes	Yes	Yes
Observations	44,198,563	63,142,608	63,142,608	63,142,608
R-squared	0.630	0.609	0.609	0.609

Notes: t-stats are in parentheses. Standard errors are clustered at the country-pair level. $Tariff_{ijkt}$ stands for $1 + \tau_{ijkt}$. All variables are in logarithm ; all nominal variables are expressed in US dollars. The level of significance is the following: *** p<0.01, ** p<0.05, * p<0.1.

C Model linearization

Here we detail the linearization of the model presented in the last section of the paper.

Trade balance

$$B = X - M \tag{B.1}$$

$$dB = dX - dM \tag{B.2}$$

$$\frac{dB}{Y} = \frac{dX}{Y} - \frac{dM}{Y} \tag{B.3}$$

Exports in foreign currency are determined by:

$$X = X_0 Q^{\epsilon} (1+\tau^*)^{-\zeta\epsilon} {Y^*}^{\gamma^*}$$

For small tariffs, we have $\frac{d(1+\tau^*)}{(1+\tau^*)} = dln(1+\tau^*) \simeq d\tau^*$, hence:

$$\frac{dX}{X} = \epsilon\frac{dQ}{Q} - \zeta\epsilon d\tau^* + \gamma^*\frac{dY^*}{Y^*} \tag{B.4}$$

Imports in foreign currency are determined by:

$$M = M_0 Q^{-\epsilon} (1+\tau)^{-\zeta\epsilon} Y^{\gamma}$$

For small tariffs, we have $\frac{d(1+\tau)}{(1+\tau)} \simeq d\tau$, hence:

$$\frac{dM}{M} = -\epsilon\frac{dQ}{Q} - \zeta\epsilon d\tau + \gamma\frac{dY}{Y} \tag{B.5}$$

Assuming $P = P^* = 1$, the real exchange rate equals the nominal exchange rate: $Q = E$. Around $B = 0$, we have:

$$\frac{dB}{Y} = \phi\left[2\epsilon\frac{dE}{E} + \zeta\epsilon\left(d\tau - d\tau^*\right) + \gamma\left(\frac{dY^*}{Y^*} - \frac{dY}{Y}\right)\right] + v, \tag{B.6}$$

where $\gamma = \gamma^*$, $\phi = \frac{X}{Y} = \frac{M}{Y}$, and v an exogenous shock.

Domestic output

With $C = c\frac{PY}{P_c}$, $I = I_0(1+r)^{-\alpha}$, $P_c = P^{1-\eta}(P^*)^{\eta}(E)^{\lambda_e\eta}(1+\tau)^{\lambda_\tau\eta}$, and $P = P^* = 1$, we have:

$$Y = cE^{-\lambda_e\eta}(1+\tau)^{-\lambda_\tau\eta}Y + I_0(1+r)^{-\alpha} + EB \tag{B.7}$$

$$\begin{aligned}\frac{dY}{Y} &= cE^{-\lambda_e\eta}(1+\tau)^{-\lambda_\tau\eta}\frac{dY}{Y} - c\eta\lambda_e E^{-\eta\lambda_e}\frac{dE}{E} - c\eta\lambda_\tau(1+\tau)^{-\eta\lambda_\tau}\frac{d(1+\tau)}{(1+\tau)} \\ &\quad - \frac{\alpha I_0}{Y}(1+r)^{-\alpha}\frac{d(1+r)}{(1+r)} + \frac{BdE}{Y} \\ &\quad + \phi E\left[2\epsilon\frac{dE}{E} + \zeta\epsilon\left(d\tau - d\tau^*\right) + \gamma\left(\frac{dY^*}{Y^*} - \frac{dY}{Y}\right)\right] + v + u,\end{aligned} \tag{B.8}$$

where $\frac{d(1+r)}{(1+r)} = dln(1+r) \simeq dr$ if $r \simeq 0$, and u is an exogenous shock.

We linearize around an initial equilibrium where $\tau \simeq 0$, $E = 1$, $r \simeq 0$ and $B \simeq 0$:

$$\begin{aligned}\frac{dY}{Y} = &-\frac{\eta c}{1-c+\phi\gamma}\left(\lambda_e\frac{dE}{E} + \lambda_\tau d\tau\right) - \underbrace{\frac{\alpha I}{Y(1-c+\phi\gamma)}}_{\mu}dr \\ &+ \frac{\phi}{1-c+\phi\gamma}\left(2\epsilon\frac{dE}{E} + \zeta\epsilon\left(d\tau - d\tau^*\right) + \gamma\frac{dY^*}{Y^*}\right) + \frac{v+u}{1-c+\phi\gamma}\end{aligned} \tag{B.9}$$

Around the initial equilibrium, we can write: $\frac{dB}{X} = b$, $d\tau = \tau$, $dr = r$ and $\frac{dE}{E} = dlnE =$

$de = e$, $\frac{dY}{Y} = y$ and $\frac{dY^*}{Y^*} = y^*$. We get:

$$y = -\frac{\eta c}{1-c+\phi\gamma}(\lambda_e e + \lambda_\tau \tau) - \mu r + \frac{\phi}{1-c+\phi\gamma}\left(2\epsilon e + \zeta\epsilon(\tau - \tau^*) + \gamma y^*\right) + \frac{v+u}{1-c+\phi\gamma} \tag{B.10}$$

$$b = \phi\left(2\epsilon e + \zeta\epsilon(\tau-\tau^*) + \gamma(y^* - y)\right) + v \tag{B.11}$$

$$e = \delta(r^* - r) \tag{B.12}$$

Calibration

To calibrate μ, we re-write y so that it only depends on the two policy variables r and τ, on the different parameters and on the two shocks u and v:

$$\begin{aligned} y = &-\left(-\frac{\eta\lambda_e c}{1-c+\phi\gamma} + \mu + 2\epsilon\phi\right) r + \left(\frac{\phi\zeta\epsilon - \eta\lambda_\tau c}{1-c+\phi\gamma}\right)\tau + \left(\frac{2\zeta\epsilon - \eta\lambda_e c}{1-c+\phi\gamma}\right) r^* \\ &- \frac{\phi\zeta\epsilon}{1-c+\gamma\phi}\tau^* + \frac{\phi\gamma}{1-c+\gamma\phi} y^* + \frac{v+u}{1-c+\phi\gamma} \end{aligned} \tag{B.13}$$

We thus have the following impact of τ and r on y and on b:

$$\frac{\partial y}{\partial r} = -\left(\mu + \frac{2\phi\epsilon}{1-c+\phi\gamma} - \frac{\eta\lambda_e c}{1-c+\phi\gamma}\right) \tag{B.14}$$

$$\frac{\partial y}{\partial \tau} = \left(\frac{\phi\zeta\epsilon}{1-c+\phi\gamma} - \frac{\eta\lambda_\tau c}{1-c+\phi\gamma}\right) \tag{B.15}$$

$$\frac{\partial b}{\partial r} = \left(\frac{\phi 2\epsilon(1-c-\gamma(1-\phi))}{1-c+\phi\gamma} - \frac{\eta\lambda_e c}{1-c+\phi\gamma} + \gamma\mu\right) \tag{B.16}$$

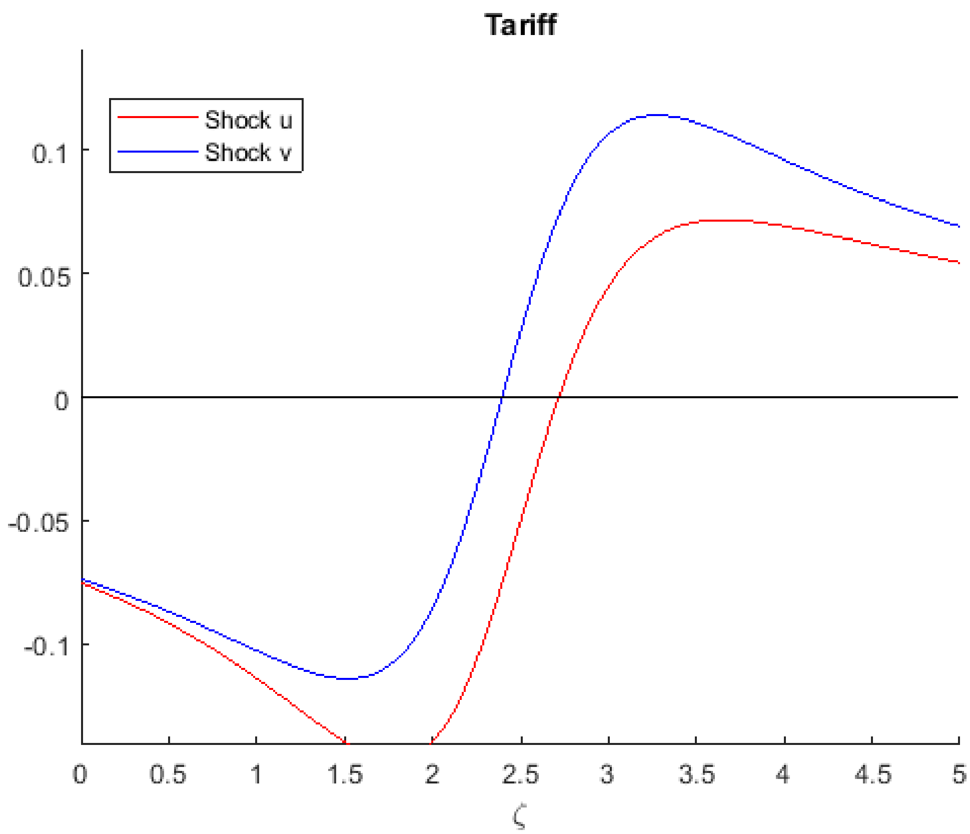
$$\frac{\partial b}{\partial \tau} = \left(\frac{\phi\zeta\epsilon(1-c-\gamma(1-\phi)) + \gamma\eta\lambda_\tau c}{1-c+\phi\gamma}\right) \tag{B.17}$$

We calibrate the impact of r on y based on the literature showing the impact of an interest rate cut on US output. For an overall impact of 0.3 we have the following:

$$\begin{aligned} -\left(\mu + \frac{2\phi\epsilon}{1-c+\phi\gamma} - \frac{\eta\pi c}{1-c+\phi\gamma}\right) &= -0.3 \\ \Leftrightarrow \mu + \frac{0.1}{0.36} - \frac{0.07}{0.36} &= 0.3 \\ \Leftrightarrow \mu &= 0.22 \approx 0.2 \end{aligned} \tag{B.18}$$

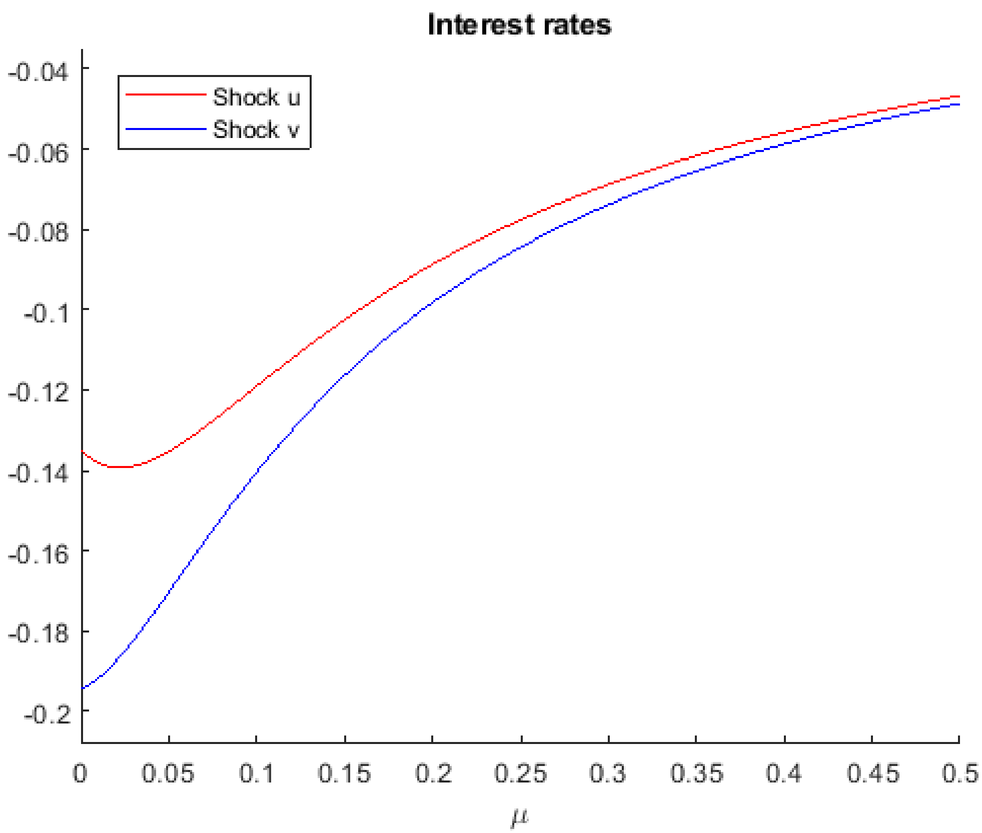
D Additional figures

Figure D1: Optimal reaction of the tariff depending on ζ



Note: policy responses to a negative demand shock of $u = -1\%$ in red, and to a negative trade shock $v = -1\%$ in blue. Source: model simulations.

Figure D2: Optimal reactions of the interest rate depending on μ



Note: policy responses to a negative demand shock of $u = -1\%$ in red, and to a negative trade shock $v = -1\%$ in blue. Source: model simulations.

E Two-country extension of the model

Here we rely on our baseline calibration but study a two-country framework where Home and Foreign are symmetric economies. We consider a non-cooperative setting where each government tries to stabilize national output and the trade balance. They both react to a common shock using either the interest rate or the import tariff, considering the policy of the other government as given (Nash equilibrium). When both countries have two instruments available, the model is overidentified;[4] therefore we only consider the cases where only one instrument is available in each country.

Although foreign policy instruments are considered exogenous to the home government, the foreign economy itself (represented by y^* and b^*) is not: when cutting the home interest rate, the home government knows that doing so will affect foreign output, which will in turn affect home exports. Thus, an additional, indirect channel of policy transmission is now at play.

Suppose for instance that the home government cuts the home interest rate. This decision will have a positive impact on home output and on the home trade balance through the combination of the domestic transmission channel (higher investment) and the external channel (currency depreciation increasing competitiveness but reducing purchasing power). Now, there is also an indirect channel that goes through foreign output. Since the foreign currency appreciates but the foreign interest rate does not increase (Nash hypothesis), foreign output is in fact expected to increase following the shock, thanks to higher purchasing power. Hence, the home government expects its interest-rate cut to have more positive impact on home exports and output, compared to the small open economy case.

In turn, if the home government increases its import tariff, it can expect a fall in

[4] Stabilizing the trade balance of the home country automatically stabilizes the trade balance of the foreign economy.

Table E4: Nash equilibria: negative demand shock

	τ, τ^*	r, r^*	b, b^*	y, y^*	L, L^*
Domestic shock $u = u^* = -1\%$					
One instrument: τ, τ^*	-0.0752	0	0	0	0
One instrument: r, r^*	0	-0.0926	0	0	0
External shock $v = v^* = -1\%$					
One instrument: τ, τ^*	0.0493	0	-0.01	-0.0552	0.0016
One instrument: r, r^*	0	-0.0981	-0.01	0.002	0.00005

Note: the table reports deviations from baseline.
Source: model simulations.

foreign output, hence reduced impact on home exports and output. As shown in Table E4, it is now optimal to react to a negative demand shock by cutting the import tariff rather than increasing it: the tariff cut stimulates home purchasing power with little impact through the combined direct and indirect external channels.[5]

Because the demand shock is symmetric and hits two symmetric economies, the reactions are the same. A common negative demand shock ($u = u^* = -1\%$) decreases both outputs but leaves the trade balances unaffected. Both government can thus stabilize their output by either cutting the tariff (to regain purchasing power) or by decreasing the interest rate to boost investment. Whatever the instrument, output is fully stabilized in both countries (see Table E4).

When facing a negative trade shock ($v = v^* = -1\%$), the trade balances cannot be stabilized, because the symmetric reactions in tariff or interest rate cancel each other. Both countries choose to increase the tariff and decrease the interest rate to try to stabilize their output, just as for a negative shock on domestic demand. Comparing the losses in the last column of Table E4 suggests that a monetary response is stabilizing whereas trade policy is not.

Hence, the results obtained in the small-economy case are confirmed in the two-

[5] In the two country setting, we have the following partial derivatives for the Home economy: $\frac{\partial y}{\partial r} = -0.38$, $\frac{\partial y}{\partial \tau} = -0.02$, $\frac{\partial b}{\partial r} = -0.08$ and $\frac{\partial b}{\partial \tau} = 0.13$.

country model: with our calibration, monetary policy appears more appropriate than trade policy to stabilize the economy after a demand shock. The risk of a trade war is now also limited by the fact that each country anticipates the negative impact of a tariff on its own exports, even without anticipating any form of trade retaliation.