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The impact of an exchange rate realignment on the trade balance – Euro vs. national currency- Some preliminary results with a/simmetrie model of the Italian economy[§]

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Theoretical background

Most of the debate about the costs and benefits of a monetary union hinges upon the impact of an exchange rate realignment on the trade balance. In our view this is a moot question, mostly because adopting a fixed exchange rate (or adopting a single currency) implies giving away much more than a more or less useful mechanism for the rebalancing of the external accounts. Once we quit a textbook perspective, and we approach the scientific literature, we find evidence that:

(1) Exchange rate flexibility has a crucial signaling function (e.g., Tornell and Velasco, 2000), which prevents the international financial markets from overlending, hence the domestic debtor form overborrowing,

(2) Exchange rate flexibility is an essential mechanism of enforcement of international economic agreements (Meade, 1957; Bagnai, 2014), because nominal appreciation will (at least partly) offset the impact of any aggressive deflationary "beggar-thy-neighbour" policy practiced by unfair trade partners.

(3) Even within a fixed exchange rate regime, the existence of a national currency imposes a stop-loss on domestic governments, because once the foreign exchange reserves are exhausted, it becomes impossible to "defend" the assumed parity and a nominal realignment *must* follow (for good or worse). In a currency union, instead, there is no need to "defend" any parity anymore, but this does not mean that any possible imbalance will not imply a transfer of resources from the crisis country to the foreign creditors (as Thirlwall, 1991 had seen before and Merler and Pisani-Ferry, 2012, saw after the Eurozone crisis).

In other words, a currency union (i.e., the surrender of a national currency):

[§] Preliminary version, June 2014. Comments welcome.

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(1) Induces domestic governments to postpone reforms, for the very reason that in a currency union the imbalances following from domestic structural problems become much more easy to finance with foreign credit than to address with national (or supranational) policies (Fernandez-Villaverde *et al*., 2013). This recent result conforms to the basic economic intuition that an economic agent will make a less careful use of a cheaper resource than of an expensive one. The whole point of financial integration was exactly to make money cheaper within the Eurozone, this favoring the indebtedness of catching-up countries (see for instance Blanchard and Giavazzi, 2002). The obvious moral hazard problems that this measure would create went completely unaddressed until the crisis erupted. Put in another way, basic moral hazard reasoning allows to understand that there is a plain contradiction between financial integration and financial discipline.

(2) Allows domestic government to "buy time" indefinitely (using the same words as Frenkel, 2013), thereby postponing also the resolution of the crisis (after having postponed the adoption of reforms that could possibly avoid its eruption).

View in the light of these agency problems, the question of external trade rebalancing, though being relevant, appears in our view of a lesser order than the huge political economy and agency problems created by a single currency. Nevertheless, since it is the most frequently cited issue, and the most easy to understand for the general public at large, it still deserves to be addressed in a rigorous way.

The political relevance of the exchange rate rebalancing function is (indirectly) demonstrated by the fact that in the media the appropriate scientific literature is never quoted, although it is well-known by the international economists, and its main point is not difficult to understand. The recent debate about the effectiveness of the exchange rate flexibility started with Obstfeld (1997) and Feldstein (1997), and originated a well-known dispute among them and Engel (2000) and Devereux and Engel (2003). The whole discussion revolved around a practical and testable question: what is the prevalent pricing behavior within the Eurozone?

In order to understand the importance of this question, one should remember that the "social market economy" of the Eurozone features, as every other advanced economy, a mostly oligopolistic market structure. Under such circumstances, firms price their goods not according to the respective marginal costs, but following a mark-up rule. In other words, firms endowed with some market power will price the goods they offer by charging a mark-up on marginal costs. The mark-up depends on the price elasticity of demand, but can vary according to a host of strategic considerations. In particular, a foreign producer could decide either to stabilize the final price of his product in the local currency (LCP, local currency price stabilization), or in his own currency (PCP, producer currency price stabilization). In the first case (LCP), if the domestic (local) currency depreciate, the foreign producer, instead of raising the prices in local currency, will charge a smaller mark-up, i.e., he will accept to receive less foreign currency (hence to lower his profit rate) in order not to lose market shares in the local market. In the second case (PCP), the foreign producer will keep the price of his goods stable in the currency of his country (the producer country), which implies that if the local currency depreciates, the price of the foreign imported good will raise. If the good is sufficiently price-inelastic, the possible loss of market share will be negligible in comparison to the loss of revenues determined by a LCP strategy.

To put it in another way: with LCP the exchange rate pass-through to import prices is almost zero, because the exchange rate swings will be offset by the producer mark-up variation, and in this case there will be no import substitution effect on the local market. If instead PCP prevails, the pass-through will be almost complete, and there will be an import substitution effect, with benefits on the domestic balance of trade.

The empirical literature on this point has been often inconclusive, with pass-through analyses giving evidence of partial PCP (or partial LCP) behavior (see e.g. Campa and Goldberg, 2005). However, the most recent evidence, both at a macro level (Campa and Gonzalez Minguez, 2006) and at a micro level (Antoniades, 2012) points out that in the Eurozone PCP prevails. This confirms the hypothesis of Obstfeld and Feldstein that giving up exchange rate flexibility would entail significant costs for most Eurozone countries.

At a different level, another strand of the empirical literature, the one that addresses the measurement of international trade elasticities, provides a relatively consistent body of evidence confirming that in the Eurozone countries the Marshall-Lerner condition is mostly satisfied, in particular as far as Italy is concerned (e.g. Hooper, 2000; Langwasser, 2009; DG-ECFIN, 2010).[1] As a consequence, if the mark-up does not offset nominal exchange rate swings, and if the trade flows are elastic enough to relative price movements, one should expect that exchange rate flexibility is an effective tool for external trade rebalancing. In other words, the surrender of this flexibility is a big mistake, as anticipated by Obstfeld and Feldstein among many others (and besides the more cogent arguments listed at the beginning of this note).

Econometric background

The a/simmetrie medium-run econometric model of the Italian economy is a medium-sized structural econometric model (72 equations, of which 29 stochastic), estimated on

[1] It is worth noting that according to the two more recent studies Italy features the largest relative price elasticity of exports among the “big four” Eurozone countries (Germany, France, Italy and Spain), at or above 1.7 in absolute value. which implies that the Marshall-Lerner conditions are satisfied for Italy even without taking into account the import substitution effect.

annual data, which was built with the aim of providing a consistent framework in which to assess the medium-run impact (one to five years) on the Italian economy of economic policy measures, as well as of changes in the European and global macroeconomic environment. The theoretical framework is provided by the AS/AD model, which is the standard reference for models of comparable structure (Helliwell *et al*., 1986). The equations are in error correction form, with the long-run relations estimated through either Gregory and Hansen (1996) or Hatemi-j (2008) estimators, that take into account the possible presence of shifts in the long run structural parameters (see the technical appendix).

The foreign trade block of the model features fourteen equations modelling the export and import flows between Italy and seven different areas: the Eurozone core, the Eurozone periphery, the other European countries, the United States, the OPEC countries, the BRIC countries, and the rest of the world. This allows the researcher to assess the impact on the Italian economy of a number of different scenarios, among which different exchange rate realignments of either the euro, or an hypothetical new national currency, against seven different groups of trading partners (the Appendix provides details on the data sources and econometric model specification).

The long-run elasticities of the trade equations are summarized in Table 1.

Table 1 – Long-run elasticities of the export and import equations

	Export equation elasticities				Import equation elasticites				
	Income		Prices		Income		Prices		ML condition
Eurozone core	1.84	***	-1.28	***	2.12	***	1.03	***	2.31
Eurozone periphery	2.79	***	-1.94	*	3.18	***	1.95	***	3.89
United States	3.72	***	-1.04	***	1.41	***	0.39	***	1.43
Other European countries	1.86	***	-1.53	***	1.83	***	-0.44	***	1.09
OPEC countries	0.27	***	-0.67	***	-0.17	**	0.16	***	0.83
BRIC	1.37	***	-1.19	**	0.92	*	0.75	***	1.94
Rest of the world	1.54	***	-0.45	**	1.52	***	1.16	***	1.61

Note: *, **, ***, indicate that the coefficient is statistically significant at the 10%, 5% and 1% level, respectively.

The Marshall-Lerner condition on the relative prices elasticities are satisfied for all trade partners, with the exception of OPEC countries, where the imports are price inelastic, as is to be expected given the recent trends in price elasticities in the crude oil market (Baumeister and Peersman, 2013) . This implies that an exchange rate realignment will have the expected impact on six out of seven bilateral trade relation (namely, a devaluation will bring about an improvement of the bilateral trade balance in nominal terms). Since the OPEC countries account for less than 10% of the Italian trade, the net effect of an overall downward realignment of the Italian exchange rate will be an improvement in the nominal trade balance.

Table 2 – Impact elasticities of the export and import equations

	Export equation elasticities				Import equation elasticites				
	Income		Prices		Income		Prices		ML condition
Eurozone core	2.98	***	-0.96	***	3.83	***	0.85	***	1.81
Eurozone periphery	2.64	***	-1.07	***	3.28	***	0.71	**	1.78
United States	3.86	***	-0.93	***	1.94	***	0.29	*	1.22
Other European countries	0.83	*	-1.10	***	2.77	***	0.36	*	1.46
OPEC countries	1.89	***	-0.16	***	0.00		0.38	***	0.54
BRIC	2.15	**	0.00		3.29	***	0.44	**	0.44
Rest of the world	0.00		-0.58	***	3.87	***	0.47	***	1.05

Note: *, **, ***, indicate that the coefficient is statistically significant at the 10%, 5% and 1% level, respectively.

The impact elasticities, in turn, are summarized in Table 2. The Marshall-Lerner conditions now are not satisfied by both the OPEC and the BRIC countries, and barely satisfied for the rest of the world.

The income elasticities deserve some further comment. First, both in the long- and in the short-run they are relatively larger than what is found in most studies on aggregate trade flows; second, the impact elasticities are often larger than the long-run ones. Starting from the last feature, the short-run overshooting of the income effect is documented also by other studies, in Italy as well as in other countries (see for instance Hooper *et al*., 2000; Langwasser, 2009). As for the other feature, namely, the relatively large size of the income elasticities, in comparison to what is usually found in aggregate estimates, this should also come as no surprise. In fact, there is a growing body of evidence that the estimation of elasticities on aggregate flows leads to downward biased estimates, basically because aggregation smoothens the variance in the data (see e.g. Imbs and Méjean, 2009; Mann and Plück, 2005).

These results have important policy implications. First, since the countries for which the ML condition is likely not to apply in the short run account for about 40% of Italian trade, and since there is evidence of overshooting in the income elasticity of imports, there could be some *J*-curve effect on the response of the Italian trade balance to a realignment of the nominal exchange rate. Moreover, since the Eurozone core accounts for a large share of Italian trade (about 40%), and its income elasticities is the second largest (at 3.83), this implies that the relief that some Italian economists and politicians are expecting from a possible devaluation of the euro could be illusory. In fact, such a policy measure would propel the exports towards (and dampens the imports from) the non-Eurozone countries, with an increase in Italian domestic demand. However, this would in turn imply a more than proportional increase in imports from the Eurozone core, that could possibly offset the benefits determined by the increase of foreign demand from outside the Eurozone.

At a more general level, the income elasticity estimates show that any attempt at fostering Italian domestic growth without considering a realignment of the nominal exchange rate will have a very large impact effect on Italian imports, thus immediately undermining the sustainability of its external balance. In other words, any claim by Italian politicians that the Italian crisis can be solved by "banging his own fist on the European table", asking for a loosening of the EU fiscal parameters, lacks of economic rationale, because, should this request be considered as acceptable by the European partners, it would imply a sudden worsening of the Italian current account.[2]

Simulations

The properties of the trade flows block were tested by simulating the impact of a 20% downward realignment of the euro, and of the Italian national currency. The first hypothesis was implemented by realigning the nominal exchange rate in the trade flows equations of the non-Eurozone blocks, leaving unaffected the nominal exchange rate toward the core and periphery Eurozone countries. The second hypothesis was implemented by simulating an overall downward realignment of the nominal exchange rate (a realignment towards the other Eurozone countries obviously implies the exit of Italy from the Eurozone).

Before presenting the results, it is worth noting that the simulations proposed were performed using only the foreign trade block of the model, supplemented with the national income identity and the price deflators equations. As a consequence, the results presented have only a partial equilibrium meaning and are still preliminary. In particular, they take into account the feedback on imports following from the expansion of aggregate demand caused by the increase in exports, as well as the inflationary effects following from the increase in import prices determined by the nominal exchange rate devaluation, but they do not take into account the "second round" inflationary effects determined via Phillips curve by the decrease in unemployment, which could possibly offset in the longer run the effect of a nominal realignment.

[2] It is worth remembering that this request is meaningless at the outset, because on April 20, 2012, the Italian Constitution has been amended by including a "balanced budget" rule. As a consequence, it would be pointless for an Italian government to ask to the premier of another country the permission to exceed a limit which is inscribed in the Italian constitution.

Table 3 – Dynamic multipliers of a 20% realignment of the Italian currency

	Euro realignment scenario			*Lira realignment scenario*		
	World	*of which:*		World	*of which*	
Year		EZ	non-EZ		EZ	non-EZ
0	-6.8	-12.9	6.1	47.8	50.4	-2.6
1	-5.7	-22.4	16.6	74.8	74.1	0.8
2	-6.0	-26.9	20.9	87.7	85.9	1.9
3	-3.0	-26.6	23.6	97.7	92.1	5.6
4	0.9	-24.1	25.0	102.8	94.4	8.4
5	4.2	-19.4	23.6	94.5	80.9	13.6

Note: deviation of the trade balance from the baseline scenario, expressed in billion EUR at current prices.

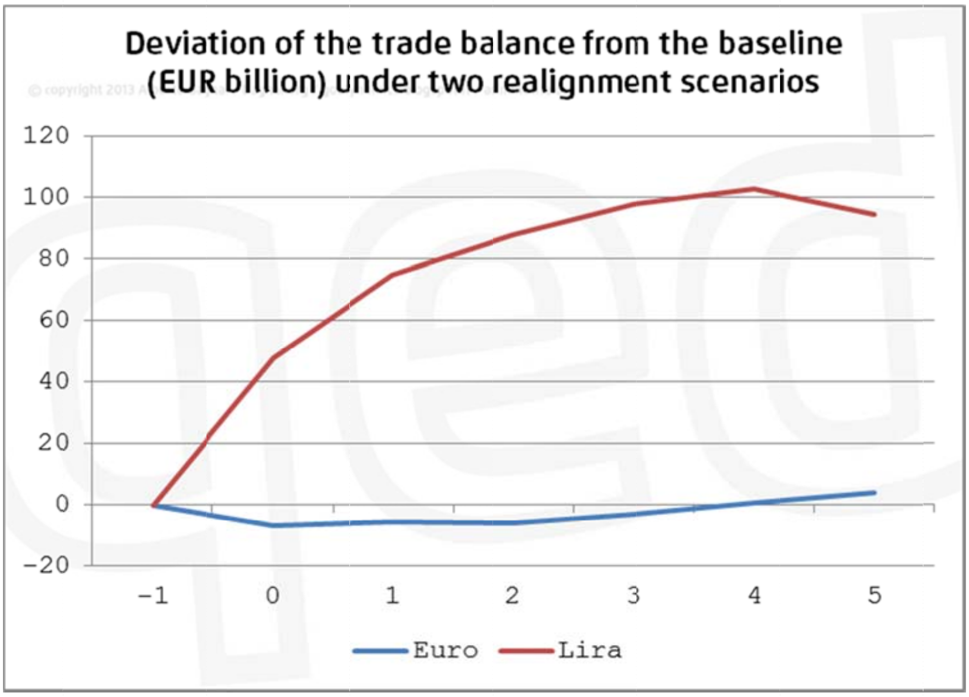

Figure 1 – Deviation of the trade balance from the baseline under two realignment scenarios (EUR billion). The realignment occurs at time zero.

A 20% downward realignment of the euro

The leftmost panel of Table 3 (Euro realignment scenario) summarizes the impact on the Italian trade balance of a 20% persistent downward realignment of the EUR/USD exchange rate. The results show that a realignment of the European single currency would improve the external balance of Italy only after a very prolonged *J*-curve effect. In the year of the realignment, the trade balance will actually worsen by about 6.8 billion USD with respect to the baseline scenario; only after four years the downward realignment will bring about a net benefit for the Italian external balance. While contrary to the conventional wisdom, that claims that a devaluation of the euro would be beneficial for the Italian economy, these results conform both with the structure of trade elasticities summarized in Tables 1 and 2. In fact, if we split the result by considering the balances towards the Eurozone and the non-Eurozone countries, we see that a devaluation of the euro causes a worsening of the first one, by about -12.9 billion EUR, larger than the improvement of the second one (equal to about 6.1 billion EUR). This happens because, in the absence of any realignment towards the EZ countries, the domestic aggregate demand expansion following from the increase in the net exports to non-EZ countries determines a more than proportional increase in imports from the EZ, which in turn causes a worsening of the EZ balance, larger than the improvement of the non-EZ balance. Since the Marshall-Lerner condition are not satisfied in the short run in some non-EZ bilateral relations, it takes some time before the improvement in the non-EZ balance is such as to offset the worsening in the EZ balance.

By the way, this may actually explain while previous empirical studies on the impact of a EUR/USD exchange rate realignment on the Eurozone economy, such as Bagnai and Carlucci (2003), found that the Eurozone as a whole does not respect the ML conditions. The reason is that owing to the structure of the bilateral trade elasticity, a realignment of the common currency is likely to be at best a zero sum game for the Eurozone as a whole.

A 20% downward realignment of the Italian national currency

The rightmost panel of Table 3 shows the impact on the Italian trade balance of a 20% persistent downward realignment of the Italian currency (a "unilateral withdrawal" scenario).[3] In this case the situation is almost completely reversed: the large and positive overall effect (+47.8 billion EUR with respect to the baseline) results from a large improvement of the Italian balance vis-à-vis the EZ countries, partially offset by a *J*-curve effect with respect to the non-EZ countries. The latter effect is explained by the former: in this case, net exports towards non-EZ countries worsens because of a larger income effect on imports, determined by the much larger expansion of the domestic aggregate demand caused by the increase of net exports towards the EZ.

Figure 1 compares the impact on the overall nominal trade balance under the two realignment scenarios. Figures 2 and 3 show the patterns of the bilateral trade balances under the euro realignment and the "lira" realignment scenarios respectively.

[3] It is worth noting that the unilateral withdraval of Italy would probably lead to a euro breakup, and in this case the Eurozone periphery is likely to experience a larger downward realignment than Italy with respect to the core countries, which in turn would imply that the Italian national currency would actually appreciate with respect to the currencies of the Eurozone periphery (see e.g. Bootle, 2012). In other words, the results presented in the rightmost panel of Table 3 are likely to overestimate the actual benefits of a Italian withdraval from the Eurozone. It should be kept in mind, however, that the EZ periphery accounts for less than 10% of Italian trade, as compared to about 40% for the EZ core. The bias in the simulation results is therefore unlikely to be large.

Conclusions

This note presents some preliminary results of scenario analyses carried out with the foreign trade block of the a/simmetrie medium-run model of the Italian economy. The simulations aim at assessing the impact on the Italian external accounts of a realignment of the EUR towards the USD, as well as of the realignment of an hypothetical Italian national currency (in case of unilateral withdrawal of Italy from the Eurozone). The structure of the model, as summarized by the short- and long-run elasticities of trade flows to income and relative prices, is in line with the most recent empirical evidence on trade equations in the Eurozone (including DG-ECFIN, 2010). The sign and size of these elasticities suggest that the claim that Italy can benefit from a euro realignment is illusory, because any improvement in our position with respect to our more distant and smaller partners, following from a relative price effect, will be offset by a worsening of our position with respect to our closer and bigger partners, following from an income effect. The results of the dynamic simulations confirm this hypothesis. A realignment of the common currency will bring about an improvement of the Italian external balance only to a limited extent and after a very prolonged *J*-curve effect. The opposite happens in case of a realignment of the Italian national currency.

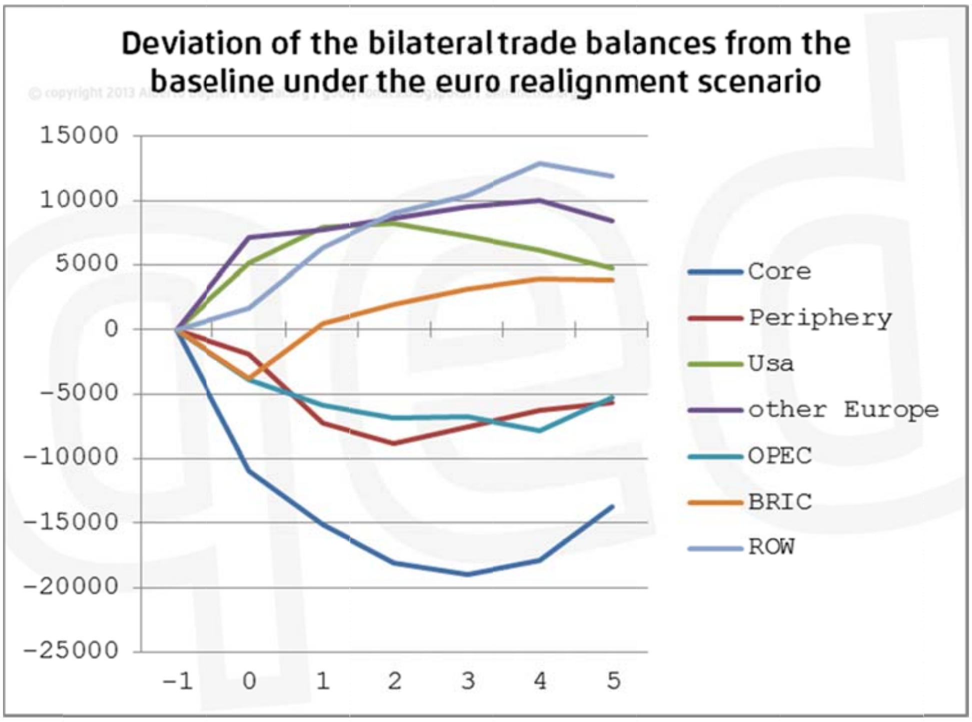

Figure 2 – Deviation of the bilateral trade balance from the baseline under the EUR realignment scenario (EUR million). The realignment occurs at time zero.

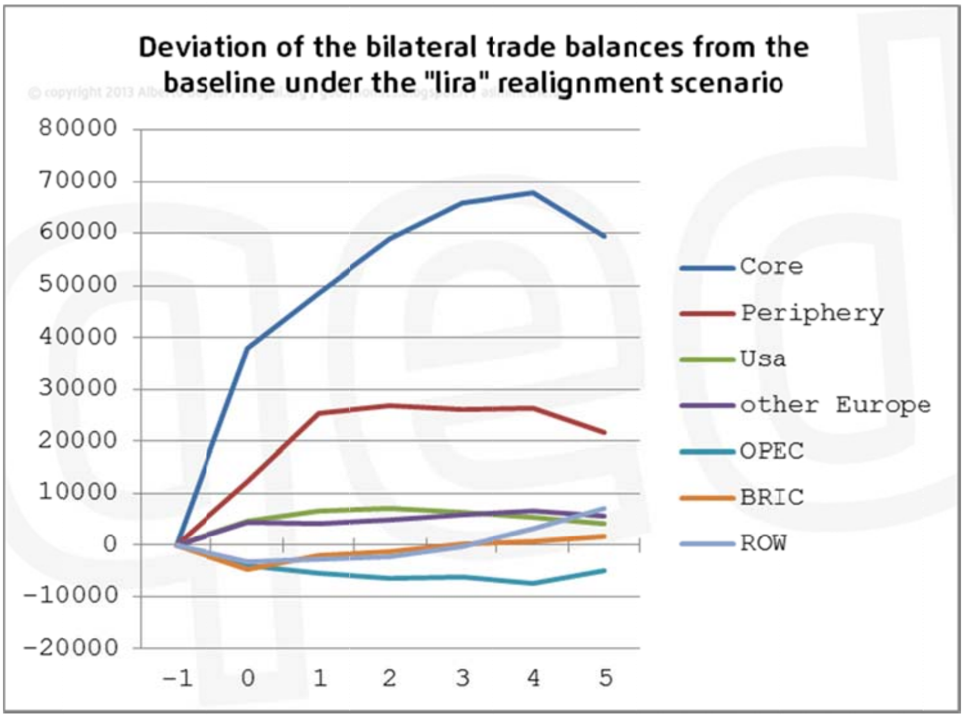

Figure 3 – Deviation of the bilateral trade balance from the baseline under the “lira” realignment scenario (EUR million). The realignment occurs at time zero.

Two remarks are here in order.

First, the results of these simulations are perfectly consistent with the recent stylized facts on the Italian trade balance. The Italian external indebtedness has constantly worsened since the peg of the Italian lira to the euro, despite the large up-and-downs experienced by the ECU-EUR/USD exchange rate in the last 17 years. This pattern is explained by the trade elasticity structure documented in this paper, whose main consequence is that any swing in the common currency is likely to result in a zero (if not negative) sum game for the Italian economy.

Second, what applies in case of an expansion of domestic demand brought about by an increase in Italian net exports, will also apply in case of an expansion of domestic demand determined by an expansionary fiscal policy. In other words, any claim that Italian politician may solve the problem of Italian recession by “banging their fist” on Frau Merkel’s table is completely devoid of any economic rationale, because, should Germany favor an expansionary fiscal policy in peripheral countries, in the absence of a nominal exchange rate realignment this would lead to a dramatic worsening of these countries’ net external indebtedness. To put it simply, within the single currency, less austerity today must imply more austerity tomorrow, unless the expansionary policy are undertaken first, and to a much larger extent, by the core countries of the Eurozone. This is however unlikely to occur, simply because such an expansionary stance of Northern countries would imply a “top-down” redistribution of income, i.e., an income policy which is not in the immediately perceived interest of the dominant social force behind German authority.

Technical appendix

Specification of the trade equations

Total exports and imports of goods and services are both given as sum of the corresponding flows of goods, on the one hand, and services, on the other hand. The real value of exports/imports of goods are originally given in US dollars, modeled as bilateral flows, and are expressed in euro by using the EUR/USD exchange rate in the base year.

Bilateral flows depend on two variables which reflect demand (foreign for exports, domestic for imports) and competitiveness. As for the former, exports to country/block *i* depend on the partner's demand, proxied by its GDP (in US dollars) and imports from country/block *i* are a function of Italian GDP.

The competitiveness measure is the same either in the exports and the bilateral imports functions and is given by relative prices expressed in US dollars, i.e., the real exchange rate, *RER*, with respect to the partner country/block. This measure is given by the ratio of domestic exports prices (P_X, converted in US dollars) and the export prices of country/block *i* ($P^{\$}_{X,i}$):

$$RER_i = P_X \times (\overline{ER} / \overline{ER}_b) \; / \; P^{\$}_{X,i}$$

where $\overline{ER}$ is the EUR/USD exchange rate, considered as exogenous, and $\overline{ER}_b$ its base year value.

Aggregate exports/imports of goods in US dollars are obtained as the sum of bilateral flows

$$xg^{\$} = \sum_i xg_i^{\$}$$

$$mg^{\$} = \sum_i mg_i^{\$}$$

The previous aggregates are then converted in constant euros by dividing them by the base year EUR/USD exchange rate and enter in the definition of final demand/output after having added the expenditure relative to exports/imports of services:

$$xgs = xg^{\$} / \overline{ER}_b + xs$$

$$mgs = mg^{\$} / \overline{ER}_b + ms$$

where xgs, mgs, xs and ms are, respectively, total exports of goods and services, total imports of goods and services, exports of services and imports of services.

The deflator of italian imports in US dollars is given as a trade weighted average of other blocks' exports deflators:

$$P_M^{\$} = \sum_i \mu_i P_{X,i}^{\$}$$

where μ_i is the trade share of partner i, i.e., $\mu_i = mg_i / mgs$.

Data

Partner's GDP in US dollars come from the *World Development Indicators*[4] (WDI) database (series NY.GDP.MKTP.KD). The Italian series (nominal and real GDP, aggregate trade flows, etc.) were obtained from *OECD.Stat*, compiled by the OECD statistical office and available on-line at http://stats.oecd.org/.

Bilateral trade in current US dollars by partner come from two sources. From 1988 to the last available observation we used the *International Trade by Commodity Statistics* (ICTS) database (Harmonised System 1988), available from *OECD.Stat*.[5] Before 1988 we recontructed the series from *ICTS* by using the corresponding series available in the *CHELEM* database.[6] The nominal series have been converted in real terms by using Italy's aggregate exports deflator for bilateral exports and the partner's aggregate export deflators for bilateral imports. Aggregate exports data come from the WDI database. Deflators have been obtained as the ratio of aggregate exports in current US dollars to aggregate exports in USD at 2005 prices. Bilateral relative prices were constructed as the ratio of Italy's aggregate exports deflator to the partner's aggregate exports deflators, all in US dollars. Exports (imports) of services are obtained as the difference between aggregate exports (imports) and exports (imports) of goods.

As it is unfeasible to estimate bilateral trade equations for *all* of Italy's partners, we aggregated them in seven blocks, reported in Table A.1. This aggregation is, of course, arbitrary. However, it was dictated by geo-political and economic considerations: Europe is split into *Core*, *Periphery* and *Non-euro* countries as this subdivision (specially the Core/Periphery one) has been at the heart of the debate after the great

[4] http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators

[5] http://stats.oecd.org/Index.aspx?DataSetCode=HS1988

[6] http://www.cepii.fr/anglaisgraph/bdd/chelem.htm

financial crises and the Euro area problems; the United States is usually considered as a single area in most multicountry models; shocks from oil prices can be better modelled by aggregating oil-exporting countries, which are included in the *OPEC* block; the most integrated and influential new industrialised countries are grouped in the BRIC block; trade coherence is achieved by creating a *Rest of the world* partner.

Table A.1 – Trade partners by blocks.

Block	Countries
Core	Austria Belgium Finland France Germany Luxembourg Netherlands
Periphery	Greece Ireland Portugal Spain
USA	United States
Non-euro	Denmark Sweden Switzerland United Kingdom
OPEC	Algeria Angola Libya Nigeria Iran Iraq Kuwait Qatar Saudi Arabia United Arab Emirates Ecuador Venezuela
BRIC	Brazil Russia India China
Rest of the world	World total minus the countries above

Methodology

The model equations were estimated by adopting the cointegration framework and the associated error-correction model (ECM) which allow to represent both the long-run relationships and the associated short-run adjustments.

One issue to take into account when estimating cointegrating models is the possible presence of structural breaks in the cointegrating vector. While the reasons for which structural breaks can occur are intuitive, and thus we will not proceed with a discussion on this, solutions proposed for uncovering a cointegrated model with structural breaks are vast.[7] The method adopted in this paper is due to Gregory and Hansen (1996a and 1996b; GH henceforth) and is based on the estimation of the following models

$$y_t = \alpha_1 + \alpha_2 D_t + \beta' x_t + \varepsilon_t \qquad \text{model } C$$

$$y_t = \alpha_1 + \alpha_2 D_t + \beta' x_t + \delta t + \varepsilon_t \qquad \text{model } C/T$$

$$y_t = \alpha_1 + \alpha_2 D_t + \beta_1' x_t + \beta_2' x_t D_t + \varepsilon_t \qquad \text{model } C/S$$

$$y_t = \alpha_1 + \alpha_2 D_t + \beta_1' x_t + \beta_2' x_t D_t + \delta_1 t + \delta_2 t D_t + \varepsilon_t \qquad \text{model } C/T/S$$

where D_t is a dummy variable defined as

$$D_t = \begin{cases} 0 & \text{if } \; t \le [N \times \tau] \\ 1 & \text{if } \; t > [N \times \tau] \end{cases}$$

where τ is a parameter that denotes the relative timing of change point (uknown *a priori*), N is the sample size and [.] indicates the integer part. In the previous models β' and δ are, respectively, the slopes the trend coefficient in the "partial breaks" models C and C/T, while α_1, β_1' and δ_1 are, respectively, the intercept, slopes and trend coefficient in the first regime, and α_2, β_2' and δ_2 are corresponding values in the second regime. As in the non-breaking case, the null hypothesis is no cointegration and it is tested by conducting an ADF tests on ε_t by using GH critical values.

GH models are general enough to accommodate for alternative specifications of cointegration with regime shift: C is a level shift model, C/T is a level shift with trend model, C/S is a regime shift model, and $C/T/S$ is a regime and trend shift model. Moreover, the most appealing aspect of this methodology is that the break date is endogenously determined: the various models are estimated for all possible dates in a

[7] See, for instance, a recent review on structural breaks by Perron (2005).

properly trimmed sample, i.e., $\tau \in (\kappa, 1-\kappa)$ where κ is usually 0.15,[8] and the cointegration test statistic ADF* is the corresponding smallest value (the largest negative value).

An extension of the GH models to the two-breaks case has been proposed by Hatemi-J (2008). Considering only the *C/S* equation, the model becomes

$$y_t = \alpha_1 + \alpha_2 D_t + \alpha_3 D_t + \beta_1' x_t + \beta_2' x_t D_t + \beta_3' x_t D_t + \varepsilon_t \qquad \text{model } C/S$$

where the new parameters α_3 and β_3' are the intercept and slopes in the third regime, and D_{1t} and D_{2t} are dummy variables defined as

$$D_{1t} = \begin{cases} 0 & \text{if} \quad t \le [N \times \tau_1] \\ 1 & \text{if} \quad t > [N \times \tau_1] \end{cases}$$

and

$$D_{2t} = \begin{cases} 0 & \text{if} \quad t \le [N \times \tau_2] \\ 1 & \text{if} \quad t > [N \times \tau_2] \end{cases}$$

where τ_1 and τ_2 are the unknown relative timing of the structural change and are found by minimising the ADF* statistic over all possible breaks points in a trimmed subsample ([(0.15+τ_1)×N], [0.85×N]) and such that $\tau_1 \in (0.15, 0.70)$ and $\tau_2 \in (0.15 + \tau_1, 0.85)$.

If a cointegrating relationship emerges, with or without breaks, we will exploit the Granger representation theorem and will specify the short term dynamics by means of an error correction model (ECM) which takes the form

$$\Delta y_t = \mu + \theta' \Delta x_t + \gamma\, \varepsilon_{t-1} + u_t$$

where ε_{t-1} is the residual term of the cointegrating equation.

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[8] The value of 0.15 for κ is suggested by Gregory and Hansen (1996a) as it is small enough so that the statistics can be computed.

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