Trade and currency weapons compared*

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Abstract

The debate on currency wars has re-emerged in the wake of ultra-expansionary monetary policies carried out by several central banks after the 2008 financial crisis. Using product level data for 110 countries over the 1989-2013 period, we estimate trade elasticities to exchange rates and tariffs within the same empirical specification. We find that, over the whole sample, the impact of a 1 percent increase in import tariffs is equivalent, in terms of trade flows, to a 3 percent depreciation of the importer's currency. We analyse the implications of this equivalence for the incentives of an open economy to use trade versus currency 'weapons'. Faced with a negative trade shock, the government may choose to depreciate its currency or increase its import tariffs. If both instruments are available, he will depreciate the currency and at the same time cut tariffs in order to compensate for the detrimental effect of the depreciation on domestic purchasing power. This result applies to all periods except the 1989-93 one where the optimal response to a negative shock is rather to increase the tariff and appreciate the home currency. We also find that more intra-industry trade, and a more powerful direct channel of monetary policy both tend to raise the incentive to use the monetary "weapon" rather than the trade one.

Keywords: tariffs, exchange rates, trade elasticities, protectionism.
JEL classification: F13, F14, F31, F60.

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1 Introduction

After decades of continuous progress towards global trade integration, the issue of protectionism has come back at the top of the policy agenda since the early 2010s. On the one hand, the large exchange rate movements recorded in the wake of the global financial crisis have raised concerns about looming "currency wars" (Mantega, 2010). On the other hand, a rise in tariffs has been increasingly mentioned in policy discussions in advanced economy, as a delayed reaction to the "de-industrialization" observed since the 1990s. Evenett (2012) confirms the fear of "a steady stream of protectionist measures".

Theoretically, a tax on imports (combined with a subsidy on exports) has the same impact on trade flows as a currency devaluation. In both cases, the relative price of foreign suppliers is increased in the short term; depending on pass-through effects and on trade elasticities, the volume of exports rises while the volume of imports falls. In the longer run, the upward adjustment of domestic prices progressively erases these effects.

In practice, however, there are significant differences between tariffs and currency changes. In particular, tariffs are a policy variable while exchange rates are generally determined on financial markets, hence changes in tariffs may be considered more persistent than exchange rate fluctuations, thus affecting the decision by the exporter to offset the induced change in relative prices by adjusting its mark up. The two instruments also differ in their welfare implications. While trade wars are undeniably a negative sum game (despite the fact that they crate revenues for the government), monetary policies that lead to a depreciating exchange rate may in some cases be beneficial to foreign countries, particularly if the latter choose appropriate policy responses.[1]

Article XV of the WTO may authorize trade restrictions against a "currency manipulator", but only after the currency manipulation has been confirmed by the IMF. In turn, Article IV of the IMF prohibits the manipulation of exchange rates in order 'to prevent effective balance-of-payment adjustment or to gain unfair competitive advantage'. However it is difficult to

[1] See Eichengreen (2013b) and Blanchard (2016). When the interest rate is at the zero lower bound, however, Caballero et al. (2015) show that a "currency war" is in fact a zero-sum game.

prove currency manipulation. Bergsten and Gagnon (2012) consider that the conjunction of rising foreign-exchange reserves and a current-account surplus defines a currency manipulator, for countries whose GDP per capita is above the world median. But the IMF accepts foreign-exchange interventions or even capital controls to mitigate a large and sudden capital inflow. Currency manipulation would then be declared only in the case of prolonged under-valuation of the currency with respect to an "equilibrium" exchange rate that needs to be calculated and agreed upon. As a matter of fact, no country has ever been declared a "currency manipulator" by the IMF.

At national level, the threat of a rise in tariffs is often mentioned in the context of exchange-rate variations. In the United States for instance, Congress can impose a rise in tariffs on a country that is found to be a "currency manipulator", although the semi-annual report of the US Treasury on foreign-exchange policies routinely concludes that no major country "meets the standards" of currency manipulation. In the policy debate, though, tariffs are often intended to be used as retaliation against perceived undervaluation by trading partners.

Surprinsingly, though, there is limited evidence on the compared effects of currency undervaluation and tariffs on trade flows. One of the two variable is often taken into account by fixed effects when estimating the impact of the other one. For instance, Berthou (2008) estimates a gravity equation for 20 OECD exporting countries and 52 developed and developing importing countries, at the industry level. The specification used allows to estimate the impact of the real exchange rates, but trade barriers are controled through fixed effects. In another type of specification, Anderson et al. (2013) develop a structural gravity model to estimate the impact of the exchange rates on trade flows at the industry level. More specifically, they use a database of Canadian provincial production and trade panel data that allow them to identify possible exchange rate real effects via their interaction with the international border, while trade costs are controlled through fixed effects. In both cases, the elasticity of exports to the exchange rate cannot be compared to the elasticity to tariffs. Using a totally different methodology, de Sousa et al. (2012) derive and estimate a ratio-type gravity equation at the industry level for 151 countries, which allows them to estimate trade costs effects without using fixed effects. Controlling for bilteral tariffs and for relative prices, they find that the effect of a tariff is, on average, ten times larger than that of relative prices. However they do not estimate the impact of the exchange rate itself.[2]

The aim of this paper is to provide trade elasticities for exchange rate changes and changes in tariffs within the same empirical specification, and to compare the elasticities with each other. We use a database of 110 countries, covering 83% of world trade in 2013, with annual data going back to 1989 at the product level (HS6). The specification follows the general framework of gravity models, which have been used extensively to assess the effect of exchange rate changes or tariffs. One key technical difficulty in this type of estimation is that unlike tariffs, real bilatreral exchange rates are not true dyadic variables: they are correlated to origin and destination fixed effects (Head and Mayer, 2014). We circumvent this problem by replacing some of the fixed effects by specific controls.

The results indicate that the effect of tariffs is comparatively much larger than the effect of exchange rate changes, although the magnitude of the difference between the two elasticities depends on the specification. In our preferred specification, a 10% depreciation of the exchange rate is associated with a rise in exports by 4.7% and a similar cut in tariffs leads to a rise in exports by 13.7%. Both elasticities are magnified for intra-industry trade. We also provide cross-section estimates for five-year windows.

The policy implications of our estimations are investigated within a simple model where the government of an open economy has two objectives: internal and external equilibrium, the weight on the latter reflecting the "mercantilist" tendency of the country. Faced with a negative trade shock, the government will optimally cut the home interest rate so as to depreciate the currency, or increase the tariff on imports. If both instruments are available, one will be used in a pro-competitive way while the other one is used to stabilize the purchasing power of domestic households. The mix between trade and monetary reaction then crucially depends on the "equivalence" between the two. When the tariff has three times more impact on exports than the exchange rate (our preferred estimates over the whole sample), it is

[2]Relative prices react to the exchange rate depending on pass-through effects that may vary across sectors and countries.

optimal to react to a negative trade shock by depreciating the currency while cutting the tariff on imports. For higher equivalence for instance (cf. our estimations over the 1989-93 window), it is rather optimal to increase the import tariff and appreciate the home currency. We also find that more intra-industry trade, and a more powerful direct channel of monetary policy both tend to raise the incentive to use the monetary "weapon" rather than the trade one.

The rest of the paper is organized as follows. Section 2 reviews the existing literature. Section 3 outlines our econometric methodology. Section 4 presents the data and key stylized facts. Section 5 reports the main empirical results. Section 6 studies the policy implications within a sketch model. Section 7 concludes the paper.

2 Literature review

Our paper is motivated by the renewed debate on currency wars and trade wars, emerging from the current context of the 2008 crisis and the near zero interest rate. Several researchers show that the zero lower bound (ZLB) increases the risk of non cooperative policies: government have incentives to use 'beggar-thy-neighbour' policies to regain global demand at this expense of the trading partners (Caballero et al., 2015; Eggertsson et al., 2016; Gourinchas and Rey, 2016). The strategy is to depreciate or increase tariffs to partly export the recession abroad and run a current account surplus.

Until the recent years, trade wars and currency wars have been studied separately, despite the event of the interwar period studied by Eichengreen and Irwin (2010) and even though exchange rate variations have been highlighted as a macroeconomic determinants of increased protectionism (Knetter and Prusa, 2003; Bown and Crowley, 2013; Georgiadis and Gräb, 2013; Bown and Crowley, 2014). Besides, the literature on these matters is largely uneven. On one hand, there have been an extended number of studies of protectionism, starting from the seminal papers of Grossman and Helpman (1994) and Grossman and Helpman (1995): they show the impact of lobbies on tariff protectionism, by pressuring governments. On the other hand, the literature on currency wars is quite new. Eichengreen (2013a) focuses on the last event of currency war and dissects the Great Depression crisis and the non-cooperative environment that came out of the policies used by depressed economies. One of the challenge when studying these competitive devaluations is to detect currency manipulations, which is the main focus of Bergsten and Gagnon (2012): they consider that the conjunction of rising foreign-exchange reserves and a current-account surplus defines a currency manipulator. Our paper aims at focusing at the two instruments that are used in these two kinds of 'beggar-thy neighbour' policies, and investigates whether exchange rate and tariff can be used as substitutes or as complements.

More specifically, our paper is related to the trade literature aiming at estimating trade elasticities of both real exchange rate and tariffs. The estimation of these two elasticities has been successfully done several times, as reported in the meta-analysis of Head and Mayer (2014). But, estimating trade elasticities of both exchange rate and tariff within the same econometric specification is rarely done: this is partly due to the fact that the logarithm of the real exchange rate is colinear to the fixed effects used in standard gravity equations (see Section 3). de Sousa et al. (2012) circumvent this issue by estimating trade elasticities of both tariffs and relative prices using a ratio-type gravity equation for 151 countries, during the period 1980-1996. Though they use exports to a specific country over total exports as dependent variable, we find similar estimates when comparing their estimates on relative prices to our figure for the real exchange rate. They find larger estimates on tariffs than us, and thus find that the effect of a tariff is, on average, ten times larger than that of relative prices.

Our methodology is very similar to the one used by Fontagné et al. (2017): they regress the value of exports on the real exchange rate and on tariffs, as we do. They also perform instrumental-variable estimations to deal with the endogeneity of prices and trade flows. Their estimates indicate that a 10% appreciation of the domestic currency decreases exports by 6% and that a 10% increase in the power of the tariff decreases exports by almost 20%. Their paper differs in the database that is used: they focus on firm-level data, for France only, from 1996 to 2010, where we use an extended dataset of international trade flows at the product level for 110 countries. Despite this difference, we find similar estimates on the real exchange rates and on tariffs.

3 Empirical methodology

In order to compute an equivalence between tariffs (trade wars) and exchange rates (currency wars), we estimate the elasticity of exports to both variables, respectively, relying on the following gravity equation at the detailed product level:[3]

$$X_{ijkt} = \underbrace{\frac{Y_{ikt}}{\Omega_{ikt}}}_{S_{ikt}} \underbrace{\frac{X_{jkt}}{\Phi_{jkt}}}_{M_{ikt}} \phi_{ij}, \tag{1}$$

where X_{ijkt} denotes the exports of country i to country j of good k during year t, Y_{ikt} is the total production of good k in country i during year t, and X_{jkt} is the total expenditure of importer j on good k during year t. In turn, Ω_{ikt} and Φ_{jkt} are the "multilateral resistance" terms defined by Anderson (1979) and Anderson and Wincoop (2003), and ϕ_{ij} accounts for all types of trade costs between country i and country j. To estimate this structural gravity equation, standard procedures consist in taking the logarithm of Equation 1:

$$lnX_{ijkt} = lnS_{ikt} + lnM_{jkt} + ln\phi_{ij}. \tag{2}$$

The variables lnS_{ikt} and lnM_{jkt}, which combine size and resistance, are generally captured by fixed effects:[4]

$$lnX_{ijkt} = \lambda_{ikt} + \mu_{jkt} + \nu_{ij} + \epsilon_{ijkt} \tag{3}$$

Introducing the bilatereal real exchange rate of country i against country j, $lnRER_{ijt}$, and the tariff imposed by country j on product k imported from country i, $ln(1+\tau)_{ijkt}$,[5]

[3]See Head and Mayer (2014) for a complete review of gravity models.

[4]The use of GDPs to account for those terms, as in naive gravity equations, is considered a "gold medal mistake" by Baldwin (2007): the estimates will be marked by omitted variable biases, here the multilateral resistance terms.

[5]The reason for using this log transformation of the tariff τ_{ijkt} is given below.

yields:

$$lnX_{ijkt} = \alpha_1 lnRER_{ijt} + \alpha_2 ln(1+\tau)_{ijkt} + \lambda_{ikt} + \mu_{jkt} + \nu_{ij} + \epsilon_{ijkt} \quad (4)$$

The problem with Equation 4 is that the real exchange rate is colinear to the exporter-product-time (ikt) and importer-product-time (jkt) fixed effects, since it is the difference between countries i and j log-price indices (corrected for the nominal exchange rate). One way to get around this identification issue (see Head and Mayer, 2014) is to substitute an exporter-product fixed effect to the usual exporter-product-time fixed effect, and to complement it with a vector of controls Z_{it} that will capture the variance in the exporter-time dimension. We therefore estimate the following equation:

$$lnX_{ijkt} = \alpha_1 lnRER_{ijt} + \alpha_2 ln(1+\tau)_{ijkt} + \alpha_3 Z_{it} + \lambda_{ik} + \mu_{jkt} + \nu_{ij} + \epsilon_{ijkt} \quad (5)$$

The dependent variable is the logarithm of exports from country i to country j in product k during year t, expressed in current dollars. The first variable of interest is the logarithm of the bilateral real exchange rate between country i and country j in year t, defined such as an increase in the real exchange rate is an appreciation of the exporter's currency. The second variable of interest is the logarithm of the "power of the tariff", defined as one plus the bilateral tariff imposed by importer j for product k coming from country i in year t.[6] The vector of exporter-time controls Z_{it} includes variables to compensate the loss of the exporter-time dimension in the fixed effects, such as the exporter's GDP.

Alternatively, Equation (5) is estimated while replacing the exporter-importer fixed effect, ν_{ij}, by a set of standard gravity controls such as dummies for regional trade agreements, common currency, contiguity, common language, colonial history, and the logarithm of the distance.

Surprisingly, few authors have introduced the real exchange rate in a gravity equation. Berthou (2008) derives and estimates a gravity equation for 20 OECD exporting countries and 52 developed and developing importing countries, at the industry level. The specification

[6] Using the power of the tariff rather than the tariff itself allows us to circumvent the fact that the tariff is often zero (given the large network of free trade agreements). For a small tariff, we have $\ln(1+\tau_{ijkt}) = \tau_{ijkt}$.

used allows to estimate the impact of the real exchange rate. In another type of specification, Anderson et al. (2013) develop a structural gravity model to estimate the exchange-rate impact on trade flows at the sectoral level. More specifically, they use a database of Canadian provincial production and trade panel data that allow them to identify possible exchange rate real effects via their interaction with the international border, skipping the use of fixed effects. Using a totally different methodology, de Sousa et al. (2012) derive and estimate a ratio-type gravity equation at the industry level for 151 countries, which allow them to estimate the impact of trade costs without using fixed effects. But they only control for the tariffs and relative prices, not directly for the real exchange rate.

4 Data

4.1 Data sources

The dataset covers 110 countries, from advanced to developing economies,[7] from 1989 to 2013, with annual data. In 2013, these countries represented 83% of world exports. We use harmonized bilateral trade data at the detailed HS6 product level from the BACI database (Gaulier and Zignago, 2010).[8]

Bilateral real exchange rates are from the IMF or computed by the USDA[9] using IMF data. Yearly-average nominal bilateral exchange rates are corrected for consumer prices indices.[10] Gross domestic product (GDP) data in current dollar are from the Penn World Tables. The gravity controls are from Head et al. (2010), and de Sousa (2012).

Tariffs are taken from the TRAINS database (UNCTAD), at the HS6 product level. When the two countries i and j are covered by a Preferential Trade Agreement (PTA), we use the corresponding tariffs. Otherwise, we use the Most-Favoured Nation (MFN) tariffs, i.e. which

[7]See country list in Appendix A.

[8]Using original data from the COMTRADE database, BACI is constructed by reconciling the declarations of the exporter and the importer, providing a very complete dataset for exports, at the HS6-digit product level.

[9]United States Department of Agriculture.

[10]Although a currency devaluation concerns the nominal exchange rate, governments want to monitor the real exchange rate, which is closer to price competitiveness. Since the consumer price index only adjusts with a delay, the real exchange rate closely follows the nominal one in the short term.

Table 1: Summary statistics

	Mean	Within s.d.	Median	1st decile	9th decile
Level					
Tariffs (%)	6.43	2.9	0.99	0	20
Real exchange rate (100=2010)	103.5	15.2	100	73	136.6
Variations (%)					
Real exchange rate	0.9	9	0.6	-1.7	3.6

Notes: The real exchange rate index is based 100 in 2010. The variations in the real exchange rate are not symetrical due to the different number of occurence in the database, depending on the number of products exchanged by the country-pair at time t.

are the tariffs applied outside PTAs and cannot exceed the bound tariffs negotiated at the WTO (hence MFN tariffs are the highest rates that WTO members can charge one another).

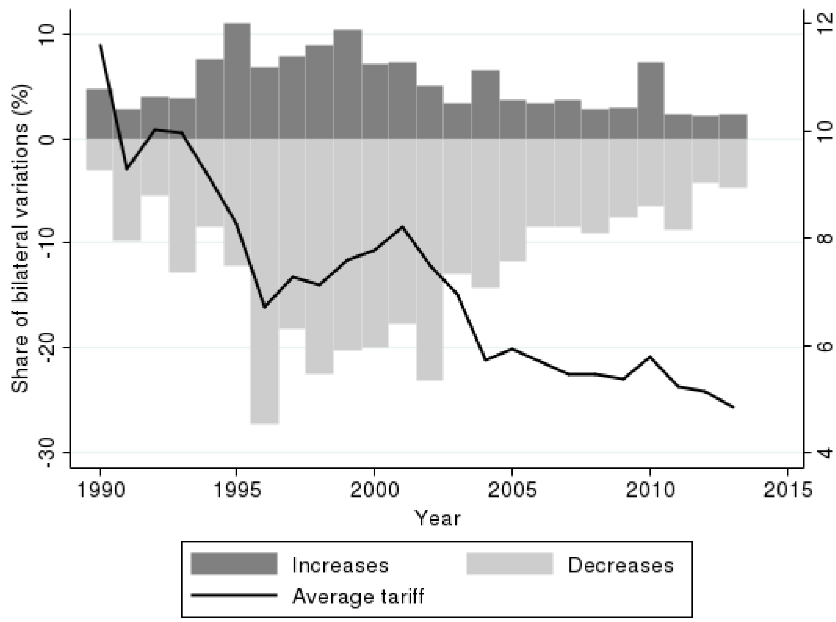
4.2 Descriptive statistics

Table 1 presents some summary statistics for tariffs and real exchange rates. The average tariff is of 6.43%, but the median value (0.99%) shows the importance of low tariffs in the data: half of the imposed tariffs are equal to zero. There are also extreme values[11], but they are rare, as shown by the 20% tariff value for the last decile. These statistics confirm the fact that the real exchange rate is much more volatile than tariffs: on average, the (within) standard deviation is much higher for exchange rate (15.2%) than for tariffs (2.9%).

Figure 1 illustrates the variations of tariffs (PTAs and MFNs) in our sample, from 1990 to 2013. The black line is the average tariff, the dark-grey bars are the number of tariff increases and the light-grey bars are the number of tariff decreases, both calculated as a share of the total number of bilateral variations, for each year. The last twenty five years were marked by a global trade liberalization that shows up in two waves in our data: first between 1993 and 1996, and then again during the pre-crisis period from 2002 to 2013. Overall, the average tariff decreased from 11.5% to 4.5% between 1990 and 2013. This trade liberalization relies

[11] The maximum tariff is of 3000% imposed in 1990 by the Indonesian government on some milk and cream products. Such rate was also imposed in 2008 by the Egyptian government on some beverages, and by other countries to a lower extent.

Figure 1: Tariffs variations



on both the reduction of MFN tariffs, and the increasing number of regional PTAs[12], which alo appears in our sample: in 2013, a substantial share of the available tariffs in our sample are equal to zero (50% in 1990 versus 62% in 2013).

The general trend in tariffs is further illustrated when looking at the variations in tariffs: two third of them are decreases. Over the sample, the average decrease in tariffs is of 5.4 percentage points. The smallest decrease is of 0.1 percentage point[13], when the largest one goes up to 3000 percentage points.

However, the decreasing trend in tariffs is not linear: there are some episodes of increase in the average tariff, particularly in 1992-1993 and 1997-2001. Increases in tariffs happen more rarely, but when they do, the variations are greater than when tariffs decrease: one third of the variations are increases, with a 6.9 percentage point rise on average. The biggest peak in the number of tariff increases is in 2010, during the Great Recession.

[12] see *Key statistics and trends in trade policy 2015*, UNCTAD.

[13] The computation of tariff equivalent of quotas on agricultural products may artificially increase the count of variations, therefore we exclude variations of less than 0.1 percentage point.

5 Results

5.1 Baseline results

Before presenting the estimations of Equation 5, we report the estimation results of a naive gravity model where bilateral exports depend on both countries' GDP (in logarithms) on the top of our two variables of interest. We just add export-import-product and time fixed effects so as to get a within estimation of the parameters.[14] The results are reported in the first column of Table 2. The four coefficients are significant at the 1 percent confidence level, with the expected signs. On average, a 10% depreciation in the real exchange rate of the exporter country (decrease in RER_{ijt}) implies a 3% increase in its exports, while a 10% cut in the power of the tariff in the destination country implies a 6.4% increase in exports.

In Column (2), the GDP of the exporting country is replaced by exporter-product-time fixed effects. Consistently, time fixed effects are eliminated, while export-import-product fixed effects are replaced by importer-product and exporter-importer fixed effects. The results are qualitatively similar as in Column (1), but exports now react less to the exchange rate and more to the tariff.

We now turn to the baseline estimation of Equation 5. Column (3) presents the results when the vector of controls Z_{it} is limited to the exporter's GDP, whereas column (4) adds a crisis dummy[15] for the exporting country, always clustering at the country-pair level. Again, all the coefficients are significant at the one percent confidence level, with the expected signs. However, the elasticities differ from those obtained with the naive gravity model. Now, a 10% depreciation of the real exchange rate is associated with a 4.7% increase in exports in both specification, while a 10% cut in the power of the tariff in the destination country is associated with a 13.7% increase in exports. Hence, a 10% depreciation of the real exchange rate in the destination country is equivalent, in terms of exports, to a 3.4% increase in tariffs.

[14] We also cluster the results in the ij dimension.

[15] This crisis dummy is constructed using the database of Laeven and Valencia (2012), and refers to banking crisis, currency crisis and sovereign debt crisis.

Table 2: Baseline results

	Dependent variable: $Exports_{ijkt}$			
	(1)	(2)	(3)	(4)
	Naive gravity	FE ikt-jk	Baseline	Controls it
RER_{ijt}	-0.300***	-0.153***	-0.474***	-0.472***
	(-8.98)	(-5.63)	(-8.02)	(-7.99)
$Tariff_{ijkt}$	-0.637***	-0.985***	-1.366***	-1.365***
	(-9.42)	(-20.89)	(-14.88)	(-14.88)
GDP_{it}	0.724***		0.694***	0.693***
	(16.97)		(12.35)	(12.31)
GDP_{jt}	0.440***	0.450***		
	(14.85)	(19.84)		
$Crisis_{it}$				-0.011*
				(-1.86)
FE ijk - t	Yes			
FE ik - jkt			Yes	Yes
FE ikt - jk		Yes		
FE ij		Yes	Yes	Yes
Cluster	ij	ij	ij	ij
Observations	61,611,845	62,667,491	63,203,049	63,203,049
R-squared	0.771	0.645	0.640	0.640

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

5.2 Robustness tests

Table 3 presents a number of robustness tests. Column (1) recalls the baseline estimation. In Column (2), we replace the exporter-importer fixed effect by a standard set of gravity controls, some of which vary over time: common border dummy ($Contiguity_{ij}$), common language dummy ($Language_{ij}$), former colonial link dummy ($Colony_{ij}$), geographic distance ($Distance_{ij}$), regional trade agreement (RTA_{ijt}), a common currency ($Currency_{ijt}$). All added variables are significant at 1% with the expected sign. The estimates imply that a 10% depreciation of the real exchange rate in the destination country is equivalent to a 2.4% increase in the tariffs. Using the standard errors in brackets, we see that the estimates on the real exchange rates and tariffs of Column 1 and Column 2 are significantly different at the 95% level.

Column 3 adds a dummy for intra-European Union trade (EU_{ijt}). The dummy has positive and highly significant impact on trade, while the impact of the exchange rate is slightly increased. In Column 4, we limit the sample to the pre-crisis, 1989-2007 period. The results are broadly unchanged. In Column 5, the sample is restricted to the manufacturing products. The results are very similar to those obtained over the whole sample (Column 2).

Finally, we come back to the baseline specification but lag the three variables by one year, in order to correct for possible reverse causality or possible lags in the impact of the different variables. The estimates are reported in Column 6. The impact of the exchange rate is similar as in the benchmark regression, while the impact of the tariff is reduced but stays significant at 1%. It should be noted here that tariff variations may be announced in advance by a government, which will speed up the impact on trade. Conversely, trade may react with a delay to an exchange-rate variation due to the high volatility of this variable.

Table 4 presents another set of robustness tests. The first three columns explore the possibility of an asymmetric reaction of exports to an increase or a decrease in the tariff in the destination country (Column (1)), a non-linearity depending on the level of the real exchange rate (Column (2)), or an asymmetry between exchange appreciation or depreciation (Column (3)). In Column (1), where the power of the tariff is interacted with dummies for

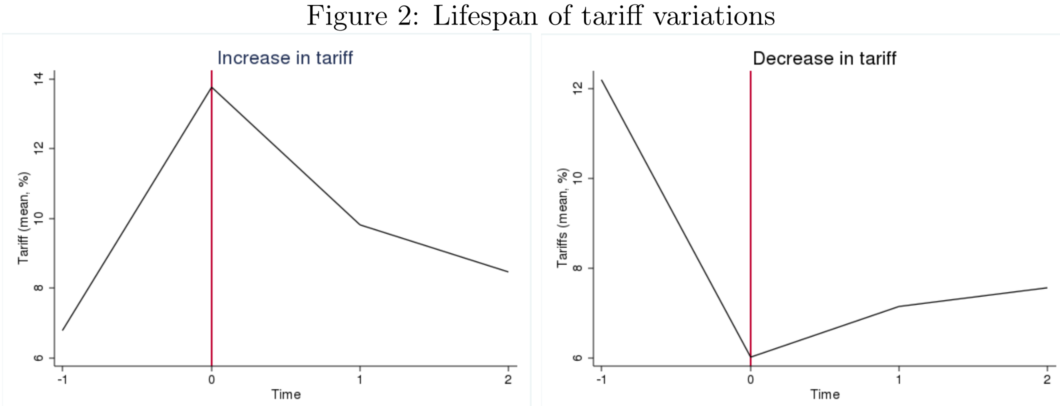
Table 3: Robustness checks

	Dependent variable: $Exports_{ijkt}$					
	(1) Baseline	(2) Gravity controls	(3) EU dummy	(4) Pre-crisis 1989-2007	(5) Manuf. products	(6) Lagged variables
RER_{ijt}	-0.474***	-0.413***	-0.431***	-0.514***	-0.419***	-0.505***
	(-8.02)	(-7.037)	(-7.936)	(-7.880)	(-7.225)	(-6.401)
	[0.059]	[0.054]	[0.054]	[0.065]	[0.058]	[0.079]
$Tariff_{ijkt}$	-1.366***	-1.744***	-1.645***	-1.467***	-1.584***	-0.853***
	(-14.88)	(-12.77)	(-11.96)	(-10.16)	(-9.553)	(-7.921)
	[0.090]	[0.137]	[0.138]	[0.144]	[0.166]	[0.108]
GDP_{it}	0.694***	0.739***	0.735***	0.722***	0.771***	0.722***
	(12.35)	(15.21)	(15.08)	(11.61)	(15.07)	(11.17)
RTA_{ijt}		0.115***	0.096***	0.143***	0.132***	
		(3.467)	(2.829)	(3.724)	(3.896)	
$Currency_{ijt}$		0.238***	0.192***	0.231***	0.242***	
		(4.614)	(3.741)	(4.150)	(4.539)	
$Contiguity_{ij}$		0.555***	0.563***	0.548***	0.554***	
		(9.571)	(9.687)	(9.085)	(9.246)	
$Language_{ij}$		0.316***	0.319***	0.306***	0.342***	
		(7.433)	(7.518)	(7.070)	(7.832)	
$Colony_{ij}$		0.303***	0.319***	0.301***	0.318***	
		(5.821)	(6.089)	(5.676)	(5.839)	
$Distance_{ij}$		-0.833***	-0.819***	-0.816***	-0.856***	
		(-38.38)	(-35.98)	(-36.16)	(-38.03)	
EU_{ijt}			0.163***			
			(3.646)			
RER_{ijt-1}						-0.263***
						(6.015)
$Tariff_{ijkt-1}$						-0.0013***
						(-5.253)
GDP_{it-1}						0.176***
						(4.458)
FE ik jkt	Yes	Yes	Yes	Yes	Yes	Yes
FE ij	Yes	No	No	No	No	Yes
Observations	63,203,049	62,902,461	62,902,461	41,139,004	53,984,183	34,320,029
R-squared	0.640	0.610	0.610	0.616	0.612	0.659

Notes: t-stats are in parentheses. In brackets are the standard errors, clustered at the country-pair level, and they are robust to a cluster at the exporter-importer-product level. All variables are in logarithm except for the gravity dummies RTA_{ijt}, $Currency_{ijt}$, $Contiguity_{ij}$, $Colony_{ij}$ and for EU_{ijt}. All nominal variables are expressed in US dollars. Column (5) contains only the manufactured products, dropping all agricultural products. Column (6) contains less observations due to missing data in the lagged tariff variable. The level of significance is the following: *** p<0.01, ** p<0.05, * p<0.1.

tariff increase or decrease from the previous year, it can be concluded that the tariff in the destination country has less impact just after an increase than when it is either constant or declining. This intriguing result may be linked to the fact that tariff hikes are generally short lived over the period of investigation, in contrast with tariff cuts. Indeed Figure 2 illustrates the duration of a variation in tariffs. On average, an increase is offset by half a year after, when a decrease is only followed by a slight increase the year after. This interpretation is reinforced by the very small asymmetric effect found for the real exchange rate, which is almost the same whether the real exchange rate appreciates or depreciates (Column (3)). The mean reversal of real exchange rate variations is similar for appreciations as for depreciations. Finally, interacting the real exchange rate and the tariff (Column (2)) shows a greater impact of exchange-rate variations when the tariff is high in the destination country, since the interacted coefficient is fo the same sign (and highly significant) as that on the real exchange rate itself: trade and monetary barriers tend to reinforce each other.

Figure 2: Lifespan of tariff variations



The second part of Table 4 disentangles the impact of tariffs and exchange rates on unit export values and on export volumes. Unit export values (in dollar) decline by less than one-to-one to a depreciation of the home currency: in line with the literature, we find incomplete pass-through. Conversely, unit values do not react to changes in tariffs, hence they are entirely passed on to the importer. The final column is consistent with these results: the elasticity of the value of exports to the real exchange rate (Column 1) is the sum of the elasticity of the unit value (Column 4) and that of the export volume (Column 5). The latter is in the range of the existing literature. In turn, the elasticities of export values and volumes are not significantly different, which is consistent with insignificant reaction to unit values.

5.3 Intra-industry trade

The detailed level of disaggregation of the data allows us to test whether the elasticities may differ for intra-industry trade (trade of varieties) compared to inter-industry trade. The share of intra-industry trade is measured through the Grubel-Lloyd index at the product level:

$$GL_{ijkt} = 1 - \frac{|Exports_{ijkt} - Imports_{ijkt}|}{Exports_{ijkt} + Imports_{ijkt}} \tag{6}$$

The index may vary from 0 (only inter-industry trade) to 1 (only intra-industry trade). We expect it to be higher for trade amongst advanced economies than for trade between advanced and emerging or developing countries. It is also higher for manufacturing products than for primary goods. The GL index is then interacted with the real exchange rate and with the power of the tariff in order to test for different elasticities depending on the share of intra-industry trade.

The results are displayed in Table 5, Column 1. More intra-industry trade unambiguously increases both elasticities: it raises the reaction of bilateral exports both to the exchange rate and to the power of the tariff. For inter-industry trade (GL=0), a 10% depreciation in the destination country is equivalent to a 1.5% increase in the tariff, while for intra-industry trade (GL=1), the equivalent is a 0.85% increase in the power of the tariff. Hence, a tariff hike appears relatively more powerful to curb imports than a real exchange-rate depreciation when intra-industry trade is higher. However we cannot directly compare these estimates with the baseline model since introducing the GL index leads to a drammatic reduction in the sample size[16]. Column 2 provides an estimation of the baseline equation over the same sample as in Column 1. Disregarding the share of intra-industry trade, a 10% depreciation of the real exchange rate in the destination country is equivalent to a 2.4% increase in the tariff. We also run a regression with the intra-industry trade quartiles interacted with real exchange rate and

[16] In many cases, the GL index cannot be computed, due to missing values in $Exports_{ijkt}$ or $Imports_{ijkt}$.

Table 4: Asymmetric reactions and pass-through

	Dep. var. : Value of exports			Unit values	Volume
	(1)	(2)	(3)	(4)	(5)
RER_{ijt}	-0.428***	-0.401***	-0.405***	0.419***	-0.833***
	(-6.773)	(-7.333)	(-7.406)	(10.51)	(-11.97)
$Tariff_{ijkt}$	-1.931***	-1.743***	-1.680***	0.0728	-1.749***
	(-8.690)	(-12.68)	(-12.18)	(0.969)	(-11.32)
GDP_{it}	0.733***	0.736***	0.733***	-0.0957***	0.830***
	(14.14)	(15.10)	(15.02)	(-6.212)	(15.13)
RTA_{ijt}	0.109***	0.109***	0.115***	-0.0401***	0.153***
	(2.968)	(3.300)	(3.455)	(-3.258)	(4.132)
$Currency_{ijt}$	0.217***	0.236***	0.243***	-0.0812***	0.329***
	(4.249)	(4.578)	(4.713)	(-5.997)	(5.869)
$Contiguity_{ij}$	0.540***	0.558***	0.558***	-0.0615***	0.618***
	(9.159)	(9.643)	(9.648)	(-3.796)	(9.592)
$Language_{ij}$	0.323***	0.315***	0.315***	-0.0221	0.338***
	(6.777)	(7.414)	(7.415)	(-1.520)	(6.840)
$Colony_{ij}$	0.296***	0.308***	0.303***	-0.0683***	0.368***
	(5.125)	(5.932)	(5.818)	(-3.566)	(5.898)
$Distance_{ij}$	-0.872***	-0.832***	-0.834***	0.157***	-0.995***
	(-34.68)	(-38.47)	(-38.48)	(22.69)	(-40.94)
$Tariff_{ijkt} * Increase_{t-1,t}$	0.764***				
	(4.028)				
$Tariff_{ijkt} * Decrease_{t-1,t}$	-0.258				
	(-1.379)				
$RER_{ijt} * Tariff_{ijkt}$		-0.150***			
		(5.366)			
$RER_{ijt} * Depreciation_{t-1,t}$			-0.00428**		
			(2.536)		
FE ik-jkt	Yes	Yes	Yes	Yes	Yes
Observations	43,945,095	63,142,608	63,142,608	61,949,253	61,949,253
R-squared	0.630	0.609	0.609	0.715	0.668

Notes: t-stats are in parentheses. Standard errors are clustered at the country-pair level, and they are robust to a cluster at the exporter-importer-product level. All variables are in logarithm except for the gravity dummies RTA_{ijt}, $Currency_{ijt}$, $Contiguity_{ij}$, $Colony_{ij}$ and for EU_{ijt}. All nominal variables are expressed in US dollars. Column (1) contains less observations due to missing data in the tariff variable when computing its year-on-year variation. Column (4) and (5) contain less observations due to missing data in the quantity of exports variable. The level of significance is the following: *** p<0.01, ** p<0.05, * p<0.1.

the power of the tariff. The results, in Column 3, show that more intra-industry trade raises the sensitivity of trade is with respect to both the real exchange rate and the tariff.

Now, we normalize the product-level Grubel-Llyod index by the country-level index in order to identify whether the elasticities differ for those goods that are more subject to intra-industry trade, for each couple of countries. The normalized index is $\widetilde{GL}_{ijkt} = \frac{GL_{ijkt}}{GL_{ijt}}$, with:

$$GL_{ijt} = 1 - \frac{|Exports_{ijt} - Imports_{ijt}|}{Exports_{ijt} + Imports_{ijt}}, GL_{ijt} \in [0, 1]. \quad (7)$$

A higher normalized GL index means that there is more intra-industry trade for the corresponding good. Column 3 reports the results. The normalized GL index has much less impact on the two elasticities than the non-normalized index. This result suggests that trade between countries that carry out much intra-industry trade tends to react more both to the real exchange rate and to the tariffs, but more intra-industry trade for a specific product has little additional impact. One interpretation may be that trade between high income countries is more reactive. We subsequently introduce a high-income dummy, which is equal to unity if i and j both are high income economies (World Bank classification), and interact this dummy with the variables of interest. The results are reported in the last column. The dummy actually reduces the elasticity to the real exchange rate, while it has no significant impact on the coefficient for the tariff.

5.4 Cross-section analysis

So far, we have estimated tariffs and real exchange rate trade elasticities in the within dimension over the entire 1989-2013 period. However this period has witnessed important changes. For instance, the average tariff has fallen from 9.9 to 4.0% in our sample. Our assumption of a constant elasticity does not allow the possibility of reduced sensitivity to tariffs when the latter are close to zero. More importantly, the development of global value chains may have reduced the size of the elasticities (Swarnali et al., 2017). But at the same time, the growing share of emerging countries in world trade may have raised the sensitivity of the demand to relative prices.

Table 5: Intra-industry trade

	Dependent variable : $Exports_{ijkt}$				
	GL index (1)	Baseline same sample (2)	GL quartiles (3)	GL normalized (4)	High income (5)
RER_{ijt}	-0.232***	-0.309***	-0.252***	-0.251**	-0.423***
	(-2.648)	(-3.40)	(-2.899)	(-2.888)	(-7.725)
$RER_{ijt} * GL_{ijkt}$	-0.053***				
	(5.885)				
$RER_{ijt} * GL1_{ijkt}$			0.0497***		
			(-6.03)		
$RER_{ijt} * GL2_{ijkt}$			0.0203***		
			(-6.001)		
$RER_{ijt} * GL2_{ijkt}$			0.005***		
			(-4.042)		
$RER_{ijt} * GLnorm_{ijkt}$				-0.0005***	
				(3.978)	
$RER_{ijt} * HI_{ij}$					0.040***
					(-4.043)
$Tariff_{ijkt}$	-1.685***	-1.284***	-2.273***	-2.033***	-1.658***
	(-7.456)	(-10.01)	(-9.979)	(-10.01)	(-10.89)
$Tariff_{ijkt} * GL_{ijkt}$	-1.116***				
	(-4.785)				
$Tariff_{ijkt} * GL1_{ijkt}$			0.892***		
			(4.236)		
$Tariff_{ijkt} * GL2_{ijkt}$			0.439***		
			(5.548)		
$Tariff_{ijkt} * GL3_{ijkt}$			0.224***		
			(7.628)		
$Tariff_{ijkt} * GLnorm_{ijkt}$				-0.015***	
				(-4.010)	
$Tariff_{ijkt} * HI_{ij}$					-0.212
					(-0.909)
Controls	Yes	No	Yes	Yes	Yes
FE ik-jkt	Yes	Yes	Yes	Yes	Yes
FE ij	No	Yes	No	No	No
Observations	30,028,517	30,027,791	30,221,509	30,028,517	62,902,461
R-squared	0.614	0.694	0.667	0.667	0.610

Notes: t-stats are in parentheses. Standard errors are clustered at the country-pair level, and the standard errors are robust to a cluster at the exporter-importer-product level. All variables are in logarithm. The gravity controls are those included before: RTA_{ijt}, $Currency_{ijt}$, $Contiguity_{ij}$, $Colony_{ij}$ and $Distance_{ij}$. All nominal variables are expressed in US dollars. The level of significance is the following: *** p<0.01, ** p<0.05, * p<0.1

Here we test whether our elasticites are constant over time through several cross-section estimations over five-year windows.[17]. For each of these periods we compute the average of our key variables: exports, the real exchange rate, tariffs, and the exporter's GDP (averages are denoted by a bar); hence we drop the time dimension in our estimation and adjust the fixed effects accordingly:

$$ln\overline{X}_{ijk} = \alpha_1 ln\overline{RER}_{ij} + \alpha_2 ln(1+\overline{\tau})_{ijk} + \alpha_3 ln\overline{GDP}_i + G_{ij} + \mu_{jk} + \epsilon_{ijk} \quad (8)$$

The dependent variable is the logarithm of average exports from country i to country j in product k, expressed in current dollars. The first variable of interest is the logarithm of the average of the bilateral real exchange rate between country i and country j, where the real exchange rate is computed using price levels[18], and defined such as $\overline{RER}_{ij} > 1$ means that the cost of the consumption basket is higher in country i than in country j. The second variable of interest is the logarithm of one plus the average bilateral tariff imposed by importer j on product k coming from country i. We add the logarithm of the average exporter's GDP and the standard gravity controls in G_{ij}. Finally, because of the colinearity of the real exchange rate variable with the standard fixed effects, we only introduce an importer-product fixed effect, droping the exporter-product one.

Table 6 presents the results of the estimations of Equation 8 for the different periods. All estimates are significant at 1% with the expected sign. We observe an increase in the exchange-rate elasticities in the 2000s compared to the 1990s. As for the elasticity to the tariff, it is lower over 1994-2003 than either before or after this 10-year period. In terms of equivalence between both instruments, a 10% appreciation of the exporter's currency was equivalent to a 1.2% increase in the importer's tariffs in 1989-1993, an equivalent that goes up to a 5.1% increase in the importer's tariffs for the third period (1999-2003). The equivalence then stabilizes: a 10% appreciation of the exporter's currency is equivalent to a 4% increase in the importer's tariffs for the fourth period, and to a 3% increase for the last period of the

[17] Each period contains five years except the last one where we excluded the 2009 crisis year.

[18] The real exchange rates in levels are calculated based on purchasing power parity conversion factors from the World Bank.

Table 6: Cross-section analysis

	(1) 1989-1993	(2) 1994-1998	(3) 1999-2003	(4) 2004-2008	(5) 2010-2013
$\overline{RER}_{ij}$	-0.111***	-0.105***	-0.228***	-0.349***	-0.393***
	(-3.288)	(-4.400)	(-10.38)	(-13.52)	(-13.39)
$\overline{Tariff}_{ijk}$	-0.950***	-0.419***	-0.447**	-0.868***	-1.317***
	(-3.602)	(-2.725)	(-2.362)	(-4.317)	(-5.183)
$\overline{GDP}_i$	0.498***	0.503***	0.515***	0.576***	0.621***
	(34.40)	(46.22)	(52.46)	(51.89)	(57.08)
$Contiguity_{ij}$	0.687***	0.575***	0.561***	0.560***	0.580***
	(7.452)	(8.789)	(8.999)	(9.119)	(9.212)
$Language_{ij}$	0.286***	0.240***	0.190***	0.169***	0.109***
	(4.982)	(5.778)	(5.264)	(4.433)	(2.747)
$Colony_{ij}$	0.0295	0.0829	0.0647	0.0167	0.0616
	(0.429)	(1.606)	(1.380)	(0.344)	(1.198)
$Distance_{ij}$	-0.455***	-0.494***	-0.532***	-0.594***	-0.659***
	(-19.26)	(-28.34)	(-33.86)	(-33.52)	(-37.43)
Equivalence ζ	8.6	4	2	2.5	3.4
FE jk	Yes	Yes	Yes	Yes	Yes
Observations	2,012,414	4,214,004	5,329,769	6,190,856	5,712,610
R-squared	0.411	0.418	0.421	0.423	0.429

Notes: the 2009 crisis year is excluded from the sample. The number recorded as equivalence the trade impact of tariffs relatively to the one of exchange rate. T-stats are in parentheses. Standard errors are clustered at the country-pair level, and the standard errors are robust to a cluster at the exporter-importer-product 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

sample.

6 Policy implications

Here we study the policy implications of our empirical results, based on a stylised model featuring a small open economy whose government wishes to reach both internal and external equilibrium. The internal equilibrium is defined as GDP being equal to its potential level, whereas the external equilibrium is the equilibrium of the trade balance. The weight on the latter objective (labelled θ) reflects the "mercantilist" tendency of the government. There may be two policy instruments (trade policy and monetary policy), in which case both objectives can be reached simultaneously; or only one instrument (either trade or monetary policy), in which case a trade-off needs to be made between internal and external equilibrium. In this short-term setting, an import tariff or a depreciated currency has a positive impact on the trade balance, but it reduces households' purchasing power. We compare the optimal policy mix depending on the relative impact of tariffs and of the exchange rate on trade flows.

6.1 A stylized model of a small open economy

We start with the the following accounting identity, expressed in units of the domestic good:

$$Y = C + I + \frac{EB}{P}, \tag{9}$$

where Y, C and I denote GDP, consumption and investment, respectively, all expressed in units of domestic good, B is the trade balance expressed in units of foreign currency, E is the nominal the exchange rate (units of domestic currency per unit of foreign currency) and P is the GDP deflator.

The volume of consumption C is assumed to be a fixed share $c \in [0, 1]$ of the purchasing power of domestic income: $C = c\frac{PY}{P_c}$, where P_c is the consumer price index: $P_c = P^{1-\eta}(EP^*(1+\tau))^\eta$, with P^* the price of the foreign good (in foreign currency), τ the import tariff and $\eta \in [0, 1]$ the share of the foreign good in the consumption basket. As for the volume of investment I, it is assumed to react to the interest rate r with an elasticity $\alpha > 0$: $I_0(1 + r)^{-\alpha}$, where $I_0 > 0$ is a constant.

Since we are interested in the short-term equilibrium, we assume the price of both the domestic and the foreign goods to be fixed: $P = P^* = 1$. Equation 9 becomes:

$$Y = cY[E(1 + \tau)]^{-\eta} + I_0(1 + r)^{-\alpha} + \frac{EB}{P}, \tag{10}$$

The first term represents the negative impact of a weaker currency (higher exchange rate E) or an import tariff τ on consumption through reduced purchasing power. The second term shows the positive impact of a lower interest rate on investment. The third one represents net external demand. We write the trade balance B as the difference between the value of exports and that of imports, both being expressed in foreign currency. With $P = P^* = 1$, we have:

$$B = X_0 E^{\epsilon}(1+\tau^*)^{-\zeta\epsilon} Y^{*\gamma^*} - M_0 E^{-\epsilon}(1+\tau)^{-\zeta\epsilon} Y^{\gamma} \tag{11}$$

where τ^* and Y^* represent the foreign import tariff and foreign GDP, respectively (both exogenous), $\gamma, \gamma^* > 0$ are the home and foreign income elasticities of imports, $\epsilon > 0$ is the elasticity of imports to the exchange rate, and $\zeta > 0$ is a multiplier applied to this elasticity to get the elasticity of imports to the tariff. Consistent with our estimations, both ϵ and ζ are assumed to be equal in the home as in the foreign country. Finally, $X_0 > 0$ and $M_0 > 0$ are constants.

Equations 10 and 11 can be linearized around the internal and external equilibria, and around $E = 1$, $r = 0$ and $\tau = 0$. With $y = dY/Y$, $y^* = dY^*/Y^*$, $e = dE/E$ and $b = dB/X$, and denoting by u and v exogenous shocks, we get (see Appendix C):

$$y = \frac{-\eta c}{1-c}(e+\tau) - \mu r + \lambda b + u, \tag{12}$$

$$b = \zeta\epsilon(\tau - \tau^*) + 2\epsilon e + \gamma(y^* - y) + v, \tag{13}$$

where $\mu = \frac{\alpha I_0}{Y(1-c)} > 0$ and $\lambda = \frac{X}{Y(1-c)} > 0$.

Following the uncovered interest parity, the exchange rate depreciates when the home interest rate r falls relative to the foreign one r^*, the latter being exogenous:

$$e = \delta(r^* - r), \tag{14}$$

where $\delta > 0$ measures the expected persistence of the interest differential.

Following Blanchard (2016), we finally assume that the government[19] has two objectives: internal equilibrium (GDP equal to its potential level, e.g. a zero output gap), and external

[19]We use the generic term of government to cover any public authority or combination of public authorities, e.g. the government and the central bank.

equilibrium (a trade balance equal to zero).[20] The government's programme is the following:

$$\underset{r,\tau}{Min} L = \frac{1}{2}(y^2 + \theta b^2) \tag{15}$$

The government has two policy instruments: the interest rate and the import tariff. Their impact on the domestic output and on the trade balance are the following:

$$\frac{\partial y}{\partial r} = -\frac{1}{1+\lambda\gamma}\left(-\frac{\eta c}{1-c} + \mu + 2\lambda\epsilon\right) \tag{16}$$

$$\frac{\partial y}{\partial \tau} = \frac{1}{1+\lambda\gamma}\left(-\frac{\eta c}{1-c} + \lambda\zeta\epsilon\right) \tag{17}$$

$$\frac{\partial b}{\partial r} = -\frac{1}{1+\lambda\gamma}\left(2\epsilon + \frac{\gamma\eta c}{1-c} - \gamma\mu\right) \tag{18}$$

$$\frac{\partial b}{\partial \tau} = \frac{1}{1+\lambda\gamma}\left(\zeta\epsilon + \frac{\gamma\eta c}{1-c}\right) \tag{19}$$

The interest rate has an ambiguous effect on domestic output: on the one hand, a rate cut stimulates investment and (through the involved currency depreciation) raises net exports; on the other hand, the depreciation reduces the purchasing power of consumers. The tariff also has ambiguous effect on output since it stimulates net exports but reduces households' purchasing power. We expect an interest-rate cut or an increase in the import tariff to have a positive net impact on output in the short run if the purchasing power effect is less than the other effects.

6.2 Calibration

We calibrate our model to fit the US economy. Using the World Bank Development Indicators for the year 2015, we recover the consumption share $c = 0.8$ and the ratio of trade to GDP $X/Y = 0.12$. We assume that this ratio also represents the share of the import good in the consumption basket, hence $\eta = 0.12$, and deduce the λ coefficient: $\lambda = 0.6$.

Based on our own estimations of the elasticity of trade to the exchange rate and to the import tariff, we set $\epsilon = 0.5$ and $\zeta = 3$. We also found a trade elasticity to revenue varying

[20] Alternatively, the government may target any positive or negative level of trade balance, which will not affect our results.

between 0.45 and 0.7. We choose the median value, and set $\gamma = 0.6$. Like Blanchard (2016), we assume $\delta = 1$, i.e. an interest-rate variation is expected to last one year.

To calibrate μ, we solve the model so that y and b only depend on the two policy variables r and τ, on the different parameters and on the two shocks u and v, and calibrate the impact of r on y based on the literature showing the impact of a rate cut on US output.[21] Using a DSGE model for the period from 1988 to 2013, Brayton et al. (2014) find the short-term response of output to a 1 percentage point fall in the US policy rate to be comprised between +0.1 and +0.4 percent. Alternatively, Boivin et al. (2010) build a standard New Keynesian DSGE to estimate the transmission mechanisms of a conventional monetary policy. Focusing on the 1984-2008 period, they find that a rate cut by 1 pp increases output by 0.2% in the short run. We select the medium figure of 0.2 which, given the other parameters, leads to $\mu = 0.25$.

Finally, we assume that the internal and external objectives of the government bear equal weights, hence $\theta = 1$.

With this calibration, a 1 percentage point increase in the interest rate decreases the trade balance by 0.84% by deteriorating the domestic competitiveness, and it decreases the output by 0.27% through the trade balance and a lower investment, even though it increases the purchasing power of consumers. On the opposite, a 1 percentage point increase in tariffs increases b by 1.32% because it improves the competitiveness, and increases the ouput by 0.31% through this increase in b, despite the negative impact on the purchasing power[22].

6.3 Trade or monetary policy?

Here we simulate the optimal reaction of the government to a shock when only one policy instrument is available (trade or monetary), or when both are available.

Table 7 shows the optimal policy response to a negative demand shock of 1 percent. With only tariffs available, the government reacts through reducing the tariff, which lowers the trade balance, but at the same time allows to regain purchasing power. Ex post, output is

[21] See Appendix C.

[22] The calibration gives $\frac{\partial y}{\partial r} = -0.27$, $\frac{\partial y}{\partial \tau} = 0.31$, $\frac{\partial b}{\partial r} = -0.84$ and $\frac{\partial b}{\partial \tau} = 1.32$.

Table 7: Negative demand shock: $u = -1\%$

	τ	r	b	y	L
One instrument: τ	-0.0038	0	0.0015	-0.0072	0.00003
One instrument: r	0	0.0055	0.0018	-0.0074	0.00003
Two instruments: τ, r	-0.1667	-0.2500	0	0	0

Table 8: Negative trade balance shock: $v = -1\%$

	τ	r	b	y	L
One instrument: τ	0.0054	0	0.0005	-0.0023	0.000003
One instrument: r	0	-0.0085	0.0005	-0.0021	0.000002
Two instruments: τ, r	-0.0467	-0.08	0	0	0

partially stabilized. However the trade balance increases since the lower tariff is not enough to compensate the impact of lower domestic demand on imports.

With the only monetary policy is available, the logic is the same: the government raises the interest rate, so that the appreciation that follows increases the purchasing power. Ex post, output is partially stabilized and the trade balance increases.

Finally, when both instruments are available, the government cuts both the tariff and the interest rate, so both objectives (internal and external equilibrium) are reached.

The case of a negative trade balance shock of one percent is presented in Table 8. This time, the optimal response to the shock is either to raise the import tariff or to cut the interest rate (and depreciate the currency). In both cases, the trade balance is almost stabilized but output falls due to reduced purchasing power. When both policy instruments are available, it is optimal to cut the interest rate ten times more than when it is the only instrument available, and at the same time cut the import tariff in order to compensate the impact of the currency depreciation on consumers' purchasing power. Both objectives are reached.

As evidenced in Table 6, the equivalence between the two policy instruments varies greatly over time. Table 9 presents the optimal policy reaction to a negative demand shock with ζ corresponding to the different sub-period estimations, when both instruments are available. For all subperiods but the first one, the optimal policy mix is to cut both the interest rate and the import tariff. For 1989-93, however, the optimal reaction to the shock is an increase in both the interest rate and the import tariff. This result can be understood by noting that the purchasing power of the two instruments is always the same (it only depends on the openess factor η) but the interest rate has a direct impact on aggregate demand through investment. Hence, for relatively small values of ζ, the interest rate is a more efficient instrument than the tariff to stabilize aggregate demand. When ζ increases, the tariff has relatively more impact than the exchange rate on the trade balance. For a high value of ζ ($\zeta = 8.6$), it becomes optimal to stabilize aggregate demand through an increase in the tariff while compensating the negative impact on purchasing power through an exchange-rate appreciation (hence an interest-rate increase). Table 10 presents the optimal policy reaction to a negative trade shock for the different sub-periods and exhibits the same conclusions. In Appendix C, we plot the optimal policy response to a negative demand or trade shock as a function of ζ and see a policy reversal for $\zeta > 4$.

Table 9: Policy response in time: shock u

	τ	r	b	y	L
Two instruments					
1989-1993: $\zeta = 8.6$	0.0196	0.0845	0	0	0
1994-1998: $\zeta = 4$	-0.5	-1	0	0	0
1999-2003: $\zeta = 2$	-0.04	-0.04	0	0	0
2004-2008: $\zeta = 2.5$	-0.0519	-0.0649	0	0	0
2010-2013: $\zeta = 3.4$	-0.1124	-0.191	0	0	0

Table 10: Policy response in time: shock v

	τ	r	b	y	L
Two instruments					
1989-1993: $\zeta = 8.6$	0.0045	0.0094	0	0	0
1994-1998: $\zeta = 4$	-0.115	-0.24	0	0	0
1999-2003: $\zeta = 2$	-0.0092	-0.0192	0	0	0
2004-2008: $\zeta = 2.5$	-0.0119	-0.0249	0	0	0
2010-2013: $\zeta = 3.4$	-0.0258	-0.0539	0	0	0

Another calibrated parameter brings our attention, μ, which is the impact of the interest rate on the output, put aside the exchange rate channel. As already mentioned, the existing literature suggests an interval from 0.1 to 0.4 for this parameter. In Appendix C, we plot the policy response to both demand and trade balance shock against this parameter. As expected, trade policy does not depend on μ. The interest rate response decreases as the impact of monetary policy on output through the investment channel (μ) increases. With both instruments, a small value of μ brings a reaction through tariff, while a value greater than 0.17 brings a currency depreciation. The conclusions are the same when considering a negative trade balance shock with one or both instruments. Considering that financial liberalization and development tends to raise the sensitivity of aggregate demand to the interest rate, we therefore expect countries with large financial sectors to use the currency "weapons" more intensively than the trade one.

Finally, we have found that more intra-industry trade tends to inflate the elasticities of exports to both tariffs and the exchange rate. Table 11 simulates the optimal policy response to a shock depending on the extent of intra-industry trade. For a demand shock, the optimal policy response is lowered when there is more intra-industry (third quartile of the Grubel-Llyod index compared to the first quartile). For a trade shock, more intra-industry trade tends to lower the tariff response but to increase that of monetary policy. Hence we expect countries engaged in intra-industry trade to use the monetary "weapon" relatively more intensively.

Table 11: Optimal response to a negative shock depending on intra-industry trade (with two instruments)

	τ	r	b	y	L
Negative demand shock $u = -1\%$					
First quartile: $\zeta = 6.8$	0.0331	0.1126	0	0	0
Third quartile: $\zeta = 8.3$	0.0211	0.0875	0	0	0
Negative trade shock $v = -1\%$					
First quartile: $\zeta = 6.8$	0.0076	0.0159	0	0	0
Third quartile: $\zeta = 8.3$	0.0048	0.101	0	0	0

7 Conclusion

Recent decades have witnessed a multiplication of bilateral and regional trade agreements on the top of more and more countries being part of the World Trade Organization. This evolution has constrained the protectionist reponse to shocks: unlike during the Great depression of 1929, the Great recession of 2009 has generally not been accompanied with a revival of protectionism, although a number of tariff hikes has been observed. International disputes have then moved to the monetary sphere, with some countries being accused of leading a "currency war".

In this paper, we compare the elasticity of exports to tariffs and to the exchange rate, based on a panel HS6-level bilateral trade flows for 111 countries over 1989-2013. For the whole sample, we find that a 1 percent increase in import tariffs has the same impact than a 3 percent depreciation of the importer's currency. This equivalence however varies over time, and it also depends on the extent of intra-industry trade.

We then incorporate these results into a sketchy model of an economy whose government targets both internal and external balance. We find that, if both trade and monetary "weapons" are available, the government reacts to a negative shock by depreciating the home currency while cutting the tariff to offset the negative impact of the depreciation on domestic purchasing power. This result applies to all periods except the 1989-93 one where the optimal response to a negative shock is rather to increase the tariff and appreciate the home currency. Finally, we show that more intra-industry trade, and a more powerful direct channel of monetary policy both tend to raise the incentive to use the monetary "weapon" rather than the trade one.

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Appendix A

List of countries

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

Appendix B

Domestic output We consider the following output for the small economy:

$$Y = C + I + \frac{EB}{P}, \tag{20}$$

with $C = c\frac{PY}{P_c}$, $I = I_0(1+r)^{-\alpha}$, $P_c = P^{1-\eta}[EP^*(1+\tau)]^\eta$, and $P = P^* = 1$.

$$Y = c[E(1+t)]^{-\eta}Y + I_0(1+r)^{-\alpha} + EB \tag{21}$$

$$\begin{aligned}\frac{dY}{Y} &= c[E(1+\tau)]^{-\eta}\frac{dY}{Y} - c\eta E^{-\eta}(1+\tau)^{-\eta}\left(\frac{dE}{E} + \frac{d(1+\tau)}{(1+\tau)}\right) \\ &- \frac{\alpha I_0}{Y}(1+r)^{-\alpha}\frac{d(1+r)}{(1+r)} + \frac{EdB + BdE}{Y},\end{aligned} \tag{22}$$

where $\frac{d(1+r)}{(1+r)} = dln(1+r) \simeq dr$ if $r \simeq 0$, and $\frac{d(1+\tau)}{(1+\tau)} = dln(1+\tau) \simeq d\tau$ if $\tau \simeq 0$.

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

$$\begin{aligned}\frac{dY}{Y} &= -\frac{c[E(1+\tau)]^{-\eta}}{1 - c[E(1+\tau)]^{-\eta}}\left(\frac{dE}{E} + \frac{d(1+\tau)}{(1+\tau)}\right) \\ &- \frac{\alpha I}{Y(1 - c[E(1+\tau)]^{-\eta})} + \frac{d(EB/P)}{Y(1 - c[E(1+\tau)]^{-\eta})}\end{aligned} \tag{23}$$

We assume that initially $\tau = 0$, $E = 1$, and $B \simeq 0$:

$$\frac{dY}{Y} = -\frac{\eta c}{1-c}\left(\frac{dE}{E} + \frac{d\tau}{\tau}\right) - \alpha\frac{I}{Y(1-c)}dr + \frac{EX}{Y(1-c)}\frac{dB}{X} \tag{24}$$

Trade balance

$$B = X - M \tag{25}$$

$$dB = dX - dM \tag{26}$$

Around $B \simeq 0$, we have: $$\frac{dB}{X} = \frac{dX}{X} - \frac{dM}{M} \tag{27}$$

Exports in foreign currency are determined by:

$$\begin{aligned} X &= X_0 Q^{\epsilon}(1+\tau^*)^{-\zeta\epsilon} Y^{*\gamma^*} \\ \frac{dX}{X} &= \epsilon\frac{dQ}{Q} - \zeta\epsilon\frac{d\tau^*}{\tau^*} + \gamma^*\frac{dY^*}{Y^*} \end{aligned} \tag{28}$$

Imports in foreign currency are determined by:

$$\begin{aligned} M &= M_0 Q^{-\epsilon}(1+\tau)^{-\zeta\epsilon} Y^{\gamma} \\ \frac{dM}{M} &= -\epsilon\frac{dQ}{Q} - \zeta\epsilon\frac{d\tau}{\tau} + \gamma\frac{dY}{Y} \end{aligned} \tag{29}$$

Hence, the differential of the trade balance over exports is:

$$\frac{dB}{X} = 2\epsilon\frac{dQ}{Q} + \zeta\epsilon(\frac{d\tau}{\tau} - \frac{d\tau^*)}{\tau^*}) + \gamma(\frac{dY^*}{Y^*} - \frac{dY}{Y}), \quad \text{if } \gamma = \gamma^* \tag{30}$$

After a shock, around the initial equilibrium (where $B \simeq 0$, $\tau = r = 0$ and $E = 1$) we have $\frac{dB}{X} = b$, $d\tau = \tau$, $dr = r$ and $\frac{dE}{E} = dlnE = de = e$. With $\frac{dY}{Y} = y$ and $\frac{dY^*}{Y^*} = y^*$, we have:

$$y = -\frac{\eta c}{1-c}(e+\tau) - \underbrace{\frac{\alpha I}{Y(1-c)}}_{\mu} r + \underbrace{\frac{EX}{Y(1-c)}}_{\lambda} b \tag{31}$$

$$b = 2\epsilon e + \zeta\epsilon(\tau - \tau^*) + \gamma(y^* - y) \tag{32}$$

$$e = \delta(r^* - r) \tag{33}$$

Calibration To calibrate μ, we solve the model so that y and b only depend on the two policy variables r and τ, on the different parameters and on the two shocks u and v:

$$
\begin{aligned}
y = &- \frac{1}{1+\lambda\gamma}(-\frac{\eta c}{1-c} + \mu + 2\lambda\epsilon)r + \frac{1}{1+\lambda\gamma}(\frac{\eta c}{1-c} + 2\lambda\epsilon)r^* + \frac{1}{1+\lambda\gamma}(\frac{\eta c}{1-c} + \lambda\zeta\epsilon)\tau \\
&- \frac{\lambda\zeta\epsilon}{1+\lambda\gamma}\tau^* + \frac{\lambda\gamma}{1+\lambda\gamma}y^* + \frac{\lambda}{1+\lambda\gamma}v + \frac{1}{1+\lambda\gamma}u \qquad (34) \\
b = &- \frac{1}{1+\lambda\gamma}(-2\epsilon + \frac{\gamma\eta c}{1-c} - \gamma\mu)r + \frac{1}{1+\lambda\gamma}(2\epsilon + \frac{\gamma\eta c}{1-c})r^* + \frac{1}{1+\lambda\gamma}(\zeta\epsilon + \frac{\gamma\eta c}{1-c})\tau \\
&- \frac{\zeta\epsilon}{1+\lambda\gamma}\tau^* + \frac{\gamma}{1+\lambda\gamma}y^* - \frac{\gamma}{1+\lambda\gamma}u + \frac{1}{1+\lambda\gamma}v \qquad (35)
\end{aligned}
$$

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

$$\frac{\partial y}{\partial r} = -\frac{1}{1+\lambda\gamma}\left(-\frac{\eta c}{1-c} + \mu + 2\lambda\epsilon\right) \qquad (36)$$

$$\frac{\partial y}{\partial \tau} = \frac{1}{1+\lambda\gamma}\left(-\frac{\eta c}{1-c} + \lambda\zeta\epsilon\right) \qquad (37)$$

$$\frac{\partial b}{\partial r} = -\frac{1}{1+\lambda\gamma}\left(2\epsilon + \frac{\gamma\eta c}{1-c} - \gamma\mu\right) \qquad (38)$$

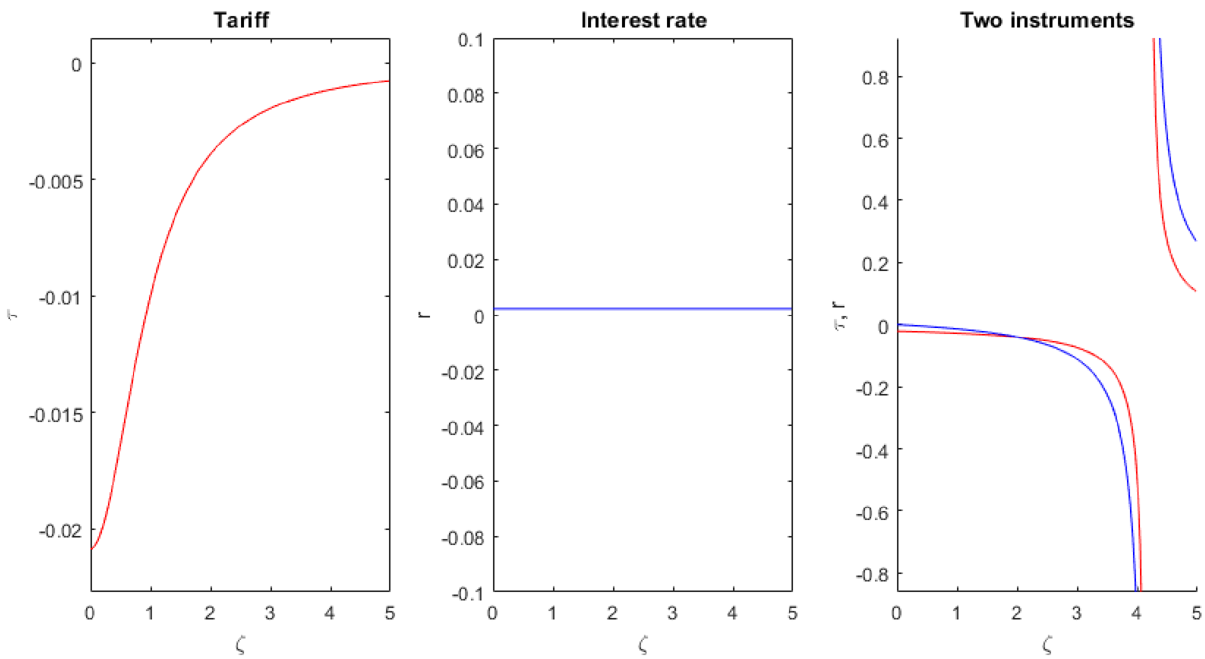
$$\frac{\partial b}{\partial \tau} = \frac{1}{1+\lambda\gamma}\left(\zeta\epsilon + \frac{\gamma\eta c}{1-c}\right) \qquad (39)$$

Then, we calibrate the impact of r on y based on the literature showing the impact of a rate cut on US output. For an overall impact of 0.2 we have the following:

$$
\begin{aligned}
&-\frac{1}{1+\lambda\gamma}\left(-\frac{\eta c}{1-c} + \mu + 2\lambda\epsilon\right) = -0.2 \\
\Leftrightarrow\ &\frac{1}{1,36}\left(-\frac{0.12 * 0.8}{0.2} + \mu + 0.6\right) = 0.2 \\
&\Leftrightarrow \mu = 0.25 \qquad (40)
\end{aligned}
$$

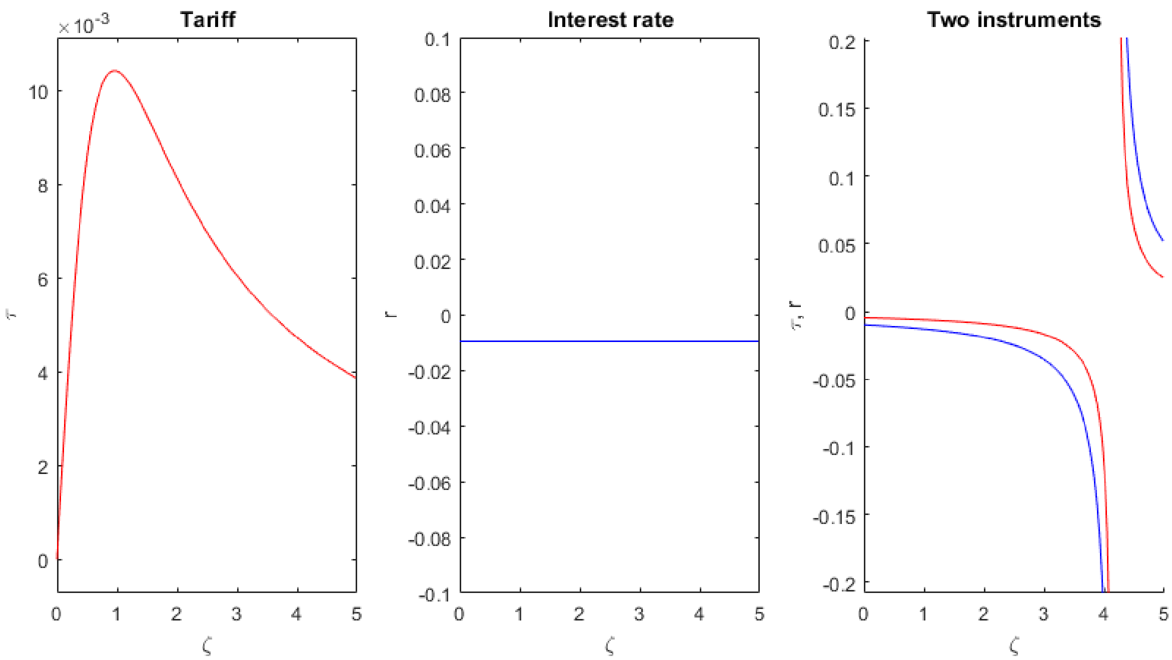
Appendix C

Figure 3: Optimal reaction to a negative demand shock $u = -1\%$ depending on ζ



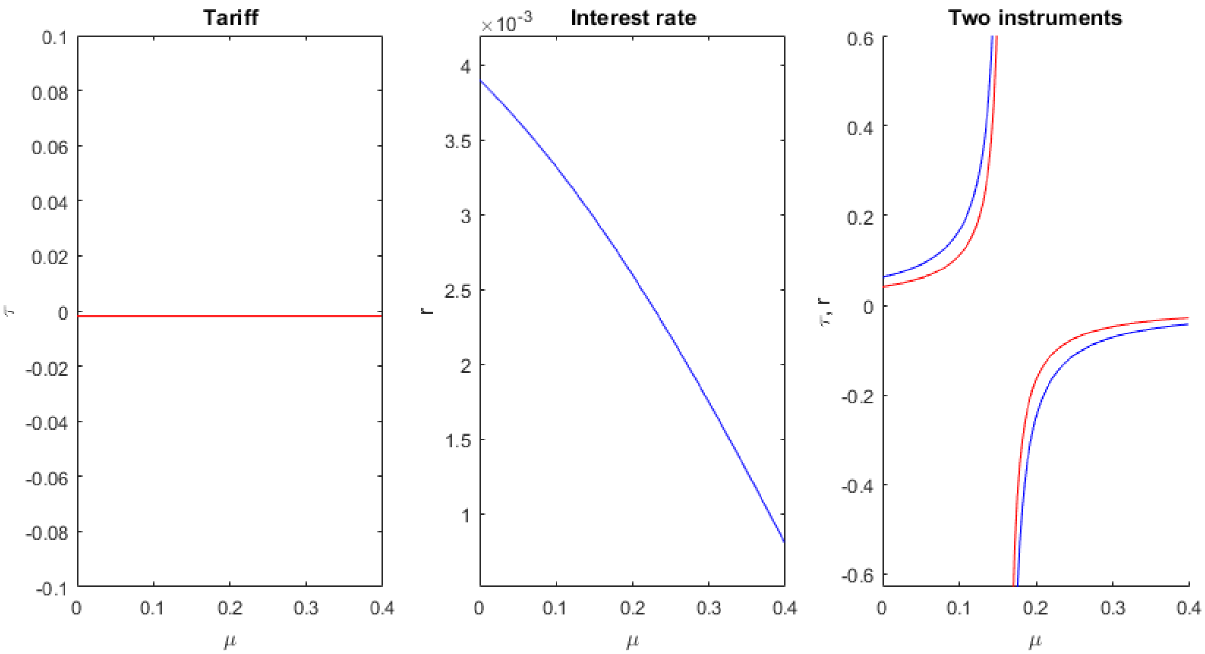
Note: policy response to a negative demand shock of 1%. The response of tariffs is in red, the one of the interest rate is in blue.

Figure 4: Optimal reaction to a negative trade shock $v = -1\%$ depending on ζ



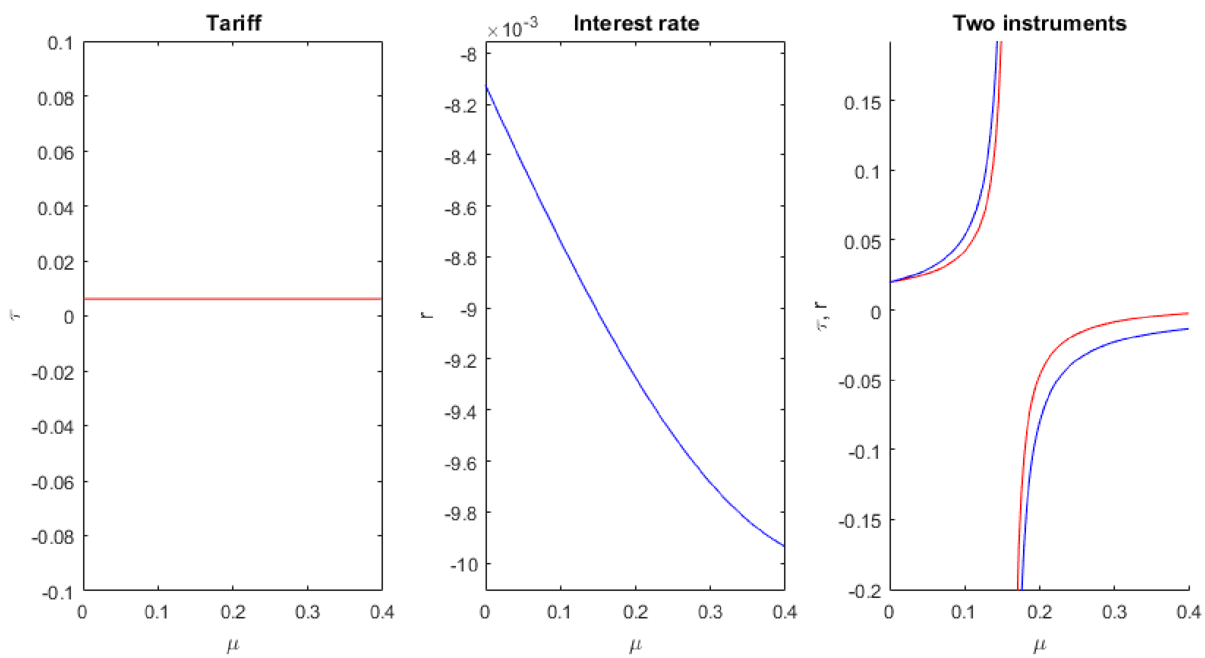
Note: policy response to a negative trade balance shock of 1%. The response of tariffs is in red, the one of the interest rate is in blue.

Figure 5: Optimal reaction to a negative demand shock $u = -1\%$ depending on μ



Note: policy response to a negative demand shock of 1%. The response of tariffs is in red, the one of the interest rate is in blue.

Figure 6: Optimal reaction to a negative trade shock $v = -1\%$ depending on μ



Note: policy response to a negative trade balance shock of 1%. The response of tariffs is in red, the one of the interest rate is in blue.