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Real exchange rates, trade, and growth: Italy 1861-2011

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Abstract

What is the relationship between real exchange rate misalignments and economic growth? And what effect, if any, did undervaluations or overvaluations of the lira/euro have on Italy's growth? We address these questions by presenting, first, three main facts: (*i*) there is a positive relationship between undervaluation and growth; (*ii*) this relationship is strong for developing countries and weak for advanced countries; (*iii*) these results tend to hold for both the pre- and the post-World War II period. Building a simple analytical model, we explore channels through which undervaluation may exert a positive effect on real GDP. We assume that productivity is higher in the tradeable-goods than in the non-tradeable-goods sector, and examine the roles of market structure, scale economies and wage flexibility in channelling resources from the latter to the former sector, increasing exports and real GDP. We then turn to Italy and verify empirically that, as the theory suggests, undervaluation has positively affected its exports. Undervaluation has been helpful, in particular, to increase the exports of high-productivity sectors, such as most manufacturing industries. Finally, we describe the misalignments of the lira/euro since 1861, analyze their determinants and draw the implications for Italy's economic growth.

JEL classification: F30, F10, O10, N00
Keywords: Currency misalignments, Competitiveness, Italy, Export, Growth

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1 Introduction

Italy's interactions with Europe and the world and the role of the external sector in its growth and development are, like those of any other country, complex and multifaceted.[1] In this paper we focus on one specific facet: the real exchange rate, or the price of goods and services in Italy relative to other countries. We utilize the real exchange rate as a window onto the policies and circumstances shaping the impact of external conditions on domestic economic development.

Why focus on the real exchange rate, one of many different prices affecting the allocation of resources and the growth of the economy? For one thing, a substantial literature connects the real exchange rate to economic development and growth. Balassa (1964) is an early and influential statement of the importance of a competitively valued real exchange rate in supporting exports and, in turn, of their role for economic growth. More recently, similar arguments have been made by, inter alia, Acemoglu, Johnson, Robinson and Thaicharoen (2003), Easterly (2005), Galindo, Izquierdo and Montero (2006), Bhalla (2007), Johnson, Ostry and Subrimanian (2007), Eichengreen (2008a) and Rodrik (2008). These recent studies also offer empirical evidence, generally from cross-country regressions on post-1980 data, suggesting a connection running from the real exchange rate to economic growth — evidence that tends to be most robust for developing countries.

What are the determinants of the real exchange rate? Since Balassa (1964) and Samuelson (1964), it has been widely observed that the real exchange rate varies with economic development. While there is a tendency for the price of tradeable goods to be equalized across countries, the relative price of non-tradeable goods will tend to be lower in developing countries. In more advanced countries, where labor productivity and wages are higher, the relative price of non-tradeable goods will similarly tend to be higher. The International Comparison Program, producer of the Penn World Table, of which we make use in this paper, is predicated on these insights (see Kravis, 1986).

At the same time, the mapping from per capita income to the real exchange rate is not mechanical. In open economies like Italy, when the domestic demand for tradeable and non-tradeable goods rises, the price of tradeable goods will still be tied down by the law of one price, at least to a first approximation. But the price of non-tradeable goods will be driven up by the additional demand and the real exchange rate will appreciate. Relative to the benchmark where domestic aggregate demand equals supply (trade is balanced), it will become "overvalued." Similarly, wage stickiness and other frictions, that prevent relative prices from adjusting following a change in the nominal exchange rate, produce temporary undervaluation or overvaluation of the real exchange rate.

As the textbooks tell us (viz Dornbusch 1980), a variety of policies affecting the balance of aggregate supply and demand will tend to influence the real exchange rate. An expansionary

[1]The views expressed in this paper are those of the authors and do not necessarily reflect those of the Bank of Italy. We thank Mary Amiti, Jonathan Eaton, Philippe Martin, Fabrizio Onida, Paolo Pesenti, Gianni Toniolo and seminar participants at the Brixen Workshop 2011, SADiBa (Perugia Conference) and the New York Fed for many useful comments. We are also grateful to Alberto Baffigi, Claudia Borghese, Claire Giordano, Dennis Quinn, Sandra Natoli, Angelo Pace and Alan Taylor for their help in the construction of the data set. E-mail: virginia.dinino@bancaditalia.it, eichengr@econ.berkeley.edu, massimo.sbracia@bancaditalia.it

fiscal policy that stimulates domestic spending will produce real appreciation and be associated with problems of overvaluation. Capital controls will limit the contribution of capital inflows to demand, avoiding those problems of overvaluation. Intervention in the foreign exchange market will prevent a sharp shift in the nominal exchange rate, whatever its source, from producing a sudden and uncomfortable change in the real exchange rate. As we write this, a surge of capital inflows creating pressure for real appreciation and raising concerns about overvaluation is causing emerging-market economies to respond with all three policies — intervening in the foreign exchange market, imposing controls, and tightening fiscal policy — conscious as they are of the advantages of a competitively valued exchange rate.

This is a distinctly modern perspective, however. How should we think about real exchange rate determination in the XIX century, before the advent of discretionary fiscal policy, capital controls, and sterilized intervention? Decisions of what monetary regime to adopt and at what level to set the domestic price of gold or silver can still affect the real exchange rate if competition in goods or labor markets is imperfect and relative prices are slow to adjust. Capital inflows and outflows, which raise and lower demand, will still affect the real exchange rate (as the literature reminds us: see Fenoaltea, 1988). Labor market distortions that slow the reallocation of labor from the low-productivity sheltered sector to the high-productivity export sector, of the sort described by Lewis (1954), will tend to depress the relative price of home goods, resulting in a persistently undervalued exchange rate. And by affecting the real exchange rate, these factors affect the development of the export sector and the growth of the economy. As we will show, there is evidence of the operation in Italy of all these mechanisms in the era since unification. Some of them, we will suggest, are pivotal for understanding the contours of the country's economic development in the post-unification period.

We start by revisiting and broadening the evidence provided by Rodrik (2008) on the relationship between economic growth and undervaluation, where the latter is measured by the real exchange rate, corrected for the Balassa-Samuelson effect. We extend Rodrik's analysis in three directions. First, we use a more recent release of the Penn World Table, which includes sharp revisions for those countries, like China, that experienced very high rates of growth and very high degrees of undervaluation. Second, we consider a variety of different measures of undervaluation. Third, and most important, we expand the time span (Rodrik covers only the post-World War II years), going back to as far as 1861. This analysis points to three main conclusions. The first two support Rodrik's main findings: there is a positive relationship between undervaluation and economic growth; and while this relationship is strong, and both statistically and economically significant for developing countries, it is weak for advanced countries. In addition, we find that these results hold regardless of the time period: in particular, they tend to hold for the pre- and the post-World War II period.

We then examine, by developing a simple analytical model, channels through which undervaluation may exert a positive effect on growth. Our key assumption is that productivity is higher in the tradeable-goods sector than the non-tradeable-goods sector — consistent with Lewis' tenet about the productivity differential between the modern and traditional sectors. We investigate the roles of market structure, scale economies and wage flexibility in channeling resources to the high-productivity tradeable-goods sector and raising GDP.

In the models of trade that we consider, we replicate the effects of a nominal depreciation of the currency with an increase in the barriers to imports and a symmetric decline in the barriers to exports. This captures the essence of what a real depreciation does: it makes exports cheaper and imports more expensive.[2] We are comforted about the soundness of this assumption by the results from the baseline model. By extending the Eaton-Kortum model of trade (Eaton and Kortum, 2002) to encompass the non-tradeable-goods sector, we show that with perfect competition, constant returns to scale, and perfectly flexible wages, a depreciation does not have any effect on equilibrium quantities and relative prices — as is to be expected in this type of model. The decline in marginal costs due to the depreciation, in fact, is completely offset by a rise, of the same extent as the depreciation, in nominal wages. This model, in fact, assumes that wages and product prices are perfectly flexible, so that, right after the depreciation, the economy jumps to a new equilibrium with higher wages and product prices. In other words, a nominal depreciation does not produce a real depreciation. The real exchange rate cannot be undervalued nor overvalued: following the nominal depreciation, the rise in wages and product prices immediately restores pre-depreciation equilibrium quantities and relative prices.

The model also shows that if wages and product prices adjust slowly, then, during the transition to a new equilibrium, the currency remains undervalued and some gains in marginal costs obtain. With sticky wages and standard assumptions about the elasticity of substitution between tradeable and non-tradeable goods, an undervalued currency channels resources to the tradeable sector. Thus, even with perfect competition and constant returns to scale, undervaluation has real effects in the short-medium run. Clearly, their duration depends on the strength of the frictions that prevent wages and prices from rising (such as, persistence of "unlimited supply of labor" to the tradeable sector, extent of unemployment, frequency of foreign exchange rate interventions, presence of capital controls, etc.). As the adjustment takes place, however, gains in marginal costs are reversed and the depreciation has no real effects in the long run.

A nominal depreciation may exert persistent real effects, also if we replace the assumptions of perfect competition and constant returns to scale with Bertrand competition and increasing returns.[3] With increasing returns to scale, firms may have an incentive to sell their goods abroad even if they make negative profits on foreign markets. These firms may decide to export in order to produce at larger scale, cut their average costs, and make large enough profits in the domestic market — a possibility precluded in models with constant returns to scale, because there is no cost advantage from producing at a higher scale.[4] A depreciation by $\delta\%$, in fact, cuts firms'

[2]For instance, in discussing the current relationship between the U.S. and China, Krugman (2010a) asserts that: "China is following a policy that is, in effect, one of *imposing high tariffs and providing large export subsidies — because that's what an undervalued currency does*" (emphasis added); and, similarly: "China is deliberately keeping its currency artificially weak. The consequences of this policy are also stark and simple: in effect, *China is taxing imports while subsidizing exports*" (Krugman 2010b, emphasis added).

[3]We are not the first to unveil persistent real effects of changes in the nominal exchange rate in the presence of increasing returns to scale. Baldwin (1988) and Baldwin and Krugman (1989), for instance, prove that these effects arise in the presence of sunk costs. Similarly, Krugman (1987) shows these effects in the presence of dynamic external economies of scale. (More recently, Melitz (2005) shows that tariffs and quotas yield welfare enhancing effects in the presence of dynamic external economies of scale.) Our results, however, are more general than those in the previous literature, because they draw on the presence of increasing returns to scale only, and do not require that costs are sunk nor that external economies of scale are dynamic.

[4]We remove the assumptions of perfect competition and constant returns to scale *simultaneously* for two main reasons. First, the model with perfect competition and increasing returns to scale, analyzed by Ethier (1982), yields several "pathologies," such as multiple equilibria, that hamper the possibility of making comparative statics. Second, the model with Bertrand competition and constant returns to scale, developed by Bernard, Eaton, Jensen

average costs by more than $\delta\%$, thanks to the additional cost gains coming from the economies of scale. Hence, a rise in relative wages by $\delta\%$ is not sufficient to offset the gain in average costs.[5] While the economy converges to a new equilibrium with higher (relative) wages following the depreciation, some domestic firms gain a competitive advantage. Thus, some domestic firms find access to the foreign market, while some goods are no longer imported and are domestically produced. Given standard elasticities, this translates into a shift of resources to the high-productivity tradeable-goods sector and, then, into a rise in real GDP. These gains obtain with the real exchange rate set at its equilibrium level and are even larger during the transition to the new equilibrium, when the currency is undervalued (owing to the same mechanisms described above).

Our analysis also explains why a growth strategy based on currency undervaluation or serial nominal depreciations in the presence of increasing returns to scale cannot be pursed *ad infinitum*. With perfect competition and constant returns to scale, wages and prices eventually adjust, offsetting the depreciation. With Bertrand competition and increasing returns to scale, the competitive gains decline with industry output and, then, become increasingly smaller as the economy develops. Finally, the maintained assumption of a positive productivity differential between the tradeable-goods and non-tradeable goods sectors — which is reasonable if these sectors broadly correspond to what Lewis (1954) dubbed as modern and traditional sectors, as it happens in many low-income countries — may not be appropriate in advanced economies where non-tradeable products include, for instance, high-productivity financial services.

We then turn to Italy and verify whether, as the theory suggests, undervaluation supported growth by increasing exports. We consider different features of Italy's exports: their growth rate, their nominal and real value, and their extensive margin (number of distinct goods sold abroad). The results show that undervaluation has positively affected all these features. Yet, these positive effects do not take place homogeneously across industries. Plausibly, undervaluation does not raise exports of primary products. It is, instead, especially helpful to increase the exports of high-productivity sectors such as machinery and transport equipment, as well as other manufactures.

Finally, we focus on the undervaluation of the lira/euro and, in light of the previous results, we assess its connection with Italy's growth and trade. Figure 1 shows two measures of undervaluation for Italy in the period 1861-2011: one is bilateral, calculated with respect to the US dollar (for which we also provide a 5% confidence band); the other is computed against a trade-weighted basket of currencies (see Section 5 for details). Evidently, Italy benefited from a strongly undervalued currency during the key catching-up phase of 1950-1973. During this crucial period, Italy recorded a very strong economic growth. Its real GDP per capita tripled, almost closing the income gap with respect to the major European countries. The currency was

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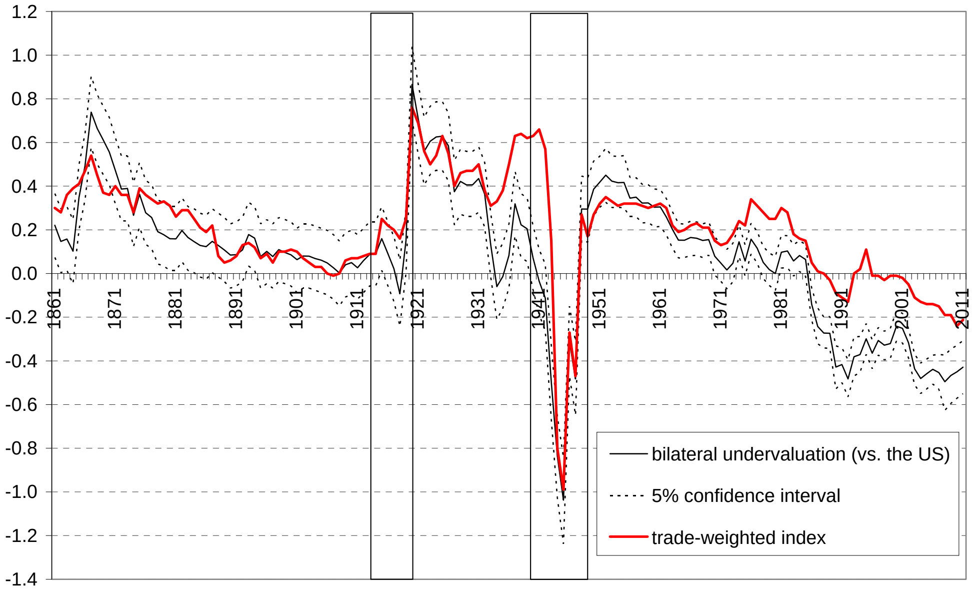
and Kortum (2003), would yield essentially the same results as the model with perfect competition. Thus, assuming increasing returns to scale is key in order to have real effects of changes in the exchange rate also in the presence of flexible wages, while Bertrand competition is needed to show these effects with a tractable model.

[5] Although relative wages could rise by more than $\delta\%$, there is no rise in relative wages that can restore the pre-depreciation equilibrium. Because the degree of increasing returns to scale is heterogeneous across industries, the decline in average costs connected to the rise in output is also different across industries. Even if increasing returns to scale were the same across industries, however, the latter are heterogeneous in productivities and, then, starting from heterogeneous output levels, the decline in average costs would be different across industries. Thus, pre-depreciation equilibrium quantities and relative prices cannot be restored across all industries.

Figure 1: Measures of undervaluation of Italy's currency: 1861-2011 (1)



Source: authors' calculations. (1) Data in logs. A positive (negative) value corresponds to undervaluation (overvaluation). The two shaded areas correspond to the periods 1914-1920 and 1939-1950.

broadly at equilibrium in 1895-1913 and again undervalued in the 1970s and 1980s (based on the trade-weighted index). In both these periods, Italy's growth was sustained, and somewhat better than that of the main European countries. From the early 1990s, a period of very slow growth, the currency was overvalued and the exchange rate provided a negative, albeit small, contribution to growth. On the other hand, Italy's currency was undervalued in 1861-1895 and during the interwar period, when growth rates were, in contrast to the predictions of the theory, very low. Economic, financial and political instability in the first 30 years of the new reign and the Great Depression in the interwar period prevented the country from taking advantage of its undervalued currency. In general, these results seem to confirm the hypothesis that an undervalued currency is a *facilitating condition*, but not an engine, of economic growth (Eichengreen, 2008a).

The rest of the paper is organized as follows. Section 2 provides the main stylized facts about undervaluation and growth. Section 3 presents a theoretical model which illustrates how undervaluation may affect growth by boosting exports and reallocating labor toward the tradeable sector. We then turn to Italy and, in Section 4 we examine the effect of undervaluation on Italy's exports. In Section 5, we compute and describe a measure of undervaluation of the lira/euro in the period 1861-2011, analyze its determinants, and then draw the implications for Italy's economic growth.

Part I

Exchange rates, trade and economic growth

2 Exchange rates and growth: cross-country evidence

We start by revisiting the evidence provided by Rodrik (2008), for the period following World War II, that undervaluation is positively related to the growth of real GDP per capita. We then ask whether the same relationship also holds in earlier years.

The key variable needed to compute the real exchange rate and, in turn, undervaluation is the purchasing power parity (PPP) rate, that is the value of the exchange rate that would yield the same price level as in the reference country, in general the United States, when expressed in a common currency (usually US dollars). The real exchange rate is defined as the ratio between the market and the PPP exchange rate, usually measured in term of units of domestic currency per one US dollar, so that an increase means depreciation. A real exchange rate above one means that goods and services are cheaper in a country than in the United States.

This measure, by itself, does not capture a misalignment of the exchange rate. As it has been well known since Balassa (1964) and Samuelson (1964), non-tradeable goods are cheaper in developing than in advanced countries, reflecting the higher productivity and, then, the higher input costs in the latter. Therefore, measures of misalignment are built by correcting for this Balassa-Samuelson effect. The correction involves regressing the real exchange rate on a variable related to the degree of development of each country (typically, real GDP per capita); undervaluation is then defined as the difference between the observed and the predicted real exchange rate. In this way, undervaluation captures the price differential between the United States and the country *in excess* of what can be predicted by considering the country's level of development.[6]

Following Rodrik (2008), undervaluation can be obtained by running the regression:

$$rer_{n,t}^{PWT} = a + by_{n,t}^{pc} + c_t + \varepsilon_{n,t} \ , \tag{1}$$

where $rer_{n,t}^{PWT}$, the log of real exchange rate from the Penn World Table (PWT) of country n at time t, is computed as

$$rer_{n,t}^{PWT} = \ln \frac{xrat_{n,t}}{PPP_{n,t}} \ ,$$

with $xrat_{n,t}$ and $PPP_{n,t}$ denoting, respectively, the nominal and the PPP exchange rate vis-à-vis the US dollar; $y_{n,t}^{pc}$ is the log of real GDP per capita; c_t is a set of time dummies; $\varepsilon_{n,t}$ the

[6] There are other possible methodologies to measure the equilibrium level of the real exchange rate. For instance, following Nurske (1945), the equilibrium real exchange rate can be defined as the relative price of tradable to domestic non-tradable goods that achieves internal (full employment) and external equilibrium (trade balance). Misalignment is then computed as the residual from a regression of the real exchange rate on a set of variables that affect prices over the long run. These variables usually include not only real GDP per capita, but also, among the others, trade openness, government consumption, and terms of trade (see, in particular, Lee, Milesi-Ferretti, Ostry, Prati and Ricci, 2008, for a recent survey of the methodologies utilized by International Monetary Fund). Berg and Miao (2010) show that this different methodology to measure undervaluation yields very similar results (see for instance, Figure 2 in Berg and Miao, 2010). Not surprisingly, Berg and Miao (2010) and MacDonald and Vieira (2010) confirm that estimates of the relationship between undervaluation and growth are robust to the method chosen to measure the former.

residual; and $a, b \in \mathbb{R}$. Undervaluation is then defined as:

$$u_{n,t}^{PWT} = \hat{\varepsilon}_{n,t} = rer_{n,t}^{PWT} - \widehat{rer}_{n,t}^{PWT} \ .$$

In the second step, one can examine whether undervaluation affects growth by estimating:

$$g_{n,t} = \alpha_n + \beta y_{n,t-1}^{pc} + \delta u_{n,t}^{PWT} + d_t + \eta_{n,t} \ , \tag{2}$$

where $g_{n,t}$ is the growth rate of real GDP per capita, $y_{n,t-1}^{pc}$ controls for the initial conditions and d_t for time specific unobserved effects, α_n are fixed effects, $\eta_{n,t}$ is the residual, and $\beta, \gamma \in \mathbb{R}$. Because it takes time for misalignments to exert their effect on growth, Rodrik uses five-year averages of all the variables. Therefore, each time t denotes non-overlapping five-year periods.

In this paper we follow the same methodology as Rodrik (2008), extending the analysis in three main directions. First, we use a more recent release of the PWT: the version 6.3, from Heston, Summers and Aten (2009), that covers the period 1950-2007, which we extend to 2009 using the May release of PWT version 7.0;[7] we also use some alternative data sources for prices, exchange rates and real GDP per capita. This is more than a just technical point, because the PWT undergoes frequent and often extensive revisions of PPP-adjusted rates (see Johnson, Larson, Papageorgiou and Subramanian, 2009, for a critique). Many authors, for instance, recommended using other versions of the PWT as a robustness test (see the section General Discussion of Rodrik's paper). The two most recent releases, in particular, entail strong revisions for those very countries, like China, experiencing the highest rates of growth and degrees of undervaluation (partly leading the result that undervaluation is positively related to growth). For example, in the period 1950-2004 (the one common to Rodrik's as well as our data set), the new data suggests that China's average rate of growth of real GDP per capita is 4.6%, as opposed to 5.5% in the previous release (version 6.2). The initial 1950 level of the same variable is 70% larger in the newer than in the older release.[8]

Second, we consider both corrected and "weakly" corrected measures of undervaluation. In particular, two alternative definitions of the real exchange rate are:

$$\begin{aligned} rer_{n,t}^{WPI} &= \ln \frac{xrat_{n,t} \cdot WPI_{us,t}}{WPI_{n,t}} \\ rer_{n,t}^{CPI} &= \ln \frac{xrat_{n,t} \cdot CPI_{us,t}}{CPI_{n,t}} \end{aligned}$$

where $WPI_{n,t}$ is the wholesale price index (or producer price index) of country n at time t, $CPI_{n,t}$ is the consumer price index of country n at time t, and the subscript us denotes the United States. Following Woodford (2008), we can plug (alternatively) $rer_{n,t}^{WPI}$ and $rer_{n,t}^{CPI}$ into

[7] The version 7.0 of the Penn World Table has undergone very frequent revisions: a first version was released in March 2011, another one in April and a third one in May, when we were revising our estimates. This version, however, still had several problems, so we kept using the version 6.3 and exploited the version 7.0 only to extend the data set to 2009 (using changes of the main variables). A fourth version of the data set has been released in June 2011, too late to be considered for this paper.

[8] The revision for China is so strong that the two latest releases of the Penn World Table make available two different country series: one (China Version 1) is similar to the series contained in the version 6.2 of the table; the other (China Version 2), which is recommended by the Penn World Table producers and the one used in our empirical analysis, incorporates stronger revisions.

the empirical model (2) in the place of $u_{n,t}^{PWT}$. Even though $rer_{n,t}^{WPI}$ and $rer_{n,t}^{CPI}$ measure only the real exchange rate, and not the degree of misalignment, according to Woodford (2008) both these measure do entail a form of correction (although "weak"), once they are plugged into the growth regression (2). The reason is that this model includes country fixed effects that, in turn, can account for the different growth rates due to factors such as the Balassa-Samuelson effect. This form of correction is "weak," because it neglects changes in the country's level of development during the sample period. Thus, it is more precise for shorter time periods (in which changes in a country level of development are small) or for countries in which real GDP per capita is more stable. Note, also, that both these rates can be corrected to obtain measures of undervaluation, denoted with $u_{n,t}^{WPI}$ and $u_{n,t}^{CPI}$, as residuals of the estimates of (1), where $rer_{n,t}^{PWT}$ is replaced with, respectively, $rer_{n,t}^{WPI}$ and $rer_{n,t}^{CPI}$. To sum up, in our empirical analysis we use five different measures of undervaluation: the corrected measures $u_{n,t}^{PWT}$, $u_{n,t}^{WPI}$ and $u_{n,t}^{CPI}$, and the "weakly corrected" measures $rer_{n,t}^{WPI}$ and $rer_{n,t}^{CPI}$.[9]

Our third and most important extension concerns the time span of the sample, which we bring back to as far as 1861, the time of Italy's unification. We gather data on exchange rates vis-à-vis the US dollar, wholesale price indices and consumer price indices (from several sources), as well as real GDP per capita (from Maddison, 2010), for 34 countries from 1861 to 1939 (details are in Appendix A). We then merge these data with the PWT to obtain a data set spanning almost 150 years.

Equation (1) is estimated, as in Rodrik, using OLS when the dependent variable is $rer_{n,t}^{PWT}$. The estimated coefficient for $y_{n,t}$ is equal to -0.26 and it is strongly significant (Rodrik finds a similar coefficient of -0.24).[10] The negative sign means that, as expected, higher income per capita reduces the degree of undervaluation for a given real exchange rate. When the dependent variable is $rer_{n,t}^{WPI}$ or, alternatively, $rer_{n,t}^{CPI}$, we estimate a panel model with random effects (see footnote 8) and the corresponding coefficients are -0.16 and -0.29, respectively, with only the latter strongly significant.

Equation (2) is estimated using a variety of methods (linear panel with fixed effects and GMM), for different samples of countries and time periods. Table 1 reports the results of the estimates for the whole time span (i.e. from 1861 to 2009), different sets of countries, and

[9] Unlike $rer_{n,t}^{PWT}$, both $rer_{n,t}^{WPI}$ and $rer_{n,t}^{CPI}$ are only index numbers and can describe the behavior over time of the real exchange rate, but do not provide any information about its level. Yet, these variables can still be included into a growth regression like equation (2), as long as the estimated specification contains country unobserved effects. Similarly, they can be used as dependent variables into a specification like (1) in order to derive corrected measures of undervaluation, as long as we account for level-differences in the base year by including fixed or random effects. In particular, we chose a random effect model,which is not rejected by a Hausman test, when we estimate equation (1) with $rer_{n,t}^{WPI}$ and $rer_{n,t}^{CPI}$ as dependent variables.

[10] Notice that a question concerns the estimation method, because real exchange rates and real GDP per capita are likely to be non-stationary and co-integrated. Then, specifications like (1) are usually estimated with panel co-integrated techniques, rather that with OLS with time dummies as in Rodrik and in this paper. However, as long as the relevant co-integrated variable is included into the specification (1), the OLS method yields super-consistent estimates, even though standard errors may not be well-behaved in small samples. While panel bootstrap methods could return precise small-sample estimates of standard errors, given the very large sample size of our sample (and the fact that proving that income per capita affects the real exchange rate is not the purpose of this study, but a result of a fifty-year-old literature), we can safely use OLS.

Table 1: Economic growth and undervaluation (1861-2009) (1)

	All Countries				Developing Countries			
	u^{CPI}	u^{WPI}	rer^{CPI}	rer^{WPI}	u^{CPI}	u^{WPI}	rer^{CPI}	rer^{WPI}
y_{t-1}	-0.032	-0.036	-0.031	-0.035	-0.039	-0.029	-0.037	-0.025
	[7.77]***	[3.79]***	[7.27]***	[3.56]***	[5.85]***	[1.83]*	[5.50]***	[1.61]
undervaluation	0.008	0.015	0.004	0.009	0.008	0.026	0.005	0.018
	[2.69]***	[1.80]*	[2.43]**	[1.08]	[2.81]***	[3.24]***	[3.11]***	[2.24]**
Constant	0.256	0.222	0.242	0.184	0.186	0.269	0.152	0.167
	[9.50]***	[3.84]***	[8.40]***	[2.86]***	[4.30]***	[1.95]*	[3.38]***	[1.32]
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Period dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1419	729	1419	729	827	350	827	350
Number of countries	161	80	161	80	130	59	130	59
R-squared	0.39	0.48	0.38	0.47	0.36	0.51	0.35	0.49

(1) Estimates of equation (2) using OLS. Robust t statistics in brackets; * significant at 10%, ** at 5%, *** at 1%.

different measures of undervaluation.[11] The coefficient on undervaluation is always positive. Corrected measures of undervaluation always return very significant coefficients, while weakly corrected measures do not return a significant coefficient in one case ($rer_{n,t}^{WPI}$ on all countries). When estimates are restricted to the sample of developing countries only — defined as the countries in which real GDP per capita is below 6,000 US dollars (2005 international dollars) — the estimated coefficients for undervaluation tend to be larger and more significant than for the full sample.

The estimated coefficients for undervaluation, when measured by $u_{n,t}^{WPI}$ and $u_{n,t}^{CPI}$, are in the 1-3% range. Thus, a 30% undervaluation, as in Italy in the early 1950s, would raise real GDP by 1.5% to 4.5% over five years (i.e. the annual rate growth would rise by 0.3% to 0.9%). In other words, results from the estimates are not only statistically significant, but also economically significant. Notice, also, the coefficient for the initial conditions is always significant with the predicted negative sign.

When we restrict the sample to the post-World War II period, we can consider also estimates in which undervaluation is measured with $u_{n,t}^{PWT}$, which is the most precise index (Table 2). All the coefficients are positive, irrespectively of the sample of countries. However, only the coefficients for the full sample and the sample of developing countries are strongly significant (2-3%), while the coefficient for advanced countries is considerably smaller (0.3%) and not significant.

[11] It is important to note that we do not have a continuous series for consumer and wholesale price indices (which would have implied using data that span through the World War years, see Section 5.1.1 for a discussion). Our time series are available in three different windows: 1861-1913, 1920-1939, and 1950-2009, each of them with a different base year (1900, 1929 and 2000, respectively). Hence, when estimates are performed for the whole sample period, we have included three sets of country fixed effects, one for each of the three time windows. The reason is that if equation (2) is the true data generating process, then we should expect the same slopes across time windows but different intercepts (due to the rebasement) for each country. In other words, the three different effects are meant to capture the different degree of undervaluation in the three base years and, as a consequence, the different growth rates on those years. Thus, the three different sets of fixed effects catch those different intercepts, while still providing a single estimate for the slope.

Table 2: Economic growth and undervaluation after World War II (1950-2009): undervaluation based on Penn World Table (1)

	All countries	Developing countries	Advanced countries
y_{t-1}	-0.029	-0.038	-0.053
	[6.24]***	[4.47]***	[8.61]***
undervaluation	0.016	0.026	0.003
	[3.41]***	[3.99]***	[0.48]
Constant	0.297	0.31	0.556
	[8.33]***	[5.08]***	[11.40]***
Country fixed effects	Yes	Yes	Yes
Period dummies	Yes	Yes	Yes
Observations	1551	852	699
Number of countries	179	125	108
R-squared	0.25	0.21	0.46

(1) Estimates of equation (2) using OLS; undervaluation measured by $u_{n,t}^{PWT}$. Robust t statistics in brackets; * significant at 10%, ** at 5%, *** at 1%.

The picture is essentially the same when we consider the other indices of undervaluation (Table 3). All the coefficients for the full sample as well as the sample of developing countries are strongly significant across all measures (except $rer_{n,t}^{WPI}$), and magnitudes are again the same (1-3% for the corrected measures). Similarly the higher dimension of the coefficient for developing countries is also confirmed.

Table 4 reports the results for the period before World War II. The coefficients are still positive, even though somewhat smaller (up to 2%). The estimates are less precise due to the dramatic decline in the number of observations. In this subsample, all the countries have an income per capita below the threshold of 6,000 US dollars. If we choose a different, lower threshold, to separate the more advanced from developing countries (2,000 US dollars, which is close to the median income for this subsample), we find that another fact tends to be confirmed: the effect of undervaluation on economic growth tends to be stronger for less developed countries.[12]

While these results highlight the positive correlation between undervaluation and growth, they do not allow to assess the direction of causality. For this, one would need to find a variable correlated with the real exchange rate but exogenous to economic growth (an instrument). In order to obtain at least some preliminary indications about this question, we estimate a dynamic panel model with the difference GMM method of Arellano and Bond (1991), with additional

[12] For the indicator based on consumer prices, we also estimate a version of equation (2) on a country-by-country basis. It emerges that the poorer countries in the sample (Brazil, Japan, Portugal, Italy, Spain and Norway, that are the countries with incomes per capita below 2,000 U.S. dollars at the turn of the century) all feature positive (albeit insignificant) coefficients. On the other hand, the richer countries in the sample (the United Kingdom and Australia, with an income per capita close to or above 4,000 U.S. dollars) display negative coefficients. The negative correlation across countries between the estimated coefficient and real GDP per capita is confirmed across the full sample.

Table 3: Economic growth and undervaluation after World War II (1950-2009): alternative indices of undervaluation (1)

	All countries				Developing countries			
	u^{CPI}	u^{WPI}	rer^{CPI}	rer^{WPI}	u^{CPI}	u^{WPI}	rer^{CPI}	rer^{WPI}
y_{t-1}	-0.031	-0.035	-0.03	-0.033	-0.037	-0.023	-0.036	-0.019
	[7.80]***	[3.74]***	[7.28]***	[3.51]***	[5.67]***	[1.47]	[5.32]***	[1.25]
undervaluation	0.008	0.014	0.004	0.009	0.008	0.027	0.005	0.019
	[2.72]***	[1.73]*	[2.55]**	[1.05]	[2.85]***	[2.77]***	[3.17]***	[2.03]*
Constant	0.329	0.374	0.312	0.342	0.313	0.24	0.281	0.138
	[11.30]***	[5.35]***	[9.95]***	[4.66]***	[6.56]***	[2.16]**	[5.70]***	[1.45]
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Period dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1210	538	1210	538	620	161	620	161
Number of countries	160	78	160	78	110	35	110	35
R-squared	0.34	0.41	0.33	0.4	0.24	0.3	0.22	0.27

(1) Estimates of equation (2) using OLS. Robust t statistics in brackets; * significant at 10%, ** at 5%, *** at 1%.

Table 4: Economic growth and undervaluation before World War II (1861-1939) (1)

	All Countries		Less Developed Countries (2)	
	u^{CPI}	u^{WPI}	u^{CPI}	u^{WPI}
y_{t-1}	-0.084	-0.082	-0.09	-0.085
	[4.69]***	[5.34]***	[3.86]***	[3.43]***
undervaluation	0.001	0.017	0.010	0.022
	[0.12]	[1.45]	[0.83]	[0.92]
Constant	0.613	0.61	0.609	0.575
	[4.75]***	[5.34]***	[3.85]***	[3.43]***
Country fixed effects	Yes	Yes	Yes	Yes
Period dummies	Yes	Yes	Yes	Yes
Observations	209	191	83	64
Number of countries	33	31	19	19
R-squared	0.54	0.56	0.51	0.45

(1) Estimates of equation (2) using OLS. Robust t statistics in brackets; * significant at 10%, ** at 5%, *** at 1%. (2) Real income per capita up to 2,000 US dollars (2005 international dollars).

Table 5: Economic growth and undervaluation (dynamic panel) (1)

	Whole sample All Countries		Whole sample Developing countries (2)		Whole sample Less developed countries (3)		Pre WW II period All Countries	
	u^{CPI}	u^{WPI}	u^{CPI}	u^{WPI}	u^{CPI}	u^{WPI}	u^{CPI}	u^{WPI}
y_{t-1}	0.242	0.24	0.199	0.147	0.3	-0.066	0.407	0.248
	[8.80]***	[6.63]***	[5.05]***	[2.51]**	[4.51]***	[0.59]	[5.37]***	[2.94]***
ln(GDP $_{t-1}$)	-0.043	-0.041	-0.033	-0.026	-0.026	-0.01	-0.003	0.004
	[15.05]***	[10.70]***	[8.30]***	[5.21]***	[3.55]***	[1.26]	[1.03]	[0.85]
undervaluation	0.006	0.021	0.006	0.025	0.009	0.044	0.004	0.004
	[3.40]***	[3.53]***	[3.26]***	[2.82]***	[1.90]*	[4.57]***	[0.38]	[0.22]
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Period dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1121	577	651	275	277	80	157	145
Number of countries	156	77	123	56	60	23	32	29
Sargan test	73.72	89.4	78.79	129.31	70.8	67.66	90.38	89.82
P value	0.45	0.09	0.30	0.00	0.26	0.01	0.00	0.00
AR (2)	-1.97	-1.96	-2.82	-2.92	-1.35	-1.47	-3.12	1.53
P value	0.049	0.05	0.005	0.003	0.176	0.141	0.002	0.126

(1) Estimates of equation (2) using OLS. Absolute value of z statistics in brackets; * significant at 10%, ** at 5%, *** at 1%. (2) Real income per capita up to 6,000 US dollars (2005 international dollars). (3) Real income per capita up to 2,000 US dollars (2005 international dollars).

lags of GDP growth and undervaluation as instruments for the lagged dependent variable and the independent variable.[13] Using lagged values as instruments shows that the coefficients for undervaluation are positive and highly significant for the whole sample period. Coefficients tend to be higher for less developed countries (income below 6,000 or 2,000 US dollars) and smaller and insignificant for the sole pre-World War II period (for which the Sargan test warns that we do not have valid instruments). The elasticity of growth with respect to currency misalignments goes from 1 to 4% on the whole sample period, and from 0.4% for the period preceding World War II.

Overall, three main facts emerge from this empirical analysis, with the first two of which confirming Rodrik's main findings: (*i*) there is a positive relationship between undervaluation and economic growth; (*ii*) this relationship is strong, and both statistically and economically significant for developing countries, while it is weak for advanced countries; (*iii*) these results tend to hold for both the post- and the pre-World War II period. Elasticities of economic growth with respect to undervaluation are generally comprised between 1-4% (both for the full sample and for developing countries); they are as low as 0.3% for advanced countries. Results also provide at least suggestive evidence that causality runs from undervaluation to growth. But what is the mechanism?

In the next section, we analyze this question and develop the following hypothesis. Un-

[13] In our sample, the Sargan test tended to accept the null that the error term is uncorrelated with the instruments when we estimated the model using Difference GMM and to reject it when we used System GMM. For an extensive set of estimates using post 1980 data with System GMM, however, see MacDonald and Vieira (2010). All their estimates confirm the main result that the relationship between undervaluation and growth is positive and the direction of causality is likely to run from the former to the latter.

dervaluation acts by enhancing the price competitiveness of tradeable goods and by shifting resources from the non-tradeable-goods to the tradeable-goods sector. To the extent that productivity in the latter sector is higher, undervaluation would successfully raise GDP growth.

3 Exchange rates and growth: a view from trade theory

We assume that the tradeable-goods sector has a higher productivity than the non-tradeable-goods sector and we investigate the conditions under which a currency depreciation is successful in shifting labor from the latter to the former, thereby raising output. Our working assumption is that, in the real models of trade considered in this section, we can replicate the effects of a nominal depreciation with a decline in the barriers to the country's exports, coupled with a *symmetric* rise in the barriers to the country's imports.

We consider first a framework with perfect competition and constant returns to scale, which is a modified version of the model of Eaton and Kortum (2002). Then, we turn to a model with Bertrand competition and constant returns to scale, à la Grossman and Rossi-Hansberg (2010).[14]

3.1 Perfect competition and constant returns to scale

We consider an economy with the following features: a tradeable-goods and a non-tradeable-goods sector, each of them producing a continuum of goods; industries with heterogeneous efficiencies, described by Fréchet distributions; labor, the only production factor, is perfectly mobile across sectors within each country and immobile across countries; the market structure is perfect competition.[15] We analyze first the closed economy and then the open economy. In the latter, we introduce asymmetric trade barriers, modeled as Samuelson's iceberg costs.

The resulting framework is a variant of the Eaton-Kortum model of trade (Eaton and Kortum, 2002; EK hereafter), in which the non-tradeable-goods sector is explicitly modeled. The reason for this modification is that *the interplay between the tradeable-goods and non-tradeable-goods sectors has a key role in our analysis.*

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[14] Both constant and increasing returns to scale are considered to be empirically relevant in many contexts. Antweiler and Trefler (2002), using data from 71 countries, provide the somewhat Solomonic result that at least one third of all good-producing industries are characterized by increasing returns to scale (induced by plant-level or industry-level externalities), while at least one third of all goods-producing industries display constant returns to scale. Focusing on the manufacturing sector (often used as a proxy for the tradeable-goods sector), Morrison and Siegel (1999) find that scale economies are prevalent in the U.S. and that, at least in part, they may be due to factors that are external to firms.

[15] While we could also consider only one single non-tradeable good, by assuming a continuum of non-tradeable industries we preserve some symmetry with the tradeable sector, which allows to simplify the results. Analogously, we could obtain similar results from a model with only two tradeable goods but, following the lesson of Dornbusch, Fischer and Samuelson (1977), we consider a model with a continuum of tradeable goods in order to represent industry productivities with a function and use the tools of calculus, simplifying the analysis neatly with respect to the discrete many-commodity case. Finally, by exploiting the insight of Eaton and Kortum (2002) of using specific distribution functions and the language of probability to describe industry productivities, we obtain even simpler theoretical results.

3.1.1 Closed economy

Consumer's problem is

$$\max_{c_i^T(j), c_i^N(j)} \left\{ \left[\left(c_i^N\right)^{\frac{\eta-1}{\eta}} + \left(c_i^T\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} ; \text{subj. to: } \sum_{m=N,T} \int p_i^m(j)\, c_i^m(j)\, dj \leq w_i L_i \right\} \tag{3}$$

$$\text{with: } c_i^m = \left\{ \int \left[c_i^m(j)\right]^{\frac{\sigma-1}{\sigma}} dj \right\}^{\frac{\sigma}{\sigma-1}}, \forall m = N, T$$

where the superscripts N and T distinguish non-tradeable from tradeable goods and i denotes the country; c_i^N (c_i^T) is the consumption bundle of non-tradeable (tradeable) goods; $c_i^N(j)$ ($c_i^T(j)$) is consumption of the non-tradeable (tradeable) good j, where goods j are indexed in the interval $[0, +\infty)$; $p_i^N(j)$ ($p_i^T(j)$) is the price of the non-tradeable (tradeable) good j; w_i is the nominal wage; L_i is labor supply; and $\sigma, \eta > 0$ are elasticities.

The parameter σ in the nested CES function (3) is the elasticity of substitution between two tradeable goods and between two non-tradeable goods; η governs the elasticity of substitution between tradeable and non-tradeable goods.[16] This frameworks allows for both elastic ($\sigma, \eta \geq 1$) and inelastic demand ($\sigma, \eta < 1$). However, in the following, we implicitly assume $\sigma > 1$, while for η we explicitly consider both $\eta \geq 1$ and $\eta < 1$, the latter being the empirically-relevant case (see Stockman and Tesar, 1995).

Goods are produced with constant returns to scale: $q_i^m(j) = z_i^m(j)\, L_i^m(j)$, $m = N, T$, where $q_i^m(j)$ is the quantity of good j of sector m produced by country i, $z_i^m(j)$ is the efficiency (productivity) of that industry j, and $L_i^m(j)$ is the number of workers employed in that industry. Perfect competition implies $p_i^m(j) = w_i / z_i^m(j)$, for any i, m, and j.

Industry productivities in the non-tradeable-goods and the tradeable-goods sector are respectively described by $Z_i^N \sim \textit{Fréchet}(N_i, \theta)$ and $Z_i^T \sim \textit{Fréchet}(T_i, \theta)$, with $N_i, T_i > 0$ and $\theta > \sigma$. The parameters N_i and T_i are related to the first moments of, respectively, Z_i^N and Z_i^T: an increase in N_i (T_i) implies an increase in the share of non-tradeable (tradeable) goods that country i produces more efficiently. The parameter θ is inversely related to the dispersion of Z_i^N and Z_i^T.[17]

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[16] The assumption that the elasticities of substitution for non-tradeable and tradeable goods are the same (equal to σ) can be relaxed, at the cost of a slightly more cumbersome algebra.

[17] If $X \sim \textit{Fréchet}(\xi, \theta)$, then the moment of order k of X (which exists iff $\theta > k$) is $\xi^{k/\theta}\Gamma\left[(\theta - k)/\theta\right]$, where Γ denotes Euler's Gamma function. In an open economy, T_i and θ are the the theoretical counterparts, in a context with many countries and a continuum of goods, of the Ricardian concepts of *absolute advantage* (due to the close link of T_i with the mean of Z_i^T) and *comparative advantage* (θ is closely connected with the dispersion of Z_i^T and the gains from trade). For some background, see Eaton and Kortum (2002).

The key equations of the autarky equilibrium (see Appendix B.1 for details) are:[18]

$$\frac{p_i^T}{p_i^N} = \left(\frac{N_i}{T_i}\right)^{1/\theta} \tag{4}$$

$$\frac{L_i^N}{L_i^T} = \left(\frac{N_i}{T_i}\right)^{(\eta-1)/\theta} \tag{5}$$

$$\frac{c_i^N}{c_i^T} = \left(\frac{N_i}{T_i}\right)^{\eta/\theta} \tag{6}$$

$$\frac{A_i^N}{A_i^T} = \left(\frac{N_i}{T_i}\right)^{1/\theta} \tag{7}$$

$$Q_i = A_i^N L_i^N + A_i^T L_i^T = \gamma_q \left(N_i^{\eta/\theta} + T_i^{\eta/\theta}\right) L_i \tag{8}$$

$$\frac{w_i}{p_i} = \gamma_w \left[N_i^{(\eta-1)/\theta} + T_i^{(\eta-1)/\theta}\right]^{1/(\eta-1)} \tag{9}$$

where γ_q and γ_w are constants.[19] These equations show: the *price* of the bundle of the tradeable goods relative to that of the non-tradeable goods (equation (4)); the *size* of the non-tradeable-goods sector relative to the tradeable-goods sector (equation (5)); the *demand* for the bundle of non-tradeable goods relative to that of the tradeable goods (equation (6)); *aggregate productivity* of the non-tradeable-goods sector relative to that of the tradeable-goods sector (equation (7));[20] *real GDP*, i.e. aggregate production of non-tradeable and tradeable goods (equation (8));[21] the *real wage* (equation (9)), that, given L_i, measures welfare (utility is $w_i L_i / p_i$ in the equilibrium).

3.1.2 Open economy

Representative consumers are identical in all countries and solve the same problem (3) described above (analytic details are in Appendix B.2).

Prices. As in the standard Ricardian model, production and trade are governed by comparative advantages and each good is bought from the producer who sells it at the lowest price. Hence, the price of a tradeable good j in country i is: (*i*) $p_i^T(j) = w_i / z_i^T(j)$, if j is domestically produced; (*ii*) $p_i^T(j) = w_n d_{in} / z_n^T(j)$, if j is imported from country n, where d_{in}

[18] Here we are mostly interested in the main macroeconomic aggregates, rather than in the single tradeable and non-tradeable goods, whose equilibrium quantities and relative prices are nevertheless determined in Appendix B.1. To economize on the notation, we report ratios not only for prices, but also for some quantities, deferring to Appendix B.1 for details.

[19] In particular, $\gamma_q = \frac{\theta}{\theta-\sigma}\left[B\left(\frac{\theta-\sigma+1}{\theta}, \frac{\theta-1}{\theta}\right)\right]^{-1}$, where B denotes Euler's Beta function, while $\gamma_w = \left[\Gamma\left(\frac{\theta-\sigma+1}{\theta}\right)\right]^{-\frac{\eta-1}{\sigma-1}}$.

[20] In the closed economy, it is easy to show that by aggregating production across industries in equilibrium, we obtain a function $Q_i^m = A_i^m L_i^m$, where A_i^m is the aggregate productivity (or labor productivity) of sector m and L_i^m is the size of this sector. In particular, A_i^m is given by the ratio between the moment of order σ and the moment of order $\sigma - 1$ of the productivity distribution of sector m (see Finicelli, Pagano and Sbracia, 2011, for details).

[21] Real GDP is defined as $Q_i = Q_i^N + Q_i^T$, where $Q_i^m = \int q_i^m(j)\, dj$ for $m = N, T$. This definition resembles the one used by statistical agencies, which proxy real GDP with the "quantity index": $\sum p(j)\, q'(j) / \sum p(j)\, q(j)$, where p and q are good prices and quantities at time 0, while $q\prime$ are good quantities at time 1.

is the iceberg cost of sending one unit of good from country n to country i (where we assume $d_{in} \geq 1$, $d_{ii} = 1$, and the triangle inequality). Iceberg costs include transportation costs as well as all tariff and non-tariff barriers to trade. The price of a non-tradeable good j is simply $p_i^N(j) = w_i / z_i^N(j)$.

Using the Fréchet assumption, it is easy to obtain the following results:

$$p_i^N = \gamma_p \frac{w_i}{N_i^{1/\theta}} \tag{10}$$

$$p_i^T = \gamma_p \frac{w_i}{\left[T_i + \sum_{n \neq i} T_n \left(\frac{w_n}{w_i} d_{in} \right)^{-\theta} \right]^{1/\theta}} \tag{11}$$

where γ_p is a constant that depends only on σ and θ.[22] Therefore, the ratio p_i^T / p_i^N is

$$\frac{p_i^T}{p_i^N} = \left[\frac{N_i}{T_i + \sum_{n \neq i} T_n \left(\frac{w_n}{w_i} d_{in} \right)^{-\theta}} \right]^{1/\theta} \tag{12}$$

Not surprisingly, *in the open economy the ratio p_i^T / p_i^N is lower than in autarky.* Of course, p_i^T / p_i^N is increasing in N_i and d_{in}, and decreasing in T_i, T_n, and w_i / w_n. We can also compute the ratio between the price of tradeable goods in the open economy and the price of the same goods under autarky, which is given by

$$\left[\frac{T_i}{T_i + \sum_{n \neq i} T_n \left(\frac{w_n}{w_i} d_{in} \right)^{-\theta}} \right]^{1/\theta} < 1$$

Hence, *tradeable goods are cheaper in the open economy*, because some goods that under autarky were produced less efficiently are now imported.

Sector sizes. Expenditures on non-tradeable and tradeable goods are simply $p_i^N c_i^N = w_i L_i^N$ and $p_i^T c_i^T = w_i L_i^T$, where L_i^N and L_i^T are the sizes of the non-tradeable-goods and tradeable-goods sectors, and

$$L_i^T = \frac{\left(p_i^T\right)^{1-\eta}}{\left(p_i^N\right)^{1-\eta} + \left(p_i^T\right)^{1-\eta}} L_i \tag{13}$$

while $L_i^N = L_i - L_i^T$. Hence, the relative size of the non-tradeable-goods sector is

$$\frac{L_i^N}{L_i^T} = \left(\frac{p_i^T}{p_i^N} \right)^{\eta - 1} = \left[\frac{N_i}{T_i + \sum_{n \neq i} T_n \left(\frac{w_n}{w_i} d_{in} \right)^{-\theta}} \right]^{(\eta - 1)/\theta} \tag{14}$$

[22] It is $\gamma_p = \left[\Gamma \left(\frac{\theta - \sigma + 1}{\theta} \right) \right]^{1/(1-\sigma)}$ (i.e. γ_p is equal to the constant γ in Eaton and Kortum, 2002).

Recall that in the open economy p_i^T is lower than in the closed economy. Then, equation (14) suggests that *the relative size of the tradeable-goods sector after opening to trade depends on the exact value of the elasticity* η. If $\eta > 1$, then the share of workers in the tradeable-goods sector rises after opening to trade, even though some domestic industries shut down. On the contrary, if $\eta < 1$, then the share of workers in the tradeable-goods sector declines, as some domestic tradeable industries are forced out of the market.

Demand. Solving the consumer's problem, we obtain:

$$\begin{aligned} c_i^N &= \frac{(p_i)^{\eta-1}}{\left(p_i^N\right)^{\eta}} w_i L_i \text{ and } c_i^T = \frac{(p_i)^{\eta-1}}{\left(p_i^T\right)^{\eta}} w_i L_i \\ \text{where } p_i &= \left[\left(p_i^N\right)^{1-\eta} + \left(p_i^T\right)^{1-\eta}\right]^{1/(1-\eta)} . \end{aligned}$$

The main difference with respect to the autarky case is that, as discussed above, the price index p_i^T now includes the prices of both domestically-produced and imported goods. Relative consumption then is:

$$\frac{c_i^N}{c_i^T} = \left[\frac{N_i}{T_i + \sum_{n \neq i} T_n \left(\frac{w_n}{w_i} d_{in}\right)^{-\theta}}\right]^{\eta/\theta} ; \tag{15}$$

clearly, *thanks to the decline in* p_i^T/p_i^N, *country* i *consumes a larger share of tradeable goods after opening to trade.*

Expenditure on non-tradeable and tradeable goods is simply: $p_i^N c_i^N = w_i L_i^N$ and $p_i^T c_i^T = w_i L_i^T$.

Before turning to trade flows, it is worth to sum up the effects of opening to trade on the tradeable-goods sector. First, the production of some tradeable goods ceases (and these goods are imported). In particular, country i keeps producing the tradeable goods j such that $z_i^T(j)/w_i = \max_n z_n^T(j)/(w_n d_{in})$ holds (and imports the others). Second, the goods (non-tradeables and tradeables) whose production continues to take place at home and that are sold only domestically face a tougher competition (from foreign producers). Third, the goods whose production continues and that are sold both domestically and abroad meet a larger demand (less demand at home, but some additional demand from abroad). Fourth, *the relative size of the tradeable-goods sector depends on the elasticity* η*: this size increases (decreases) if* $\eta > 1$ *(*$\eta < 1$*).*

Trade. It is easy to compute the value of exports from country i to country n, using the fact that the tradeable good j made in country i is exported in n if and only if $w_i d_{ni}/z_i^T(j) < w_n/z_n^T(j)$. We only have to calculate the share of these goods:

$$\pi_{ni} = \frac{X_{ni}}{X_n} = \frac{T_i (w_i d_{ni})^{-\theta}}{\Phi_n} \tag{16}$$

$$\text{where:} \qquad \Phi_n = \sum_k T_k (w_k d_{nk})^{-\theta} \tag{17}$$

and where X_{ni} is the value of exports from country i to country n, and $X_n = c_n^T p_n^T$ is the total expenditure of country n on tradeable goods. For what concerns the effect of trade barriers, note that the export share of country i into country n only depends on the barrier from country i to country n, d_{ni}; the barrier from country n to country i, d_{in}, which contributes to determine prices (equation (12)) does not have a direct effect, but only an indirect effect through relative wages.

Average productivity. We can also compute the *productivity distribution of the surviving industries*. While in autarky this is described by $Z_i^T \sim Fréchet\,(T_i, \theta)$, because all tradeable goods are produced at home, in the open economy this is described by a new random variable, call it $Z_{i,o}^T$, such that $Z_{i,o}^T \sim Fréchet\,(\Lambda_i, \theta)$, where

$$\Lambda_i = T_i + \sum_{n \neq i} T_n \left(\frac{w_i}{w_n d_{in}} \right)^{\theta} \tag{18}$$

(see Finicelli, Pagano and Sbracia, 2011, for details). Thus, the average productivity of the tradeable-goods sector of the open economy, $E\left(Z_{i,o}^T\right)$, is larger than that of the closed economy. The "productivity gain" from trade is measured by

$$\frac{E\left(Z_{i,o}^T\right)}{E\left(Z_i^T\right)} = \left(1 + \sum_{n \neq i} \frac{T_n}{T_i} \left(\frac{w_i}{w_n d_{in}} \right)^{\theta} \right)^{1/\theta} . \tag{19}$$

Of course, the productivity distribution in the non-tradeable-goods sector remains the same, because the production of all non-tradeable goods is made domestically (in other words, $Z_{i,o}^N = Z_i^N$).[23]

Wages, welfare, and real output. The model is closed by determining relative wages. Income in country i, which is $w_i L_i$, must be equal to the expenditure for non-tradeable goods and the value of its exports of tradeable goods around the world, including at home (*trade balance*); that is: $w_i L_i = w_i L_i^N + \sum_n X_{ni}$. Hence, $w_i L_i^T = \sum_n \pi_{ni} X_n$ from which we obtain:[24]

$$w_i L_i^T = \sum_{n \neq i} \frac{\pi_{ni} w_n L_n^T}{1 - \pi_{ii}} . \tag{20}$$

Using equations (10)-(11), we can also compute real wages:

$$\frac{w_i}{p_i} = \gamma_p \left\{ N_i^{(\eta-1)/\theta} + \left[T_i + \sum_{n \neq i} T_n \left(\frac{w_i}{w_n d_{in}} \right)^{\theta} \right]^{(\eta-1)/\theta} \right\}^{1/(\eta-1)} \tag{21}$$

which are always higher than in autarky, irrespectively of the exact value of relative wages w_i/w_n or of the elasticity η.

[23] In the case of two countries, it is easy to compute also the *productivity distribution of the exporters*. This is described by a new random variable, that we can denote by $Z_{i,e}^T$, such that $Z_{i,e}^T \sim Fréchet\,(\Lambda_{i,e}, \theta)$, where $\Lambda_{i,e} = T_i + T_n \left(w_i d_{ni}/w_n\right)^{\theta}$. Clearly, $\Lambda_{i,e} > \Lambda_i$, which implies that exporters are more productive than the rest of the surviving tradeable industries, a result consistent with the "exceptional export performance" documented by Bernard and Jensen (1999).

[24] In the case of zero-gravity ($d_{ni} = d_{ii} = 1$), equation (20) simplifies further to $\frac{w_i}{w_n} = \left(\frac{T_i}{T_n} \frac{L_n^T}{L_i^T} \right)^{1/2}$.

In the special case of zero-gravity ($d_{in} = d_{in} = 1$), it is also easy to compute real GDP, which is:

$$Q_i = A_i^N L_i^N + A_i^T L_i^T = \gamma_q \left[N_i^{\eta/\theta} + \left(T_i + \sum_{n \neq i} T_n \frac{w_i}{w_n} \right)^{\eta/\theta} \right] L_i$$

For the general case, see Appendix B.2.

Equilibrium. To sum up, the full general equilibrium is given by the solution of equations (10) (11), (13), (16) and (20), which form a system of $m^2 + 4m$ non-linear equations in $m^2 + 4m$ unknowns (where m is the number of countries), which are: p_i^N, p_i^T, L_i^T, w_i and π_{ni}. The parameters of the model — which are σ, η, θ, T_i, N_i, L_i, d_{in} and d_{ni} — can all be estimated or calibrated. Because of non-linearities, there is no closed-form solution.[25] Nevertheless, it is possible to simulate the model and analyze some counterfactuals. For parameter changes such as those concerning trade barriers, however, the model is simple enough in that it allows to find analytic results, as we show below.[26]

3.1.3 Changes in trade barriers with flexible and sticky wages

For simplicity, let us focus on the model with two countries only (denoted with i and n). To simulate the effects of a depreciation of country i in a model that has no money, we consider an increase in the barriers to its imports from country n (which makes country i's imports more expensive) and a *symmetric* decrease in the barriers to its exports to country n (which makes country i's exports cheaper). More formally, we consider a rise of d_{in} to $d'_{in} = \delta d_{in}$ and a decline of d_{ni} to $d'_{ni} = d_{ni}/\delta$, with $\delta > 1$. These changes can be interpreted as a depreciation in the nominal exchange rate from $e = 1$ to $e = \delta > 1$ (where the exchange rate is expressed in terms of units of country i's currency for one unit of foreign currency). For given wages w_i and w_n, these changes in trade barriers reproduce exactly what happens right after a depreciation: if good j is imported, its price increases from $w_n d_{in}/z_n(j)$ to $w_n d_{in}\delta/z_n(j)$; if good j is exported, its price decreases from $w_i d_{ni}/z_i(j)$ to $w_i d_{ni}/\delta z_i(j)$; if good j is domestically produced and sold only at home, its price does not change (and remains equal to $w_i/z_i(j)$). Let us distinguish two polar cases: flexible vs. sticky wages.

On impact (that is before wages change), the increase in d_{in} makes imports from country n more expensive, favoring import substitution and boosting the demand for both domestic tradeable and non-tradeable goods. By the same token, the decline in d_{ni} makes country i's exports cheaper, raising foreign demand for domestic tradeable goods. Hence, after the depreciation all industries in the economy (tradeable and non-tradeable) require more workers, thanks to the rise in both domestic and foreign demand.

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[25] Results by Alvarez and Lucas (2007), however, grant that a solution of the model exists and is unique.

[26] Recall that the model assumes trade balance and ignores tariff revenues that trade barriers might generate. It is, however, possible to extend the model both to incorporate imbalances (see Dekle, Eaton, and Kortum, 2007) and to take revenue effects into account (see Eaton and Kortum, 2002). By the same token, the model can be generalized to include intermediate goods (Eaton and Kortum, 2002, and Alvarez and Lucas, 2007), physical capital (see, e.g., Shikher, 2010, and Waugh, 2010), or general distributions of industry productivities (Finicelli, Pagano and Sbracia, 2011).

Of course, with flexible wages and full employment, the rise in demand puts pressure on domestic wages. For the sake of simplicity, let us normalize wages in country n, setting $w_n = 1$. Under full employment, w_i increases to exactly $w_i' = \delta w_i$. Note that this rise in w_i restores all equilibrium quantities and relative prices to their pre-depreciation levels.[27] In other words, the result of the depreciation is just a change in all the nominal variables (wages and prices), so that all real variables (quantities and relative prices) return to the previous equilibrium levels.

Clearly, whether and when the pre-depreciation equilibrium quantities and relative prices are reestablished depends on the degree of flexibility of wages and prices. If, for instance, unlimited labor supply in a low-income country prevents wages from rising, then competitive gains remain.

To make this argument more formal, suppose that wages are sticky in country i and, in particular, suppose that they are set to a level w_i which is too high to deliver full employment. In other words, L_i is lower than the full employment level. Let us consider the effects of a depreciation in this framework.[28]

Hence, assume that d_{in} raises to $d_{in}' = \delta d_{in}$ and d_{ni} declines to $d_{ni}' = d_{in}/\delta$, with $\delta > 1$. As before, the rise in d_{in} makes imports from country n more expensive, favoring import substitution, and increasing the demand for domestic tradeable goods. By the same token, the rise in d_{ni} makes country i's exports cheaper, augmenting foreign demand for domestic tradeable goods. Thus, L_i^T increases (equation (20)), because both π_{ni} and π_{ii} increase. On the other hand, the increase in d_{in} raises the price of the bundle of tradeable goods p_i^T (because the goods that are still imported and the new domestically-produced tradeable goods are more expensive) and, therefore, demand for non-tradeable goods increases (equation (15)).

Thus, employment rises in both sectors, boosting real GDP. Note that the intuition according to which a depreciation makes the tradeable-goods sector more competitive and raises the size of this sector depends on the exact value of the elasticity of substitution between tradeable and non-tradeable goods. If $\eta > 1$, then the *absolute size* of the tradeable-goods sector rises due to the increase in employment (equation (20)), but the *relative size* of this sector (with respect to the non-tradeable-goods sector) declines (equation (14)). If $\eta < 1$, then both the absolute and the relative size of the tradeable-goods sector rise. Notice that the case $\eta < 1$ is the one which is empirically relevant. In particular, using cross-sectional data from the International Comparison Program, Stockman and Tesar (1995) have estimated an elasticity of substitution between tradeable and non-tradeable goods equal to 0.44. Following their study, dynamic stochastic general equilibrium models usually calibrate η at around 0.5.

[27] For w_n normalized to 1, a simple inspection of equations (10) (11), (13), (16) and (20) reveals that if w_i solves the model (together with the other endogenous variables) for given d_{in} and d_{ni} (and given all the other parameters), then, for any $\delta > 0$, all the equations also hold if $w_i' = \delta w_i$, $d_{in}' = \delta d_{in}$ and $d_{ni}' = d_{ni}/\delta$ replace, respectively, w_i, d_{in} and d_{ni}. Uniqueness of the equilibrium grants that $w_i' = \delta w_i$ is the domestic wage that solves the model with the new trade barriers d_{in}' and d_{ni}'.

[28] Broadly speaking, while so far we have considered L_i given (set at its full employment level) and w_i endogenous, now we consider the polar case in which w_i is given and L_i is endogenous.

3.2 Bertrand competition and increasing returns to scale

We now remove the assumptions of perfect competition and constant returns to scale and replace them with Bertrand competition and increasing returns to scale, following the model of Grossman and Rossi-Hansberg (2010; GRH hereafter). We consider two countries, that we keep on labeling with i and n. As in the previous section, there is a continuum of tradeable goods, denoted with $j \in [0, +\infty)$. For the sake of simplicity, we now focus on tradeable goods only: in fact, we already know from the previous section that the direction in which workers flow in and out the tradeable-goods and non-tradeable-goods sectors depends solely on the change in the relative price of tradeables as well as on the exact value of the elasticity η; that is: $L_i^T / L_i^N = \left(p_i^T / p_i^N\right)^{1-\eta}$.

Hereafter, we follow GRH closely, making only one main departure. GRH consider trade barriers that are industry specific and symmetric between countries. Here, instead, we consider trade barriers that, as in the previous section, are identical across industries but not necessarily symmetric across countries.[29] An extension to trade barriers that are not symmetric between countries nor identical across sectors, however, would be straightforward using GRH and this paper.

3.2.1 Autarky and free trade equilibria

We retain the same notation as in the previous sections and replace constant returns to scale with increasing returns to scale by assuming

$$q_i^T(j) = z_i^T(j) \cdot A_j\left[q_i^T(j)\right] \cdot L_i^T(j) \ ,$$

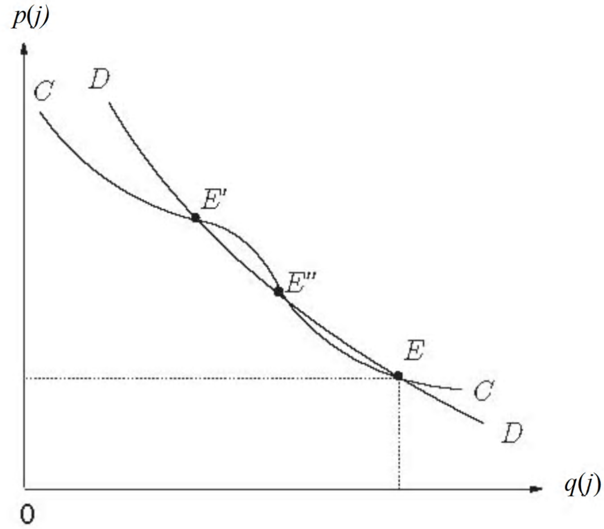
where A_j is a function with $A_j' > 0$, $A_j'' < 0$, and elasticity smaller than 1. For example, the function $\bar{A}_j\left[q_i^T(j)\right] = \left[q_i^T(j)\right]^{(\alpha-1)/\alpha}$, where $\alpha > 1$, used in Ethier (1982), fulfills these properties.

In models with perfect competition and external economies of scale, such as Ethier (1982), industries are composed of small firms that act as price takers and treat industry-scale productivities as given. Firms correctly recognize their own productivity when they make decisions about price and quantities, but do not perceive the possibility of affecting industry output and prices. By assuming Bertrand competition, instead, in this model firms are no longer price takers and perceive that, by raising output and producing at a larger scale, they can abate average costs and shave prices.

In each country i, it is assumed that there are at least two identical potential producers of good j. This assumption, coupled with Bertrand competition, is pivotal in returning a unique equilibrium in a framework with increasing returns to scale. The presence of many firms with the same productivity implies zero profits and, under autarky, that firms charge a price equal to their average cost. In addition, if there are multiple intersections between the demand and the cost curve (as it may happen with increasing returns to scale) and, then, potentially multiple equilibria with different prices and quantities, the fact that each firm recognizes that it raises its

[29] In other words, GRH consider trade barriers from country i to country n for good j, $d_{ni}(j)$, with following properties: $d_{ni}(j) = d_{in}(j)\ \forall (i,n)$ and $\forall j$, and $d_{ni}(j) \lesseqgtr d_{ni}(j')\ \forall (i,n)$ and $\forall j \neq j'$. Here, we consider trade barriers $d_{ni}(j)$ such that $d_{ni}(j) = d_{ni}(j') = d_{ni}\ \forall (i,n)$ and $\forall j \neq j'$, and $d_{ni} \lesseqgtr d_{in}\ \forall (i,n)$.

Figure 2: Multiple intersections of demand and cost curves



market share by shaving the price is sufficient to select a unique equilibrium. The equilibrium is at the intersection between the demand and the cost curve characterized by the lowest price and the highest production.

This result is illustrated by GRH by means of a simple example. Suppose that the demand (DD) and cost (CC) curves have multiple intersections, as in Figure 2 (which corresponds to Figure II in GRH). Neither E' nor E'' represents an equilibrium, because if firms charge a price associated with these points, then a deviant firm can announce a lower price for good j, get the whole market, and make positive profits. Hence, the equilibrium in each industry j is at the lowest intersection of the demand and cost curve, so long as the former cuts the latter from above. In this equilibrium, an arbitrary number of firms make sales and earn zero profits. Note that further shaving the price from the point E in Figure 2 is not feasible, because the deviant firm would not be able to cover its costs. On the other hand, if the demand curve cuts the cost curve from below, then the price of good j would tend to zero and its production to infinity. Imposing that the demand curve cuts the cost curve from above, then, grant existence and uniqueness of an industry equilibrium with finite production.

With CES preferences, the demand of the tradeable good j is

$$c_i^T(j) = \left(\frac{p_i^T}{p_i^T(j)}\right)^{\sigma} \frac{w_i L_i^T}{p_i^T} , \tag{22}$$

where $p_i^T(j)$, p_i^T, w_i, and L_i^T are defined in the previous section. The cost curve for the firm producing a quantity $q_i^T(j)$ of good j is

$$p_i^T(j) = \frac{w_i L_i^T(j)}{q_i^T(j)} ,$$

where $L_i^T(j)$ is defined above. A sufficient condition for the existence of an industry equilibrium with finite production is $\sigma \cdot \lambda_A\left[q_i^T(j)\right] < 1$ for any $q_i^T(j)$, where $\lambda_A\left[q_i^T(j)\right] = A_j'\left[q_i^T(j)\right] \cdot$

$q_i^T(j)/A_j\left[q_i^T(j)\right]$.[30] This condition is always fulfilled, for instance, if $\sigma > 1$ (as we assume in this paper) and $A_j = \bar{A}_j$ (as in Ethier, 1982).

The autarky and the free trade equilibria can be easily determined. In the former, equilibrium quantities are $c_i^T(j) = q_i^T(j)$, with $c_i^T(j)$ from equation (22), while relative prices are:

$$p_i^T(j) = \frac{w_i}{z_i^T(j)\,A_j\left[q_i^T(j)\right]}\ , \tag{23}$$

where wages w_i could be normalized to one. Equations (22) and (23) jointly determine equilibrium quantities and relative prices.[31] In general, this competitive equilibrium is not Pareto efficient, due to the presence of production externalities. Pareto efficiency is established, however, in the special case in which all industries bear a constant and common degree of scale economies (such as if $A_j = \bar{A}_j\ \forall j$; see GRH for details).

With free trade ($d_{ni} = d_{in} = 1$), demand is still given by equation (22), while the equilibrium price of good j in countries i and n (recall that the law of one price holds, absent trade barriers) is

$$p_i^T(j) = p_n^T(j) = \min\left\{\frac{w_i}{z_i^T(j)\,A_j\left[\tilde{q}^T(j)\right]}, \frac{w_n}{z_n^T(j)\,A_j\left[\tilde{q}^T(j)\right]}\right\}\ , \tag{24}$$

where $\tilde{q}^T(j) = c_i^T(j) + c_n^T(j)$, while $c_i^T(j)$ and $c_n^T(j)$ are the same as in equation (22). A remarkable result of GRH, then, is that, with free trade, the patter of specialization conforms to the pattern of comparative advantages: good j is produced in the country that makes it at the lowest cost, once that costs are evaluated at the common scale $\tilde{q}^T(j)$. In addition, there are no multiple equilibria: the possibility of multiple locations for a given industry disappears when firms recognize that their own average cost declines as the scale of production rises.

3.2.2 Non-negligible trade barriers

We now turn to the empirically relevant case of non-negligible trade barriers. Solving for the equilibrium becomes substantially harder with respect to both the model with increasing returns to scale and no trade barriers and the model with constant returns to scale and trade barriers. Relative to the former, we have to account for the fact that domestic firms enjoy a cost advantage relative to foreign firms as they can serve the domestic market without incurring trade barriers. With respect to the latter, here a firm servicing only the domestic market faces a disadvantage relative to firms that sell goods in both markets, because produces at a smaller scale. Like GRH, we focus on the somewhat simpler case of *segmented markets*, that is the case in which firms can announce different prices in different geographic locations.[32]

Let us focus on country i. In the equilibrium, some domestic industries export their goods, others serve only the domestic market, while other goods are imported. Let us analyze these three cases, starting from exports.

[30] Formally, this is the same as the condition of "Marshallian stability" (that is of stability with respect to perturbations of equilibrium quantities) invoked by Ethier (1982).

[31] Although one can always set one price, usually nominal wages, as the numeraire ($w_i = 1$), we prefer to keep w_i (as both EK and GRH), because it improves the clarity of the arguments.

[32] In the polar case of integrated markets, price differences across different geographic locations cannot exceed the value of trade barriers. Results for this case are qualitatively similar to those for segmented markets.

Suppose for a moment that firms ignore the possibility of targeting a single market, and only contemplate selling in both markets. No deviant firm in n can capture both markets if:

$$\left[\frac{w_i}{z_i^T(j)\,A_j\left[\tilde{q}^T(j)\right]}-\frac{w_n d_{in}}{z_n^T(j)\,A_j\left[\tilde{q}^T(j)\right]}\right]c_i^T(j) \\ +\left[\frac{w_i d_{ni}}{z_i^T(j)\,A_j\left[\tilde{q}^T(j)\right]}-\frac{w_n}{z_n^T(j)\,A_j\left[\tilde{q}^T(j)\right]}\right]c_n^T(j)\leq 0\;. \tag{25}$$

The first (second) addendum in (25) is the revenue that a firm of country n obtains by shaving slightly the price of good j in country i (country n).[33] This inequality grants that a firm located in n does not profit from selling in both countries i and n. Simple as it is, inequality (25) marks a very sharp difference with respect to the model with constant returns to scale. In particular, firms in country n may have an incentive to export good j in country i even if they make negative profits in that country (first addendum is negative), provided that they make large enough positive profits at home. In this case, country n sells good j in country i in order to produce at larger scale scale, cut its average cost, and make large enough profits at home. This possibility is precluded in models with constant returns to scale, because there is no cost advantage from producing at a higher scale.[34] Inequality (25) also suggests that country i can protect its domestic industries and encourage exports by lifting d_{in} and lowering d_{ni} — which is precisely what happens with a currency depreciation.[35]

Even if (25) is satisfied, good j is not necessarily exported by country i. A deviant firm located in country n could still undermine country i's exports by targeting its own market only. This deviation is unprofitable if and only if:

$$\left[\frac{w_i d_{ni}}{z_i^T(j)\,A_j\left[\tilde{q}^T(j)\right]}-\frac{w_n}{z_n^T(j)\,A_j\left[q_n^T(j)\right]}\right]c_n^T(j)\leq 0\;. \tag{26}$$

Thus, good j is produced by country i and sold both at home and abroad if and only if inequalities (25) and (26) are satisfied. Note that, of these two conditions, we do not know which one is more restrictive. If trade barriers vanish ($d_{in}, d_{ni}\to 1$), then it is condition (26) that is more restrictive (and this inequality collapses to condition (24)). For non-negligible trade barriers, instead, it may be condition (25) that determines whether country i exports good j. This is going to have a crucial importance when we analyze the effects of a currency depreciation.

Let us now turn to non-exported goods. Good j is produced by i and sold only at home if and only if the following three conditions are satisfied: (i) inequality (25) holds (i.e. country

[33] Recall that country i's average costs of making good j are $w_i/z_i^T(j)\,A_j\left[\tilde{q}^T(j)\right]$ at home, and $w_i d_{ni}/z_i^T(j)\,A_j\left[\tilde{q}^T(j)\right]$ in country n; country n's average costs are, respectively, $w_n d_{in}/z_n^T(j)\,A_j\left[\tilde{q}^T(j)\right]$ in country i, and $w_n/z_n^T(j)\,A_j\left[\tilde{q}^T(j)\right]$ at home.

[34] Recall that Bertrand competition in the presence of many identical firms implies zero profits, as in the model with perfect competition and constant returns to scale. Roughly speaking, however, with economies of scale there are two ways of making zero profits. As with constant returns to scale, one way is to set prices equal to average costs in all markets. Another way is to set prices lower than average costs in some markets, and higher than average costs in some other markets.

[35] This possibility is more than just a theoretical speculation. In the early post-World War II period, one of Italy's most important manufacturing companies, FIAT, sold cars at a loss in foreign markets. The aggressive export strategy adopted by Vittorio Valletta, FIAT general manager at that time, was feasible because profits could be made in the domestic market, also thanks to the high tariff barriers imposed to foreign producers (see Eichengreen, 2007, pp. 112-116, and Fauri, 1996).

n does not have an incentive to sell in both i and n); (ii) inequality (26) does not hold (i.e. country n has an incentive to serve its own market); and (iii):

$$\left[\frac{w_i}{z_i^T(j)\,A_j\left[q_i^T(j)\right]} - \frac{w_i}{z_i^T(j)\,A_j\left[\tilde{q}^T(j)\right]}\right] c_i^T(j) + \left[\frac{w_n}{z_n^T(j)\,A_j\left[q_n^T(j)\right]} - \frac{w_i d_{ni}}{z_i^T(j)\,A_j\left[\tilde{q}^T(j)\right]}\right] c_n^T(j) \leq 0\ ; \tag{27}$$

when inequality (27) is satisfied, firms in country i do not have an incentive to deviate and capture both markets.

Inequality (27) can be violated even while the first two conditions are satisfied. In this case, there is no equilibrium in pure pricing strategies, but there is at least one *symmetric* equilibrium in mixed strategies.[36] In this equilibrium, a firm in country n sells good j at the unit cost $w_n/z_n^T(j)\,A_j\left[q_n^T(j)\right]$ in the domestic market, while firms in country i randomize among two pricing strategies: one yields only local sales, the other yields sales in both markets (for a characterization of these mixed strategies, see GRH).[37]

There are still two possibilities left. One is that country i produces and sells domestically good j, while firms in country n adopt a mixed pricing strategy (that is the reciprocal of the previous case). The other is that good j is imported by country i (that is the reciprocal of the first case). In particular, country i imports good j if and only if: (i) inequality (25) does not hold (i.e. firms in country n have incentives to sell in both i and n); and (ii)

$$\left[\frac{w_n d_{in}}{z_n^T(j)\,A_j\left[\tilde{q}^T(j)\right]} - \frac{w_i}{z_i^T(j)\,A_j\left[q_i^T(j)\right]}\right] c_i^T(j) \leq 0\ , \tag{28}$$

i.e. no firm in country i has incentive to deviate using a pricing strategy that targets the domestic market. Clearly, imports will be lower, the higher the import barrier d_{in} (because firms in n have less incentives to sell in i and firms in i have more incentives to target at least their domestic market).[38]

Figure 3 shows the possible allocation of the production of one good j for different values of $z_i(j)/z_n(j)$ in both the cases on non-negligible trade barriers and free trade. With trade barriers, country i exports good j with a pure pricing strategy, provided that its relative productivity is sufficiently high; produces and sells at home and abroad good j using a mixed pricing strategy for somewhat lower levels of relative productivities; produces and sells good j only domestically for still lower levels of relative productivities, while country n produces the same good and either sells it both at home and abroad with a mixed strategy, or sells it only at home; imports good j for the lowest levels of $z_i(j)/z_n(j)$ (Figure 3, upper panel). Not all

[36] The presence of mixed pricing strategies is not surprising given the fact that firms are no longer price takers. For an early exploration of mixed pricing strategies in international trade with Bertrand competition (and integrated markets), see Venables (1994).

[37] Symmetric equilibria can be more than one. These multiple equilibria, however, share the same qualitative features, even though they differ in their mixing probabilities. In particular, in all these equilibria good j is either produced and exported by country i, or it is not traded.

[38] Appendix C rearranges the conditions under which the production of good j occurs in country i, in country n, or in both countries (with either pure or mixed pricing strategies).

Figure 3: Allocation of production for one industry, relative productivities, and trade barriers

these possibilities necessarily coexist. The simultaneous presence of the five zones in the upper panel of Figure 3, in fact, depends on industry specific factors (such as the degree of increasing returns to scale) as well as trade barriers. For some goods, for instance, mixed strategies and strategies targeting only the domestic market may not be feasible. In particular, when trade barriers decline, the three central zones in the upper panel of Figure 3 shrink, up to the point in which, under free trade, only complete specialization is feasible: each good j is either imported, or it is domestically produced and sold both at home and abroad (Figure 3, lower panel).

3.2.3 Changes in trade barriers

What happens if the import barrier d_{in} raises to $d'_{in} = \delta d_{in}$ and the export barrier d_{ni} symmetrically declines to $d'_{ni} = d_{in}/\delta$ (with $\delta > 1$)? On impact (that is, before wages start rising), more goods are exported and less goods are imported. In fact, for what concerns exports, both inequalities (25) and (26) are fulfilled also for smaller values of $z_i(j)/z_n(j)$ (i.e. for relatively less productive firms of country i). Similarly, for what concerns imports, the reciprocal of (25) and inequality (13) are not fulfilled only for smaller values of $z_i(j)/z_n(j)$ (i.e. now only less-efficiently produced goods are imported). In general, in industries in which all the five zones in the upper panel of Figure 3 coexist, all the four zone-borders move leftwards.

How do wages respond to the change in trade barriers? Similarly to what happens in the model with constant returns to scale, wages tend to rise. With increasing returns to scale, however, there are some major differences. The most important is that an increase in relative wages to $w'_i/w'_n = \delta w_i/w_n$ does not restore the previous equilibrium (the one before the change in trade barriers). It is easy to check that inequality (25) keeps holding for smaller values of $z_i(j)/z_n(j)$ also after such a change in relative wages. In other words, more goods will be exported also after a rise in relative wages by δ%. By the same token, the same inequality will continue to be violated only for smaller values of $z_i(j)/z_n(j)$, so that less goods will be imported.

The intuition for this result is the following. With increasing returns to scale, a depreciation by $(\delta - 1)$ % cuts firms' average costs by more than $(\delta - 1)$ %, thanks to the additional cost gains that come from the economies of scale. This is important, in particular, for the firms (at home and abroad) that target both the domestic and the foreign market, whose success in this strategy depends on whether inequality (25) is satisfied. In particular, less foreign firms find it convenient to target both markets, favoring import substitution (if foreign firms keep serving at least their own market) and exports (if they shut down). On the other hand, more domestic firms of country i have an incentive to start serving both the home and the foreign market, further boosting exports.

Relative wages, however, could rise above $\delta w_i/w_n$. While this is a possibility, it is easy to show that there is no rise in relative wages that can restore the previous equilibrium. Again, the intuition is quite simple. Because the degree of increasing returns to scale are different across industries ($A_j \lesseqgtr A_{j'}$ if $j \neq j'$), the decline in average costs after the depreciation connected to rise in output is also different across industries. However, even though increasing returns to scale were the same across industries, industries are nevertheless heterogeneous in productivities. Starting from different productivity levels, the decline in average costs would then be different across industries. Hence, the pre-depreciation equilibrium quantities and relative prices cannot be restored across all industries (for a formal argument, see Appendix C). After the depreciation, the economy converges to a new equilibrium with higher (relative) wages, but with some firms that can now access the foreign markets, and some goods that are no longer imported and are domestically produced.

How does the size of the tradeable sector change? Recall that, under the standard assumption that $\eta < 1$, workers flow to the sector in which the rise in prices is larger. Of course, productivities do not change in the non-tradeable sector and the prices of the tradeable goods that were already domestically produced also do not change. On the other hand, the price of the tradeable goods that the country keeps importing is now higher (due to the rise in import tariffs), while the price of the newly locally produced tradeable goods is also higher (with respect to when they were imported by more efficient foreign firms). Hence, the relative price of tradeable goods p_i^T/p_i^N rises, attracting workers from the non-tradeable sector.

The effect on output is also straightforward, given that more workers flow to the high productivity tradeable sector (if productivity in the latter is high enough, this effect occurs even though some workers flow to the least productive firms of the tradeable sector). On the other hand, the effect on welfare is uncertain (because barriers to imports rise, while barriers to exports decline) and need to be analyzed by counterfactual simulations — an issue that we leave for future research.

Part II

Italy 1861-2011

4 Undervaluation of the lira/euro and Italy's exports

In this section we ask whether undervaluation has helped to boost Italy's exports. We consider, in turn, their rate of growth, their nominal and real value, and their extensive margin (the number of distinct goods sold abroad).

Our data span the following periods: 1862-1939 (from Bank of Italy and Federico, Tattara and Vasta, 2011); 1940-1950 (Bank of Italy); 1962-1999 (NBER); and 2000-2009 (U.N. Comtrade).[39] Commodities are classified by 4-digit SITC category (about 750 distinct categories). Data for 1862-1950 include only Italy's 10 major partner countries.[40] For 1962-2009 we consider the 61 partner countries included in Bank of Italy's competitiveness indicators (see Finicelli, Liccardi and Sbracia, 2005). This sample encompasses all the countries that are important either at a global level and for Italy's trade.

We include information on nominal GDP (expressed in US dollars) and our three main measures of undervaluation ($u_{n,t}^{PWT}$, $u_{n,t}^{CPI}$ and $u_{n,t}^{WPI}$). The sources for nominal GDP in US dollars are the IMF for the post-World War II period and Bordo, Eichengreen, Klingebiel and Martinez-Peria (2001), complemented with national sources, for the pre-World War II period.[41]

4.1 Export growth

The main variable of interest is the US dollar value of Italy's exports of good j to country n at time t. Since the data set is made of bilateral exports, we also express undervaluation as a bilateral variable. Specifically, we calculate Italy' undervaluation to the currency of country n in year t as $u_{IT,t}^{m} - u_{n,t}^{m}$, where $u_{i,t}^{m}$ is the undervaluation of country i's currency at time t according to the measure m (where $m = PWT$, CPI or WPI, as in Section 2).

The channel through which undervaluation affects growth — as described in Section 3 — is by reallocating resources to the tradeable sector and boosting exports through enhanced price competitiveness. To verify whether this channel was at work for Italy since unification, we reestimate a version of equation (2) in which we replace GDP growth with export growth as dependent variable:

$$g_{n,t,j}^{EXP} = \alpha_{n,j} + \beta x_{n,t-1} + \delta \left(u_{IT,t}^{m} - u_{n,t}^{m}\right) + d_t + \varepsilon_{n,t} \quad (29)$$

[39] For the earlier periods (1862-1939), we cross-checked the consistency of the aggregate data with those reported in other sources, such as Stringher (1911) and Ercolani (1981).

[40] These countries are: Argentina, Austria, Belgium, France, Germany, Netherlands, Russia, Switzerland, United Kingdom and United States. For Russia, however, data on exchange rates and consumer or wholesale prices only start in 1990, so this country is actually excluded from the pre-World War II subsample.

[41] We have also gathered a set of unilateral controls (population, geographic dimension and continent) and bilateral controls (geographic distance, colonial ties and common language). Nonetheless, these controls have not been used in the empirical analysis, since the three dimensions of the data set (destination market, year and commodity), as well as the large sample size (around one million of observations), allowed to include all-encompassing time and country-pair dummies.

Table 6: Export growth and undervaluation (1)

	(A)			(B)			(C)		
	$u^{PWT\ (2)}$	u^{CPI}	u^{WPI}	$u^{PWT\ (2)}$	u^{CPI}	u^{WPI}	$u^{PWT\ (2)}$	u^{CPI}	u^{WPI}
x_{t-1}	-0.85	-0.81	-0.84	-0.8	-0.75	-0.78	-1.15	-1.06	-1.07
	[109.23]***	[101.95]***	[93.70]***	[102.55]***	[97.37]***	[90.31]***	[106.31]***	[95.67]***	[88.44]***
Undervaluation	-0.34	-0.07	-0.11	-0.28	-0.08	-0.13	-0.17	-0.01	-0.06
	[15.91]***	[6.30]***	[5.08]***	[14.62]***	[8.72]***	[7.75]***	[5.95]***	[0.84]	[3.46]***
Constant	7.5	7.62	7.89	-2.19	-1.73	-1.72	0.41	0.17	0.48
	[27.26]***	[42.96]***	[43.81]***	[8.43]***	[11.88]***	[11.84]***	[29.56]***	[7.00]***	[24.30]***
Country-good fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	192780	196877	167298	192780	196877	167298	106083	110533	93144
Number of id	44276	43376	39459	44276	43376	39459	29192	28303	25922
R-squared	0.28	0.29	0.26	0.14	0.12	0.12			

(1) Robust t statistics in brackets; * significant at 10%, ** at 5%, *** at 1%. (2) Sample period: 1962-2007. (A) Estimates of equation (29) using OLS. (B) Estimates of equation (30) using OLS. (C) Estimates of a dynamic panel version of equation (30) using GMM as in Arellano and Bond (1991).

where $g^{EXP}_{n,t,j}$ is the growth rate of Italy's exports of good j to country n at time t; $x_{n,t-1}$ (the log of nominal GDP in US dollars) controls for the initial conditions; d_t controls for time-specific unobserved effects; $\alpha_{n,j}$ are country-good fixed effects; $\varepsilon_{n,t}$ is the residual; and $\beta, \delta \in \mathbb{R}$. To preserve some consistency with the estimates of equation (2), in this preliminary analysis our series are five-year averages , in which case, t represents non-overlapping five-year periods.[42]

Due to the presence of time dummies, $u^m_{IT,t} - u^m_{n,t}$ simplifies to $u^m_{n,t}$. If undervaluation of the lira/euro raises Italy's export growth, we expect δ to be negative (we expect that overvaluation of a destination market's currency raises Italy's exports to the country in question). Note also that, since undervaluation acts on growth by reallocating resources to the export sector, we expect it to have a larger impact on exports than on GDP.

Panel A of Table 6 shows the estimates. The coefficients for undervaluation are strongly significant with the predicted negative sign across all measures $u^m_{n,t}$. The elasticities are also noticeably larger than in the growth regression of Section 2, as anticipated.[43]

A limitation of this specification is that it does not consider industry-specific and time-varying trade barriers. Nor do we control for other sector-specific and time-varying effects such as potentially heterogeneous world industry growth).[44] We therefore consider an alternative

[42] When we plug $u^{CPI}_{n,t}$ and $u^{WPI}_{n,t}$ into our regressions, we include, as in Section 2, two additional set of country fixed effects (for the pre-World War II and the interwar period) in the specification. These fixed effects are intended to account for the fact that CPIs and WPIs are price indices with three different base years (1900, 1929 and 2000). In other words, they are meant to capture the different effect of undervaluation on the dependent variable in the base year.

[43] The two elasticities, however, are not completely comparable because, in equation (2), GDP growth is referred to a panel of countries, while in equation (29), export growth is referred only to Italy.

[44] Given that we have a long time span (in which trade barriers and industry growth have been rather heterogeneous), this problem is likely to affect our estimates. For example, heterogeneous sectoral growth may affect GDP growth in countries with different specialization. In this case, we would be omitting a variable correlated with other independent variables, biasing the estimates of all the coefficients.

specification in which each variable (including the dependent variable) has been demeaned by netting for the average across countries:

$$g_{n,t,j}^{EXP} - \bar{g}_{.,t,j}^{EXP} = (\alpha_{n,j} - \bar{\alpha}_{.,j}) + \beta\,(x_{n,t-1} - \bar{x}_{.,t-1}) + \delta(u_{n,t}^{m} - \bar{u}_{.,t}^{m}) + (\varepsilon_{n,t,j} - \bar{\varepsilon}_{.,t,j})\ .$$

Adding time dummies and accounting for the fact that country-sector fixed effects encompass sector effects, this specification simplifies to:

$$\tilde{g}_{n,t,j}^{EXP} = \alpha_{n,j} + \beta x_{n,t-1} + \delta u_{n,t}^{m} + d_t + \eta_{n,t,j}\ . \tag{30}$$

where $\tilde{g}_{n,t,j}^{EXP} = g_{n,t,j}^{EXP} - \bar{g}_{n,t,j}^{EXP}$ and $\eta_{n,t,j}$ is the residual.[45] By estimating the effect of $u_{n,t}^{m}$ in equation (30), we test whether the growth of Italy's exports of good j to country n at time t are higher with respect to Italy's average export growth of the same good in the same year because the undervaluation of the lira/euro with respect to country n's currency was larger (after controlling for other determinants of $g_{n,t,j}^{EXP}$). Panel B of Table 6 reports the results of the estimates of equation (30), which confirm the previous results: the sign and statistical significance of the coefficients for undervaluation is consistent across measures.

In panel C, we control for the possible endogeneity of undervaluation by estimating a dynamic panel model with the GMM method of Arellano and Bond (1991). The main result that undervaluation raises significantly export growth is supported for two out of three measures.

4.2 Value of exports

The previous results confirm the importance of undervaluation for Italy's export growth. However, in a more traditional analysis, we can use annual data to estimate gravity-like specifications, augmented to include the undervaluation of the lira/euro. This allows us to test whether undervaluation affects the level of Italy's exports. We estimate variants of the equation:

$$y_{n,t,j} = a + bx_{n,t} + c\left(u_{IT,t}^{m} - u_{n,t}^{m}\right) + Z_{n,j} + Z_t + \varepsilon_{n,t,j}\ , \tag{31}$$

where $y_{n,t,j}$ denotes the log of the value of Italy's exports of good j to country n at time t; $x_{n,t}$ is the log of country n's GDP at time t; $u_{IT,t}^{m}$ is the undervaluation of the lira/euro (computed as in Section 2, but using annual data instead of five-year averages); $u_{n,t}^{m}$ is the undervaluation for country n; $Z_{n,j}$ and Z_t are sets of controls that are, respectively, constant across time (such as the geographic distance between Italy and country n) and constant across country-good pairs (such as Italy's GDP); and $a, b, c \in \mathbb{R}$.

When we include fixed effects (country-goods pairs) and time dummies, and demean the variables, the gravity equation (31) boils down to:

$$\tilde{y}_{n,t,j} = a_{n,j} + \beta x_{n,t} + \gamma u_{n,t}^{m} + d_t + v_{n,t,j} \tag{32}$$

[45] Note that this transformation of the data may generate heteroskedasticity in the error term. However, due to the large number of countries, this is likely to be a second-order issue (recall also that heteroskedasticity does not bias the estimates and only affects standard errors). In some robustness tests, we have addressed this issue by performing estimates in which we cluster the error term. We have also estimated a random effect model using GLS. Results from these models confirm the main findings. The main coefficients preserve their sign and statistical significance.

where $\tilde{y}_{n,t,j} = y_{n,t,j} - \bar{y}_{\cdot,t,j}$; $\alpha_{n,j}$ and d_t still denote, respectively, country-good fixed effects and time dummies; $v_{n,t,j}$ is the residual; and $\beta,\gamma \in \mathbb{R}$.[46] This simplification is due to the fact that the effect of any $Z_{n,j}$ is captured by the fixed effects and, similarly, the set of time dummies controls for the impact of any Z_t (such as Italy's GDP). Note that, among the variables that d_t controls for, there is also the US CPI; hence, we can interpret regression (32) as explaining the nominal value or the real value of exports (i.e. the nominal value of exports in US dollars divided by the US CPI, see, for example, Eichengreen, Perkins and Shin, 2011). As for equations (29) and (30), the level of Italy's undervaluation ($u_{IT,t}$) is also captured by the time dummies. If undervaluation is successful in boosting exports, we expect γ to be negative. By estimating equation (32), we attempt to verify whether Italy's exports of good j to country n at time t are different with respect to the cross-country average of Italy's exports of the same good during the same year, because the undervaluation of the lira/euro with respect to country n's currency was larger (after controlling for other possible determinants of this flow, such as the "mass" of country n, its distance from Italy, etc.).

Table 7 reports the estimated coefficients for the two main measures of undervaluation $u_{n,t}^{PWT}$ and $u_{n,t}^{CPI}$.[47] Results show that undervaluation is significant and with its predicted negative sign (recall that $u_{n,t}$ is the undervaluation of partner n's currency, i.e. it represents the relative overvaluation of Italy's currency). Elasticities of exports to undervaluation are very high (in the order of 20%) when the latter is measured by $u_{n,t}^{WPI}$; in this case a 30% undervaluation of Italy's currency (such as the one observed in the1950s) boosts its exports by about 6% per year.

Panel B of Table 7 estimates a specification that allows for a differential effect of undervaluation on the exports of primary goods (those in the SITC categories 1-4),[48] by including the interaction of $u_{n,t}$ with a dummy variable for primary products.[49] The coefficient of the interaction term is positive and significant, meaning that the effect of undervaluation is diversified across primary and industrial goods. The elasticity of primary-goods exports to undervaluation, which is measured by the sum between the coefficient of $u_{n,t}$ and that of the interaction term, remains negative. The size of the elasticity for industrial goods (given by the coefficient of $u_{n,t}$) is about 10 percentage points higher than for primary goods. Evidently, *undervaluation provides some support to the exports of primary products, but it is especially helpful to the exports of industrial goods.*[50]

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[46] The Hausman test strongly rejects the null that unobserved country-sector factors can be considered random and selects the fixed-effects model.

[47] The third measure, $u_{n,t}^{WPI}$, provides insignificant estimates. Note that because the Penn World Table is available for the period 1950-2009 and, for that period, trade data are available only from 1962, when we use $u_{n,t}^{PWT}$ the sample years are only from 1962 to 2009.

[48] Primary sectors are: Food and live animals; Beverages and tobacco; Crude materials, inedible, except fuels; Mineral fuels, lubricants and related materials; Animal and vegetable oils, fats and waxes. Non-primary sectors are: Chemicals and related products; Manufactured goods classified by material; Machinery and transport equipment; Miscellaneous manufactured articles; Commodities and transactions N.E.C..

[49] More precisely, the interaction term that we add is $\delta d_{prim}\left(u_{n,t}^{PWT} - \bar{u}_{\cdot,t}^{PWT}\right)$, where d_{prim} is the dummy for the primary goods. In fact, the specification (32) comes from the gravity equation (31), after demeaning all the variables and including country-good fixed effects and time dummies (and $d_{prim} \cdot u_{\cdot,t}^{PWT}$, unlike other variables, would not simplify away).

[50] Similarly, Colacelli (2010) finds that the elasticity of exports to the real exchange rate is significantly larger for

Table 7: Export value and undervaluation (1)

	(A) $u^{PWT\ (2)}$	(A) u^{CPI}	(B) $u^{PWT\ (2)}$
x_t	0.67	0.79	0.65
	[80.33]***	[87.38]***	[77.98]***
Undervaluation	-0.21	-0.01	-0.24
	[14.54]***	[1.68]*	[14.96]***
Undervaluation* Primary products indicator			0.14
			[3.74]***
Constant	-1.05	-0.05	-1.38
	[2.34]**	[0.00]	[2.41]**
Country-good fixed effects	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes
Observations	919628	934599	919628
Number of id	48420	46686	48420
R-squared	0.12	0.18	0.12

(1) Robust t statistics in brackets; * significant at 10%, ** at 5%, *** at 1%. (2) Sample period: 1962-2009. (A) OLS estimates of equation (32). (B) OLS estimates of equation (32), including an interaction term.

A finer disaggregation of differential effects can be obtained by estimating a separate coefficient for each of the 10 sectors classified under SITC at the 1-digit level. The estimated specification becomes:

$$\tilde{y}_{n,t,j} = \alpha_{n,j} + \beta x_{n,t} + \gamma_s u^m_{n,t} + d_t + v_{n,t,j} \ , \tag{33}$$

where γ_s $(s = 1, ..., 10)$ depends on the SITC 1-digit level classification of good j. Results, shown in Table 8, confirm that the effect of undervaluation is quite different across sectors: Italy's exports in all industrial sectors except chemicals are positively affected by undervaluation of the lira/euro. On the other hand, Italy's exports in some primary sectors tend to be negatively affected or unaffected.

Overall, these results confirm that undervaluation of the lira/euro has a positive effects on Italy's export growth. In particular, the contribution is significantly stronger for non-primary sectors, in which productivity is generally supposed to be higher.

4.3 Extensive margin

To analyze whether undervaluation has increased the number of varieties exported, we construct a measure of extensive margin following Hummels and Klenow (2005) and Bergin and Lin (2008). This is a weighted sum of the number of goods exported with weights given by the value of exports of each good over world exports across all goods. It is available only for the period 1962-2000, because we do not have data on world exports by destination market and commodity

differentiated goods than for homogeneous goods. This partition of goods resembles ours, because most primary goods are homogeneous and most non-primary goods are differentiated.

Table 8: Export value and undervaluation, by sector (1)

	$u^{PWT\ (2)}$	$u^{CPI\ (3)}$
x_t	0.67	0.78
	[79.19]***	[87.71]***
Food and live animals	**-0.44**	**-0.02**
	[8.56]* **	**[2.07]** **
Beverages and Tobacco	**-0.55**	0.02
	[4.22]* **	[0.63]
Crude materials inedible except fuels	0.17	0.02
	[3.13]***	[2.31]**
Mineral fuels lubrificants and related materials	0.49	0.03
	[3.59]***	[0.95]
Animal and vegetable oils, fats and waxes	**-0.45**	0.03
	[4.25]* **	[1.01]
Chemicals and related products, n.e.s	-0.05	0.04
	[1.35]	[3.36]***
Manufactured goods classified chiefly by material	**-0.33**	**-0.02**
	[12.78]* **	**[3.08]*** **
Machinery and trasport equipment	**-0.17**	0.00
	[5.78]* **	[0.42]
Miscellaneous manufactured articles	**-0.21**	**-0.03**
	[5.64]* **	**[3.10]*** **
Commodities and transaction N.E.C.	**-0.67**	**-0.11**
	[3.76]* **	**[2.16]** **
Country-good fixed effects	YES	YES
Year dummies	YES	YES
Observations	904012	919256
Number of groups	48266	46679
R-squared	0.10	0.18

(1) Estimates of equation (33) using OLS. Robust t statistics in brackets; * significant at 10%, ** at 5%, *** at 1%. Coefficients that are significant and have the predicted sign are in bold. (2) Sample period: 1962-2007.

Table 9: Extensive margin of exports and undervaluation (1)

Models	Linear Panel	Fractional logit
	u^{PWT}	u^{PWT}
x_t	0.12	0.53
	[4.91]***	[13.01]***
Undervaluation	-0.03	-0.16
	[0.81]	[2.68]***
Constant	-0.33	-3.31
	[1.69]*	[9.92]***
Country fixed effects	Yes	Yes
Year dummies	Yes	Yes
Observations	2365	2365
Number of id	62	
R-squared	0.35	

(1) Estimates of equation (34). Robust t statistics in brackets; * significant at 10%, ** at 5%, *** at 1%. Sample period: 1962-2007.

before 1962. We estimate the following specification:

$$ext_{n,t} = \alpha_n + \beta x_{n,t} + \gamma u_{n,t}^{PWT} + d_t + \eta_{n,t} \ , \tag{34}$$

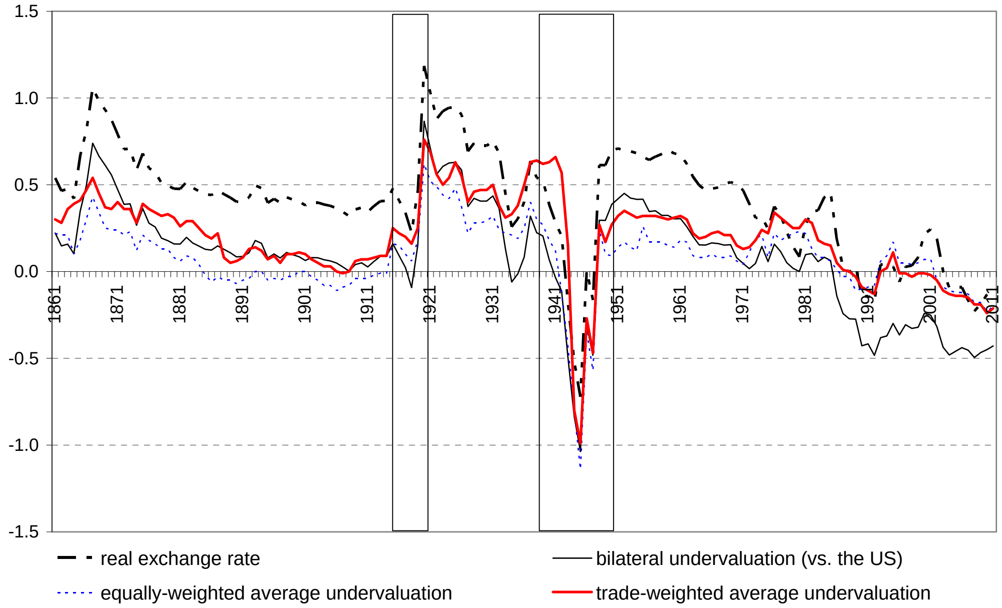
where $ext_{n,t}$ is the extensive margin of Italy's export to country n at time t, α_n are country fixed effects, $x_{n,t}$, $u_{n,t}$, and d_t are the same variables as above. The first column of Table 9 shows the results of the OLS estimates of equation (34). While the estimated coefficient of $u_{n,t}^{PWT}$ has its predicted negative sign, it is not significant. Note, however, that $ext_{n,t}$ is a proportion and, therefore, always included in the interval $(0, 1)$. For this reason, we have also estimated equation (34) using a fractional logit model. The second column of Table 9 reports the results of these estimates, and show that the coefficient of $u_{n,t}^{PWT}$ has the predicted negative sign and is strongly significant.

In conclusion, undervaluation positively affects the growth of exports, raising both their total value and extensive margin. Yet, the effect is not homogeneous across goods. In particular, undervaluation seems to have boosted exports mainly of the country's principal manufactures (manufactured goods whose weight in world exports is large).

5 The lira/euro and Italy's economic growth

Figure 1 (shown above in Section 1) plots two measures of Italy's undervaluation over the entire period 1861-2011. In this section, we describe in detail how these measures were computed and draw out their implications.

Figure 4: Real exchange rate and measures of undervaluation of Italy's currency: 1861-2011 (1)



Source: authors' calculations. (1) Data in logs. A positive (negative) value corresponds to undervaluation (overvaluation). The two shaded areas correspond to the periods 1914-1920 and 1939-1950.

5.1 Real exchange rate and misalignments of the lira/euro

We start by computing Italy's (bilateral) real exchange rate (RER), which we derive from the PWT from 1950 through 2009. The log of Italy's RER (the black thick dashed line in Figure 4) is defined as $ln\,(xrat/ppp)$, where $xrat$ is the nominal exchange rate of the lira/euro vis-à-vis the US dollar and ppp is the PPP exchange rate. The periods before 1950 and after 2009 are not covered by the PWT; for these, we use data on the nominal exchange rate vis-à-vis US dollar together with consumer price indices (CPIs) for the United States and Italy.[51]

One may worry that the CPIs for the United States and Italy are based on different baskets.[52] However, back-of-the-envelope calculations suggest that the approximation is reasonable, especially if the purpose is to use the resulting RER (or its "derivative product" undervaluation) in a regression model. If we start from PPP in a given year (say 2009) and construct a series that covers the period 1950-2009 by using CPIs, this new series has a correlation with the PWT PPP series of 99.6% (98.3% when expressed in first differences).[53]

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[51] For the year 2011, we have used Consensus Forecasts for inflation rates in the U.S. and Italy. Similarly, as a forecast for the nominal exchange rate of the lira/euro vis-à-vis the US dollar in 2011, we have followed the standard method of using the latest available market price.

[52] In practice, however, it is well known that differences in the basket of goods also affect PPP estimates, because, for instance, not all goods (and, then, their prices) are available in all countries.

[53] Nevertheless, there are sometimes large differences in levels, especially in the years adjacent to those in which

Bilateral undervaluation vis-à-vis US dollar in 1950-2009 (the black thin line in Figure 4) is calculated by correcting for the Balassa-Samuelson effect as in Section 2 (where equation (1) is estimated using annual data). Visual comparison of the RER and this measure of undervaluation shows that the correction changes the level of the latter with respect to the former, but that its time profile is basically the same.[54] The similarity in the behavior over time of the RER and undervaluation is maintained despite the fact that Italy's real GDP per capita (the control variable used to estimate undervaluation from RER) rises by 500% between 1950 and 2009.

To extend our measure of undervaluation to the periods before 1950 and after 2009, we regress this variable on the RER based on CPIs and extrapolate from the regression results. Other estimates could also be obtained using only changes across time in the RER based on CPIs, or by using other variables (either in a regression model or focusing only on the changes), such as the measure of RER based on WPIs, or the measures of undervaluation $u_{n,t}^{CPI}$ and $u_{n,t}^{WPI}$ (see Section 2). These alternative approaches in fact provide very similar results.[55]

The trade-weighted index of undervaluation is calculated in a similar fashion. We first computed RERs vis-à-vis the US dollar from the PWT for all Italy's main trading partners in the period 1950-2009, which we extended backward and forward using data on CPIs and exchange rates. The main trading partners are defined as the 61 countries included in the Bank of Italy's competitiveness indicators (see Finicelli, Liccardi and Sbracia, 2005) for the period 1950-2011; for earlier years these are the 10 main trading partners included in the data set constructed by the Bank of Italy and Federico, Tattara and Vasta (2011). RERs are then transformed into bilateral measures of undervaluation vis-à-vis the US dollar by correcting for the Balassa-Samuelson effect. The difference between Italy's and a trading partner's measures of undervaluation provides a bilateral measure of undervaluation of the lira/euro vis-à-vis the latter country's currency. Finally, we use export and import data for Italy in the period 1861-2009 (see Section 4) to construct the trade weights. By taking the weighted average, we obtain the trade-weighted index (the red thick line in Figure 4).[56]

5.1.1 Some caveats

As emphasized above, errors affecting the level of the RER (such as those due to differences across countries in the basket of goods from which the CPIs are computed) will translate into mismeasurement of the extent of undervaluation. In addition to this, there are other potential

price level data are available to the International Comparison Program (a point on which we return below). And, of course, because CPIs are indices and not price levels, when we extend the RER back in time, any error in its level at one point in time is transmitted to all previous data.

[54] The correlation between the two series is 0.95 in 1950-2009.

[55] The advantage of the regression approach is that it allows us to compute confidence intervals. For the period 1950-2009, the confidence interval for the measure of undervaluation plotted in Figure 1 is obtained from the estimates of the panel regression (2). For the remaining period, the confidence interval takes into account the additional variability due to the regression of undervaluation on RER (which is performed only for Italy). In addition, the preference for using the RER based on CPIs with respect to other variables is grounded in the fact that this measure has the largest correlation with undervaluation in the period 1950-2009.

[56] For the sake of comparison, we also considered a measure of undervaluation computed as an equally-weighted average, instead of a trade-weighted average, calculated on Italy's 10 main trading partner countries (except Russia) considered by Federico, Tattara and Vasta, 2011 (the blue thin dotted line in Figure 4).

sources of mismeasurement.

The first one concerns the use of data spanning the two world wars. Because CPIs are index numbers, in order to extend the RER (and the measure of undervaluation) we need a complete series without breaks for all years in the 1861-1949 interval before PWT data are available. Specifically, we need price series that span the war years.

Unfortunately, the alternative series for this period are very different. Our source for Italy's CPI is Mitchell (2008).[57] An available alternative is that in Global Financial Data. The two series are similar, with a correlation of 99.99% in levels, and 98.7% in first differences. There is, however, one important discrepancy. Inflation in 1944 was 340% according to Mitchell and 490% according to Global Financial Data.[58] This makes a big difference: on average, in the whole pre-World War II period, the series from Global Financial Data signals an inflation rate for Italy which is 2 percentage points higher that the one based on Mitchell's data (11.6% against 9.6%); excluding only the inflation rate in 1944, that difference would be just 0.3 percentage points (6.1% against 5.8%).

These differences can have non-negligible effects on *the level* of our measures of undervaluation. To show this, we have constructed an alternative bilateral measure of undervaluation, under the assumption that inflation in 1944 was 490% instead of 340%. According to the latter, during the period 1861-1939 undervaluation was almost 40%, against just 10% if inflation in 1944 was 340%. And this difference occurs with a correlation of 1 between the two series in 1861-1939.

Potential problems affecting the level of undervaluation, like those just described, do not prevent the use of this variable in panel growth regressions like those of Section 2 or Section 4. In fact, those regressions exploit the time-series variability of undervaluation and potential mismeasured levels are accounted for by including country fixed effects.[59] On the other hand, conclusions based on the level of this variable must be drawn cautiously, because errors in levels may not be negligible.

Another issue concerns the interpretation of the bilateral measure of undervaluation (and, in turn, of the trade-weighted index). The variable is a residual which averages zero by construction. Precisely, the cross-country average is zero in each sample year since the regression includes time dummies. The level correctly measures undervaluation to the extent that the average undervaluation across countries is zero — not an unreasonable hypothesis given our large sample. However, the precise interpretation of our measure is *the undervaluation of Italy's currency vis-à-vis the US dollar, with respect to the average undervaluation across countries.* To put it differently, *undervaluation in each country is a relative measure.* Because undervaluations are calculated against the same cross-country average, bilateral comparisons of undervaluations (which we use in the empirical analysis of Section 4 as well as to construct the trade-weighted

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[57] From 1968 to 2010, however, we have updated Mitchell's series with the "official" CPI from Italy's ISTAT.

[58] Interestingly, inflation rates in 1943 and 1945 are quite similar across the two sources, equal to 67.9% and 97.0% according to Mitchell and 67.3% and 96.2% according to Global Financial Data. Inflation rates are also similar in all the other war years (and identical in most non-war years).

[59] Note that in the empirical models of Section 2 and Section 4, we exclude data that span through the war years. In addition, we include three sets of country fixed effects, one for each macro-period (the pre-World War I, the interwar, and the post-World War II period), to account, among the other things, for the different base years of our indices.

index) correctly measure the differential degree of undervaluation in two different countries.

5.2 Misalignments of the lira/euro

Figure 4 suggests that the lira was undervalued for about 100 of 120 years from 1861 through the early 1980s. In the remaining 30 years, from the early 1980s through 2011, Italy's currency has been persistently overvalued.

How can a currency remain undervalued or overvalued for so long? In a world where wages and prices adjust less than instantaneously, a significant change in the nominal exchange rate can have persistent effects. Thus, the Italian government's decision to significantly devalue the lira following World War II, before stabilizing it against the US dollar after 1949, could give rise to a period of undervaluation because it took time for wages and prices to adjust upward.

But it is implausible that this mechanism alone could produce the kind of very persistent undervaluation and overvaluation that we observe in the data. Given the passage of "some" years, wages and prices should adjust. If the authorities attempt to resort to serial devaluations, wages and prices will adjust even faster.

Thus, the very persistent deviation of the exchange-rate-adjusted price level from the international norm must reflect in addition, or instead, other factors. For Italy, we emphasize two. First, abundant supplies of labor to the manufacturing sector flowing from the rural (especially Southern) periphery to the country's industrial core, which pushed the price level down relative to the international average for much of the 1950s and 1960s. Second, the stance of fiscal policy. This was relatively restrictive from the mid-1890s to 1913 and from 1945 to the late 1960s, restraining the growth of domestic demand and limiting the rise in the price level relative to the international norm. It was more expansionary during the two world wars, the 1930s, and especially after 1970, pushing up the price level and making for overvaluation rather than undervaluation, other things equal.[60]

In the following, we first describe the misalignments of the lira/euro since 1861, as reported in Figure 1, briefly recalling how the exchange rate was set across the different regimes. Then, we analyze empirically the factors that allowed the currency to remain undervalued, overvalued or stable, and draw the implications of the misalignments for Italy's economic growth.

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[60] Note that adherence to a metallic standard before World War II prevented countries from setting a parity with respect to another country's currency and to undervalue the exchange rate. In the textbook story of the gold standard, then, undervaluation and balance-of-payments surpluses (or their reciprocal) are only transitory phenomena, as the mechanism described by Hume's price-specie flow model restores equilibrium in the balance of payments as well as in the real exchange rate. The modern literature, however, has started to reject this myth, describing a reality that was much different from the textbook story (see Eichengreen and Flandreau, 1997). The discipline imposed by the "rules of the game" allowed only a small group of core countries to commit to gold convertibility. Many peripheral countries frequently decided to suspend gold convertibility and imposed fiat money as a legal tender. For instance, in the period preceding World War I, Italy adhered to a metallic standard for just 15 out of more than 50 years. In this case, fluctuations of the currency well outside the range of the gold points were possible, allowing for more persistent misalignments. In addition, misalignments could also follow from sticky wages and other frictions in the labor or product markets, just like after the end of metallic standards.

5.2.1 An overview of the misalignments

In 1859, on the eve of political unification, the Italian peninsula was divided into seven legally autonomous political units and six monetary zones.[61] *Silver monometallic* and *non-decimal* systems were predominant.[62] The August 1862 monetary reform (the so-called Pepoli Law, after Gioachino Pepoli, the Minister of Agriculture, Industry and Commerce who proposed it) implemented, instead, a *bimetallic* and *decimal* system. This was simply the extension to the whole peninsula of the monetary system of Piedmont, which, in turn, derived directly from the French system.

The Italian authorities deemed that the gold standard was the best available system.[63] They forecast that it would eventually be chosen by Italy's neighbors. But the authorities also acknowledged that national decisions about monetary arrangements were not independent of each other. In modern terminology, they recognized that *network externalities* characterize international monetary arrangements.[64] The government's view was that these externalities flowed from Italy's strong economic and political ties with France, strong trade relationships with Germany and other countries in which silver was legal tender, and the fact that debt obligations were sold in markets in which silver circulation was widespread.[65] In other words, *the choice of exchange rate regime was driven by factors unrelated to the quest for competitiveness*; bimetallism was adopted to maintain the same monetary arrangement as in other important partner countries.[66] As it happened, at the time of unification the lira was undervalued (Figure 1).

In its first 30 years, to the early 1890s, the currency remained undervalued. In 1866, with the birth of the Latin Monetary Union and approach of the third war of independence, Italy suspended the convertibility of the lira (*corso forzoso*), and the currency depreciated in response, achieving a very high undervaluation (over 50% in trade-weighted terms). Following the upswing in economic activity in Europe in the early 1880s, which was shared by the Italian

[61] In the Duchy of Modena and Reggio, which did not have an autonomous monetary system, trades occurred using mainly the Piedmontese and Austrian coins. A very detailed description of the situation at the time of the monetary unification is in De Mattia (1959). For a comprehensive monetary history of Italy, see Fratianni and Spinelli (2001). More focused accounts about the history of the Italian lira are Cipolla (2001) and Martinez Oliva and Schiltzer (2005).

[62] An example of non-decimal system was in place in the Kingdom of the Two Sicilies, were one *piastra* was worth 120 *grana* or 240 *tornesi* (although the unit account was the *ducato*, which was worth 100 *grana*). In many parts of Italy decimal systems were either unknown or regarded as "annoying" (De Mattia, 1959).

[63] Pepoli himself regarded it as the "most logical and perfect." See Martinez Oliva and Schiltzer (2005).

[64] See Eichengreen (2008b) for a recent perspective on this issue.

[65] Pepoli's law proposal reported that: "*Le frequenti e importanti relazioni commerciali che noi abbiamo con la Francia, con la Germania e con le altre nazioni che tengono l'argento per moneta legale, le condizioni speciali del credito italiano, per cui i titoli del nostro debito pubblico sono negoziati sui principali mercati ove si usa l'argento* [...] *renderebbero per ora inopportuna e nociva una riforma* [the gold standard, editors' note] *che operata, invece, d'accordo con le principali nazioni d'Europa riuscirebbe perfetta*" (Corbino, 1931, cited from Fratianni and Spinelli, 2001, p. 139).

[66] Limits placed to the convertibility of silver, to prevent the effects of Gresham's law, were such that the system was very close to a monometallic gold standard (a "masked gold standard," as Fratianni and Spinelli, 2001, define it).

economy, the gold standard was reintroduced in 1883. This allowed the lira to remain stable in nominal terms and the preceding undervaluation to be gradually reversed.

The 1893 financial crisis then led to a new suspension of convertibility in 1894.[67] In 1896, the defeat of the Italian Army in Ethiopia put an end to the semi-authoritarian regime of Francesco Crispi (Toniolo, 1988). By the mid-1890s, with the banking crisis finally over, the government turned to monetary discipline and fiscal consolidation (Cesarano, Cifarelli and Toniolo, 2009). These policies, pursued under both the floating exchange rate of 1894-1902 and the gold-shadowing policy of 1903-1911, resulted in a currency broadly at equilibrium levels.

When World War I broke out, the government put in place a system of consumption rationing and price controls in an (imperfectly successful) effort to contain inflation. After a period of overvaluation in 1916-1918, sharp nominal depreciation of the lira (nearly 70% vis-à-vis the US dollar between 1918 and 1921) more than offset higher consumer prices. The country therefore exited the war with an undervalued currency.

Between 1921 and the mid-1930s, the lira appreciated in both nominal and real terms. A substantial portion of the initial undervaluation was eliminated in 1927 when Benito Mussolini's government appreciated the currency in advance of restoring the gold exchange standard. The lira peg of 19 to the dollar and over 90 to the pound sterling, the so-called *quota novanta*, was the cornerstone of Mussolini's economic policy. The literature has not reached a unanimous verdict on this policy, which was driven by political motivations connected to the prestige of the fascist regime (see Cohen, 1972, Ciocca, 1976, and De Cecco, 1993).[68]

The lira then remained anchored to gold during the Great Depression, including in the "autarkic policy" period when trade embargoes were imposed against the country as a result of its invasion of Abyssinia in 1935. Italy was among the last countries to devalue, in October 1936, fostering recovery in 1937-1939.[69]

Following World War II, the quest for competitiveness grew stronger. In 1943 the military authorities in the South of Italy established a conversion rate for Allied Military Notes (so-called *amlire*) of 100 to the dollar, a depreciation that more than compensated for the inflation recorded in 1938-1943.[70] In January 1946, Alcide De Gasperi's Government gave exporters the prize of an additional 125 lire per US dollar, setting the dollar exchange rate at 225. Luigi Einaudi, the

[67] As Cesarano, Cifarelli and Toniolo (2009) remind us, it is not entirely clear when the gold standard was legally suspended. The Bank Act of 1893, which instituted the Bank of Italy, was unclear about the obligations concerning the conversion of notes into gold (indicating that conversion rules would be issued at a later date) — an ambiguity that was probably intentional.

[68] As De Cecco (1993) famously put it, "it is really difficult to express opinions about this choice, but also to establish post-hoc its insanity."

[69] The role of the gold standard in setting the stage for the Great Depression, favoring the transmission across countries while amplifying the magnitude of the crisis, and finally hampering the recovery for as long as it remained in place has been extensively analyzed by Eichengreen (1995).

[70] This was also a way for the Allies to increase their purchasing power in the country (Graziani, 1979). The nominal exchange rate underlying Figure 1 is equal to about 20 units per U.S. dollar in 1943, as from Bordo, Eichengreen, Klingebiel and Martinez-Peria (2001), which is the rate prevailing in the north of Italy (similarly, Fratianni and Spinelli, 2001, report a rate of 19 units per U.S. dollar). Note that Fratianni and Spinelli (2001) report a PPP rate of 39.31 that year. Hence, an exchange rate of 100 units per U.S. dollar, like the one established in the south of Italy, would have implied an undervalued currency. On the other hand, an exchange rate of 20 units per dollar would have resulted into an overvalued currency, as in Figure 1.

Governor of the Bank of Italy, deemed this measure insufficient to restore price competitiveness (see Carli, 1996). In March 1946, under pressure from textile producers, exporters were allowed to retain half of the dollars obtained from their sales abroad, which they could convert into lire in the free and black markets, giving rise to a multiple exchange rate system.[71]

Italy maintained this multiple exchange rate system even after joining the International Monetary Fund in 1947. In 1948, indicative of the success in the monetary stabilization, the exchange rate quoted on the free market was broadly equal to the official rate, roughly 575 lire. In 1949 the exchange rate was definitively set to 625 lire per US dollar — a further depreciation with respect to the previous year.[72] It was maintained at this level for more than 20 years.

When Italian authorities set the exchange rate vis-à-vis the dollar in 1949, they carefully considered the external competitiveness of domestic goods and services. Whereas the Annual Report of the Bank of Italy had not even mentioned the exchange rate in the entire period 1941-1945, starting in 1946 considerations of competitiveness (and about the implications of changes in the exchange rate for domestic prices) became again central to the analysis of the Bank's staff. Thus, in its Annual Report for the year 1948, the Bank of Italy wrote (see Bank of Italy, 1949):

> "*Supponendo, come sembra lecito fare, che nel 1913 il tasso di cambio della lira col dollaro corrispondesse alla parità economica, e che nel 1938 tale parità fosse variata in relazione all'aumento relativo dei prezzi in Italia, essa si stabilirebbe in tale anno a 22.6; equivalenza che, moltiplicata per l'aumento relativo dei prezzi ingrosso italiani su quelli americani tra il 1938 ed il dicembre 1947, fornirebbe per quest'ultima data una parità col dollaro di 596.*"

Because the lira was still quoted at 575 to the dollar in December 1948, the identification of an "equilibrium" rate of 596 was a call for a further nominal devaluation that, in fact, occurred the following year. Figure 1 shows that the currency was largely undervalued in 1950 and that undervaluation remained above 20% in trade-weighted terms until the early 1960s.

The 1970s saw the collapse of the Bretton Woods System and the attempt, in Europe, to recreate the system on a regional basis with the Snake. All the while, the lira depreciated serially. While the economic and financial crisis of the mid-1970s hit the country hard — in 1976 it forced the closure of the foreign exchange market for several weeks — the currency remained undervalued for much of the decade.

European countries worried that exchange rate volatility would undermine the process of regional integration, weaken the expansion of trade and fuel inflation. The European Monetary System (EMS) was an attempt to respond to the breakdown of the Bretton Woods System by reinstituting pegged but adjustable exchange rates. Realignments occurred periodically from the outset of the EMS in 1979 through 1987. There were no further realignments in the following five years, only Italy's move from the broad to the narrow band. But relatively high inflation made for overvaluation, setting the stage for the EMS crisis that erupted in September 1992, when the lira, along with other weaker European currencies, was forced to depreciate. Italian

[71] In the free market, the lira was traded at further depreciated levels.

[72] Even though of a smaller extent with respect to those established by other European countries.

authorities responded to the crisis by turning to fiscal consolidation and adopting an explicit inflation target. These measures succeeded in containing the budget deficit and consumer prices and permitted the country to reenter the EMS in 1996. In 1999, the currencies of 11 countries, including Italy, were then irrevocably locked, and the euro was introduced. That year Italy's currency was at its equilibrium level in trade-weighted terms. In the following ten year, turned into an overvaluation, that persists today.[73]

5.2.2 Main determinants of the misalignments

In this section, we perform a time series analysis for the Italian economy to examine empirically the factors that have affected the misalignments of the lira/euro since 1861. For this purpose, we construct a data set with variables commonly used in the literature on the real exchange rate (such as Edwards, 1989, and Eichengreen, 2008b).

Our dependent variable is the trade-weighted index of undervaluation of Italy's currency, as constructed above. Among its determinants, the most important variables on which we focus are the supply of labor to the manufacturing sector and the stance of fiscal policy. The former factor is measured by the relative number of workers, calculated in full time equivalent, in the agricultural sector with respect to the manufacturing sector. We take this variable as a proxy for the relative size of the traditional versus the modern sector, as described by Lewis (1954). For the latter factor, we use data about changes in the stock of public debt (as recently reconstructed by Francese and Pace, 2008), scaled by the GDP, as a proxy for the fiscal deficit over GDP. The theory suggests that an increase in the relative size of the traditional sector or a decline in the fiscal deficit raise undervaluation.

Note that, in the previous sections, we have hypothesized that undervaluation spurs growth by reducing the relative size of the traditional sector, while here we are speculating that, in turn, the relative size of the traditional sector affects undervaluation. This creates a potential endogeneity problem that, in a robustness check, we address by instrumenting our proxy.

To control for the stance of monetary policy, we consider a measure of Italy's real interest rates, built as the difference between long-term interest rates (from Fratianni and Spinelli, 2001) and the consumer price inflation rate. An increase in real interest rates reduces aggregate demand, tends to lower domestic prices and, in turn, raises undervaluation.

Other common factors used in empirical studies of the real exchange rate are measures of capital liberalization and trade openness. For Italy, we take the first of these variable from the work of Quinn (2003) and its most recent update in Quinn and Voth (2008). Trade openness is defined as the ratio between Italy's gross trade (i.e. the value of imports plus exports) and GDP. A rise in capital inflows following a capital account liberalization exerts upward pressures on the domestic currency and, therefore, tends to reduce undervaluation. At the same time, a trade liberalization, by making available cheaper foreign goods and reallocating domestic resources

[73] The extent of the bilateral overvaluation vis-à-vis the US dollar is much larger (in the order of 40%) mainly because from the 1990s the number of countries covered by the Penn World Table increases sharply, including many developing economies with an undervalued currency. Because bilateral undervaluation is a *relative* measure, calculated with respect to the cross-country average, adding a large number of countries with undervalued currencies pushes down the resulting bilateral index for Italy, without affecting much, however, the trade-weighted index.

towards more productive sectors, lowers domestic prices and enhances undervaluation.

Last, we consider an index of labor productivity in the industrial sector. A rise in productivity in the industrial sector boosts a country's competitiveness by lowering domestic prices of tradeable goods; to this extent, it tends to raise undervaluation. At the same time, however, a fast-growing country that records sharp rises in productivity attracts foreign capitals which may generate an appreciation of the currency, thereby reducing undervaluation.

Because our dependent variable is stationary, while most of the independent variables are not, we estimate the model in first differences. Our benchmark specification, then, is:

$$\begin{aligned} \Delta u_t &= b_0 + b_1 \cdot \Delta \left(\frac{A_t}{M_t} \right) + b_2 \cdot \Delta deficit_t + b_3 \cdot \Delta i_t^R + b_4 \cdot \Delta K_t \\ &\quad + b_5 \cdot \Delta O_t + b_6 \cdot g_{LP_t} + \varepsilon_t \quad , \end{aligned} \tag{35}$$

where u_t is the value of the trade-weighted index of undervaluation of the lira/euro at year t; Δ is the first-differences operator; A_t/M_t is the relative size of the workforce in agriculture versus the manufacturing sector; $deficit_t$ is the fiscal deficit, which is approximated by $D_t/Y_t - D_{t-1}/Y_{t-1}$, with D_t/Y_t being the ratio of public debt over GDP; i_t^R is the real interest rate, computed as $i_t^N - \pi_i$, with i_t^N being the long-term interest rate and π_i the rate of inflation; K_t is the index of capital account liberalization; O_t is the measure of trade openness, g_{LP_t} is the growth rate of labor productivity in the industrial sector; $b_i \in \mathbb{R}$ $(i =, 0, 1, ..., 6)$ and ε_t is the error term. The model is estimated with robust OLS and returns uncorrelated residuals.

Table 10 reports the estimates of equation (35) for different time periods. The first column shows the results for the whole sample (from 1861 to 2009). Supply of labor to the manufacturing sector and debt over GDP are significant and have the predicted sign, along with the real interest rate, capital account liberalization and trade openness. Labor productivity has a negative sign (i.e. a rise reduces undervaluation), and it is also significant. The second column reports the estimates of equation (35) for the period preceding World War II (1861-1939). Results are generally confirmed, despite the decline in the number of observations. The third column shows the results, for the period following World War II, of a regression that excludes trade openness in order to prevent a stronger decline in the number of observations (as we do not have trade data from 1950 to 1961). Again due presumably to the decline in the number of observations, only the real interest rate and labor productivity preserve statistical significance, even though all the variables have the predicted sign. In particular, both our main independent variables, relative size of the traditional sector and fiscal deficit over GDP, lose statistical significance. For the first of these variables, this result could be explained by the fact that Italy had an advanced industrial sector for most of that subsample. The lack of statistical significance of the fiscal variable is more surprising. Then, in an attempt to augment the number of observations, we also consider a subsample including also the interwar period (fourth column of Table 10). The statistical significance of the fiscal deficit over GDP returns, suggesting that the smaller sample size may have played a key role in the previous result, while the insignificance of supply of labor to the manufacturing sector remains. This is an indication that, for most of this subsample, labor supply was no longer "unlimited." In the next section, we suggest that it is in the 1960s that the achievement of full employment and the related waves of wage claims triggered this regime switch.

To check the robustness of our results, we performed a number of sensitivity tests. As

Table 10: Determinants of undervaluation (1)

Time span:	1861-2009	1861-1939	1950-2009	1920-2009
Δagric./manuf.	**0.066**	**0.064**	0.178	-0.012
	[2.51]**	**[2.22]****	[1.07]	[0.28]
Δdeficit	**-0.080**	**-0.101**	-0.138	**-0.142**
	[1.88]*	**[2.12]****	[0.80]	**[2.67]*****
Δreal interest rate	**0.014**	**0.043**	**0.013**	**0.011**
	[3.30]***	**[2.92]*****	**[3.67]*****	**[2.52]****
Δ KA liberalization	**-0.014**	**-0.021**	-0.003	**-0.010**
	[2.60]**	**[3.19]*****	[0.28]	**[1.73]***
Δopenness	**0.859**	**1.160**		**0.778**
	[5.86]***	**[4.78]*****		**[4.30]*****
labor productivity growth	**-0.266**	**-0.216**	**0.437**	**-0.243**
	[3.39]***	**[2.25]****	**[2.55]****	**[2.64]****
constant	-0.002	0.006	-0.016	-0.008
	[0.35]	[1.01]	[2.23]**	[1.24]
Observations	118	69	59	67
R-squared	0.38	0.43	0.34	0.50

(1) Estimates of equation (35). Robust t statistics in brackets; * significant at 10%, ** at 5%, *** at 1%.

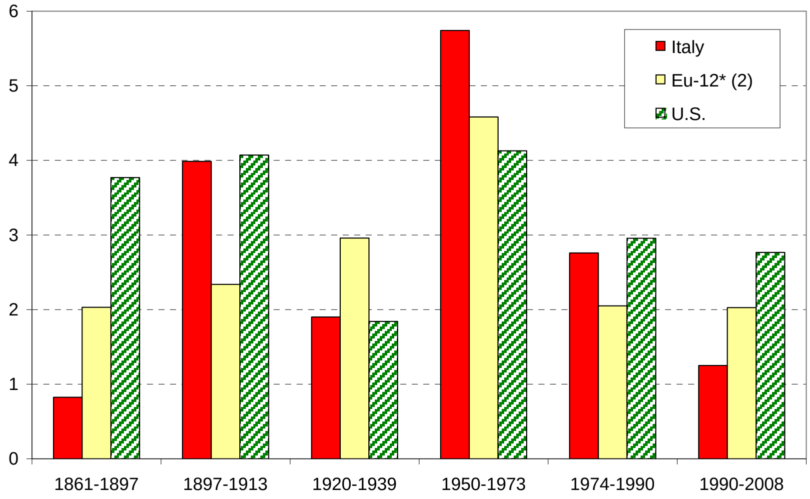
alternative proxies for the relative size of the traditional versus the modern sector, we have constructed different indexes. First, to the numerator, we have added workers in the mining, construction and retail trade sectors to agricultural workers. Second, we have counted workers using heads instead of the full-time equivalent measure. All these variables have a very high correlation with our benchmark proxy, equal at least to 98%. Not surprisingly, they provide the same results.

As for fiscal policy, we have built a series for the fiscal deficit over GDP using data from Repaci (1962) from 1861 to 1960, and the Italian Ministry of Treasury series thereafter. Because the first source contains data for fiscal years, we have used the same heuristic as Fratianni and Spinelli (2001) to transform them into calendar year data.[74] Including this variable into the benchmark specification in the place of public debt over GDP, and using its deviations from the trend (obtained by applying a Hodrick-Prescott filter), returns a significant coefficient with the predicted negative sign, while all the other independent variables preserve the correct sign and significance. In particular, the proxy for relative size of the traditional sector becomes significant at the 1% threshold.

We also tried some other regressors often considered by the literature, such as terms of trade (available from the OECD for the years 1955-2009 and, for the period 1862-1949, from our own calculation using data from Bank of Italy and Federico, Tattara and Vasta, 2011), the value of remittances over GDP, and the ratio between the male and female population (Du and Wei, 2011, discuss the role of the "sex ratio" for the real exchange rate). When included in

[74] Specifically, half of the fiscal-year deficit at time t, which ended on June 30 for most of the sample years, is attributed to the calendar year $t-1$ and the remaining half to the calendar year t.

Figure 5: Real GDP growth in selected areas (1)



Source: Maddison (2008), Johnston and Williamson (2003). (1) Annualized rate of growth in the period indicated on the horizontal axis. (2) Eu-12* is Maddison's "EU-12" excluding Italy; for the period 1861-1870 it also excludes Austria.

the benchmark regression, only the first of these factors is statistically significant (at the 10% threshold) and has the predicted negative sign (while the other variables maintain the predicted sign as well as statistical significance).

Last, we address the endogeneity problem affecting relative size of the traditional sector (which, in turn, is influenced by undervaluation) by instrumenting it with the lagged values of the first differences. The results confirm the sign and significance (at the 10% threshold) of the coefficient of the relative size of the traditional sector, and point to a somewhat higher magnitude and significance of this variable for the period preceding World War II.

These results are at least suggestive that an abundant supply of labor to the manufacturing sector (at least until the 1960s) and the stance of fiscal policy have been key determinants of the persistence of the misalignments of the lira/euro since Italy's unification.

5.2.3 Implications for Italy's growth

What are the implications of the misalignments of the lira/euro for Italy's growth? Figure 5 shows a standard periodization of real GDP growth. It distinguishes the "miracle" years, from 1950 to 1973; the phases of sustained growth during the *età giolittiana* (from the mid-1890s to the eve of World War I) as well as in 1974-1989;[75] and three phases of disappointing growth: 1861-1895, the interwar years, and the two most recent decades.

[75] The split of the first globalization era in two different periods, separated by the mid-1890s, is quite common in the periodizations of Italy's growth, following Gerschenkron (1955). For a different perspective, see Fenoaltea (2003).

The highest growth period. Figure 1 suggests that Italy benefited from an undervalued currency during the miracle years 1950-1973. That Italy's currency was undervalued in the early 1950s seems to be generally accepted (see Lamfalussy, 1963; Ciocca, Filosa and Rey, 1973; Graziani, 1979; Boltho, 1996).[76] Boltho (1996), for instance, reports an undervaluation of 17% in 1950, not far from our 27% (for the trade-weighted index). He finds that Italy's real exchange rate depreciated further in the early 1950s and remained undervalued for the rest of the decade; Figure 1 confirms his findings.

According to the estimates in Section 2, an average undervaluation on the order of 30% in 1950s and 1960s contributed 0.6% to 1.2% per year to GDP growth (the corresponding elasticities range from 2% to 4%). This is a very strong contribution for the entirety of a 20-year-long period. As a confirmation that causality may have gone from undervaluation to GDP growth, note that export growth soared in this period (see Figure 6).[77]

How could the currency remain undervalued for such a long period? Boltho (1996) points to a low rate of inflation due to wage moderation and rapid productivity growth. The fact that in the 1950s wage inflation was subdued is undisputed (see, e.g., Ciocca, Filosa and Rey, 1973, and the references cited therein). Figure 7 confirms that in the industrial sector, during that decade, nominal wages grew at a lower rate than labor productivity, while the nominal value of the lira remained stable.[78]

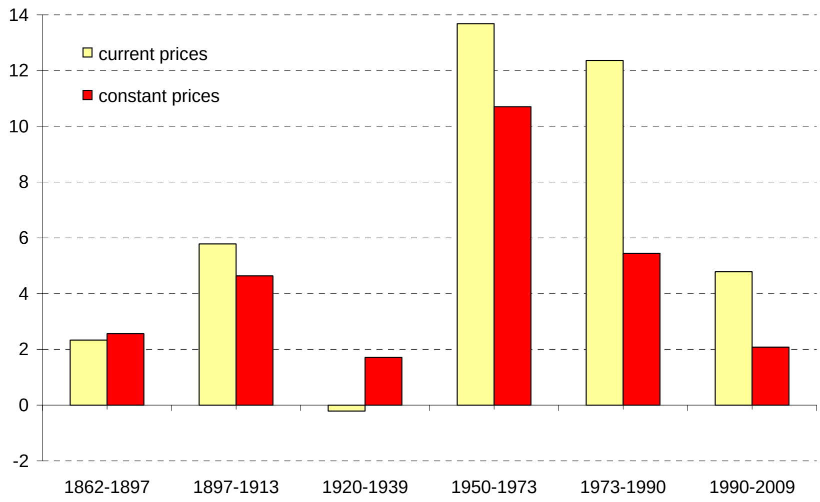
An excess supply of labor to the tradeable sector was probably key in explaining wage moderation relative to labor productivity growth in the 1950s. Several factors may have contributed to restrain wages. First, internal migration from the south to the north and from the countryside to the cities reached unprecedented levels. In each year between 1951 and 1965, about 1.5 million of people transferred their home within the country; the "industrial triangle" alone (Genoa, Milan and Turin), absorbed over 100,000 people per year (Golini, 1978). Second, unemployment was high: in the early 1950s the official rate was about 10%, with about two millions of unemployed; moreover, according to some estimates, the *underemployed* were an additional 1 to 4 millions (Ciocca, Filosa and Rey, 1973). Third, among the employed in 1950, for each person occupied in manufacturing there were two in the low-productivity agricultural sector; within 20 years, this ratio was reversed. Fourth, trade unions, which had been dismantled during the fascist regime, reemerged divided and inexperienced in the late 1940s (Horowitz,

[76] On the other hand, many authors agreed that the U.S. dollar was generally overvalued after 1949. It is interesting, in particular, to reappraise Samuelson (1964) to decipher the international developments occurred during the 1950s (as well as to gain some insight about the current tensions between the U.S. and China). In the finale of his paper, Samuelson concludes that: "(1) The dollar has been somewhat overvalued in this last decade [...] economists everywhere would prefer, if they could rerun history, that the 1949 depreciations abroad had been somewhat less sharp. (2) The overvaluation has hampered a high-employment policy at home [...]. (3) The productivity improvements abroad since 1949 [...] have not yet been matched by commensurate rises in foreign money wages relative to ours" (p. 153).

[77] The question of whether the high growth recorded during the 1950s and 1960s was "export led" is still controversial. For a discussion, see, among the others, Lamfalussy (1963), Kindleberger (1967), Stern (1967), Ciocca, Filosa and Rey (1973), Federico and Cohen (2001). Notice however that, when referring to "export-led growth," the early literature refers to a virtuous cycle of exports, investments, productivity and exports, whose theoretical foundations have been largely criticized (see, e.g., Gandolfo, 2001).

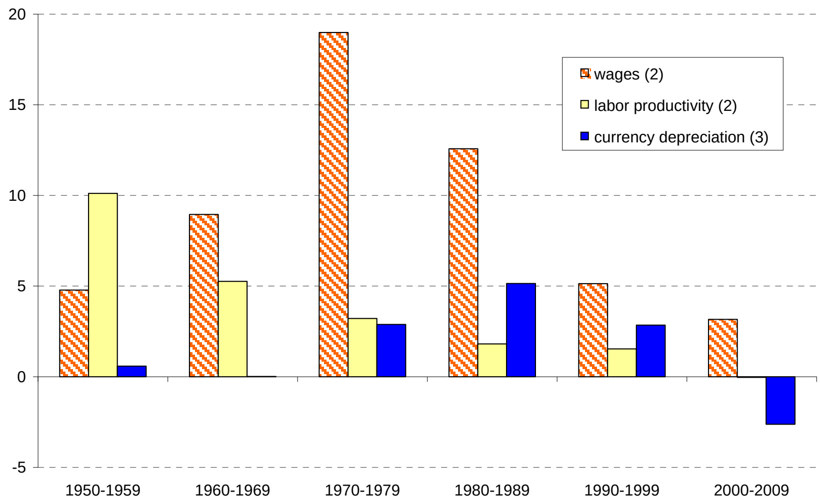
[78] Due to the difficulties in finding reliable data on the stock of physical capital and its rental cost, Figure 7 focuses only on labor as the main production factor.

Figure 6: Italy: export growth (1)



Sources: Bank of Italy; Federico, Tattara, Vasta (2011); Ercolani (1975); NBER; U.N. Comtrade. (1) US dollar value of Italy's exports.

Figure 7: Italy (1950-2007): wage and labor productivity growth in the industrial sector, and currency depreciation (1)



Sources: Bank of Italy; Ercolani (1975). (1) Annual rates of growth (in percentage). (2) Wages and labor productivity in the industrial sector. (3) A positive (negative) value corresponds to a nominal depreciation (appreciation) vis-à-vis the US dollar.

1966). Their wage claims were decentralized and, in many instances, ineffectively advanced in the 1950s.[79] Last, Italian authorities maintained a neutral stance of fiscal policy (with a deficit to GDP ratio below 3%), while money growth was also contained (Fratianni and Spinelli, 2001).

These factors were gradually reversed during the 1960s. In 1962-63, the achievement of full employment contributed to abate internal migrations. Most importantly, it led to a first wage explosion in that biennium, with a second wave of wage claims at the end of the decade (starting from 1969, with the so-called *autunno caldo*). Thus, wages began rising somewhat more rapidly than labor productivity.

The "sustained growth" periods. During the two phases of sustained growth, the currency was either broadly at equilibrium (1895-1913) or undervalued (in the 1970s and 1980s). Very different policies underlie these developments. In the earlier episode, the nominal exchange rate was stable, as a result of the consistent policies adopted in Italy. A sound banking system was restored by the mid-1890s, after the 1893 crisis. Between 1897 and 1913, the ratio of debt to GDP fell from about 130% to less than 80% (Francese and Pace, 2008). Bonaldo Stringher, appointed Director General of the Bank of Italy in 1900, carried out a successful monetary stabilization (see Fratianni and Spinelli, 2001, and Cesarano, Cifarelli and Toniolo, 2009).

In the latter period, instead, the nominal exchange rate serially depreciated to compensate for relatively high inflation. The fiscal deficit, that had averaged below 3% in the 1950s and 1960s, raised to about 5% in 1970-72 and to an astonishing 13% in 1973-1978. It averaged over 8% in the 1970s and 1980s. In only nine years, from 1970 to 1978, the ratio of public expenditure to GDP almost doubled, from 28% to 52%. Monetary policy was strongly expansionary, not last because of the monetization of the fiscal deficit (Fratianni and Spinelli, 2001). The annual rate of wage growth exceeded labor productivity growth in the 1970s and 1980s (Figure 7) and was well above 10% for the first and unique time in the century and a half since unification.

The "disappointing growth" periods. In contrast, the lira was undervalued in 1861-1895 and the interwar period, when growth rates were low. This is contrary to our hypothesis. In the first 30 years following unification, the causes of this dismal performance are mostly domestic. Economic, financial and political instability prevented the country from taking advantage of its undervalued currency. In particular, despite undervaluation, Italy was a net importer during this whole period. The newborn country was backward and poor and needed to import industrial raw materials, arms, agricultural commodities, and manufactures. At the same time, the country could not sell abroad many goods other than silk products and olive oil. It could not reach many more markets than France.[80] In the 1860s and 1870s, silkworm and grape phylloxera had more visible impact on Italy's exports than domestic economic policies. The wars plaguing Europe in the XIX century, both military or only commercial, also had severe repercussions on the Italy's economy and its trade relationships (Stringher, 1911). The 1880s, which saw the exports of

[79] An example is offered, in the early 1950s, by the negotiations for the so-called *conglobamento*, which consisted in the inclusion of many items composing the salary into a unique item. During these negotiations, CGIL, the largest Italian trade union, claimed generalized wage rises in the order of 10%. The negotiation was concluded in 1954 by Confindustria, the federation of industrial employers, and CISL and UIL, the two other main trade unions, who accepted for smaller pay rises (about 5% in the industrial sector), without the agreement of CGIL (see Horowitz, 1966).

[80] In 1862-63, silk products and olive oil, alone, represented 50% of the value of Italy's exports. France, still in 1870s, was the destination of half of Italy's exports.

the first manufactures, were dominated, on the one hand, by the uncertainties about the tariff regime (Stringher, 1911); on the other hand, the excessively expansionary monetary and fiscal policies and the lack of government supervision of the banks of issue prepared the ground for the banking crisis exploded in 1893 (Cesarano, Cifarelli and Toniolo, 2009).

From 1920 to 1939, instead, the causes of slow growth were mainly external. As Ciocca (1976) puts it, the interwar period was not a good time to be a small open economy. In Western Europe, the destination of 60% of Italy's foreign sales, the volume of exports recovered to 1913 levels only in 1928; similarly, the ratio of exports to GDP recovered to its 1913 value only in 1929.[81] It followed the Great Depression, the protectionist revival and the trade sanctions that led to the autarkic policy. The slow reabsorption of undervaluation until the mid-1930s was mostly due to the rapid loss of workers' bargaining power. The violence of the fascist regime since the early 1920s, and then the dismantling of the pre-existing trade unions and the introduction of a unique Fascist union hampered the normal functioning of the labor market, transforming wages into a policy variable.

From the early 1990s, another period of slow growth in Italy compared to other advanced economies, Italy's currency was largely overvalued. Figure 7 shows that during the 1990s and 2000s wages kept growing more rapidly than labor productivity. It also shows that the disappointing performance of labor productivity during the last 20 years is unprecedented in the whole post World War II period. Also due to the 2008-09 crisis, labor productivity growth in the 2000s has been virtually zero. The tendency to an overvaluation that had first appeared in the early 1990s and had been absorbed with EMS crisis in 1992 returned in the 2000s, as the nominal appreciation of the euro further deteriorated Italy's price competitiveness. The estimates performed in Section 2, however, suggest that the negative contribution of the exchange rate to GDP growth during the last 20 years was quite low. In fact, when restricted to the set of advanced countries, to which Italy belongs, the elasticity of growth to undervaluation is barely positive (equal to 0.3%). Even the very large bilateral overvaluation of the lira/euro vis-à-vis the US dollar (about 40%) would translate into a very small contribution of overvaluation to growth (in the order of -0.1% per year).

To conclude, Italy saw phases of rapid economic growth while the currency was either undervalued or in equilibrium. On the other hand, undervaluation did not necessarily brought about sustained GDP growth. Overall, these results are consistent with the hypothesis that an undervalued currency is rather a *facilitating condition*, but not an engine, for economic growth (Eichengreen, 2008a).

[81] In 1927, tariff levels in many European countries were still higher than in 1913, including in Germany, Italy, Switzerland, Spain and in most Eastern Europe (Liepmann, 1938).

Part III

Appendix

A Data

The source of the data used in Section 2 for the post World War II period is the Penn World Table. For the period before World War II, the sample of countries include: Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Columbia, Denmark, Finland, France, Germany, Greece, Hungary, India, Indonesia, Italy, Japan, Netherlands, New Zealand, Norway, Peru, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Taiwan, Turkey, United Kingdom, United States and Venezuela. Data sources are described below.

Nominal exchange rates vis-à-vis the US dollar: Bank of Japan (1966), Bordo, Eichengreen, Klingebiel and Martinez-Peria (2001), Carreras and Tafunell (2005), Carter, Gartner, Haines, Olmstead, Sutch and Wright (2006), Ciocca and Ulizzi (1990), Flandreau and Zumer (2004), OxLAD (2010).

Consumer and wholesale price indices: Ballesteros (1997), della Paolera and Ortiz (1995), Mitchell (2008), Norges Bank (online data), Swiss Economic and Social History (online data).

Real GDP per capita: Bordo, Eichengreen, Klingebiel and Martinez-Peria (2001), Carter, Gartner, Haines, Olmstead, Sutch and Wright (2006), Maddison (2010).

B Proofs for the model with constant returns to scale

B.1 Closed economy

To simplify he computations, we proceed in three stages.

Stage 1. Let us rewrite the consumer's problem as:

$$\max_{c_i^T, c_i^N} \left[\left[\left(c_i^T\right)^{\frac{\eta-1}{\eta}} + \left(c_i^N\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} ; \text{subj. to: } p_i^N c_i^N + p_i^T c_i^T \leq w_i L_i \right]$$

where: $p_i^m c_i^m = \int p_i^m(j)\, c_i^m(j)\, dj$, that is: $p_i^m = (c_i^m)^{-1} \int p_i^m(j)\, c_i^m(j)\, dj$, $\forall m = T, N$. From the first order conditions and the budget constraint, we get the demand for the non-tradeable and the tradeable bundles of goods:

$$\begin{aligned} c_i^N &= \frac{(p_i)^{\eta-1}}{\left(p_i^N\right)^{\eta}} w_i L_i \text{ and } c_i^T = \frac{(p_i)^{\eta-1}}{\left(p_i^T\right)^{\eta}} w_i L_i \\ \text{where } &: \; p_i = \left[\left(p_i^N\right)^{1-\eta} + \left(p_i^T\right)^{1-\eta} \right]^{1/(1-\eta)} . \end{aligned}$$

Of course, expenditures for non-tradeable and tradeable goods are:

$$\begin{aligned} p_i^N c_i^N &= \frac{\left(p_i^N\right)^{1-\eta}}{\left(p_i^T\right)^{1-\eta} + \left(p_i^N\right)^{1-\eta}} w_i L_i \\ p_i^T c_i^T &= \frac{\left(p_i^T\right)^{1-\eta}}{\left(p_i^T\right)^{1-\eta} + \left(p_i^N\right)^{1-\eta}} w_i L_i \ . \end{aligned}$$

Stage 2. Now consider the two problems:

$$\begin{aligned} &\max_{c_i^N(j)} \left[\left\{ \int \left[c_i^N(j) \right]^{\frac{\sigma-1}{\sigma}} dj \right\}^{\frac{\sigma}{\sigma-1}} ; \text{subj. to: } \int p_i^N(j)\, c_i^N(j)\, dj \leq p_i^N c_i^N \right] \\ &\max_{c_i^T(j)} \left[\left\{ \int \left[c_i^T(j) \right]^{\frac{\sigma-1}{\sigma}} dj \right\}^{\frac{\sigma}{\sigma-1}} ; \text{subj. to: } \int p_i^T(j)\, c_i^T(j)\, dj \leq p_i^T c_i^T \right] \end{aligned}$$

From the first order conditions and the budget constraint we obtain:

$$\begin{aligned} c_i^N(j) &= \frac{\left(p_i^N\right)^{\sigma-1}}{\left[p_i^N(j)\right]^{\sigma}} \frac{\left(p_i^N\right)^{1-\eta}}{\left(p_i^T\right)^{1-\eta} + \left(p_i^N\right)^{1-\eta}} w_i L_i \\ c_i^T(j) &= \frac{\left(p_i^T\right)^{\sigma-1}}{\left[p_i^T(j)\right]^{\sigma}} \frac{\left(p_i^T\right)^{1-\eta}}{\left(p_i^T\right)^{1-\eta} + \left(p_i^N\right)^{1-\eta}} w_i L_i \end{aligned}$$

where: $p_i^m = \left\{ \int \left[p_i^m(j)\right]^{1-\sigma} dj \right\}^{\frac{1}{1-\sigma}}$, $\forall m = T, N$.[82]

Stage 3. Given $p_i^N(j) = w_i / z_i^N(j)$, we now solve for the resource constraint, $c_i^N(j) = q_i^N(j)$, and obtain:

$$\begin{aligned} L_i^N(j) &= \frac{\left[z_i^N(j)\right]^{\sigma-1}}{\int \left[z_i^N(j)\right]^{\sigma-1} dj} L_i^N \text{ and } L_i^T(j) = \frac{\left[z_i^T(j)\right]^{\sigma-1}}{\int \left[z_i^T(j)\right]^{\sigma-1} dj} L_i^T \\ \text{where } L_i^N &= \frac{\left(p_i^N\right)^{1-\eta}}{\left(p_i^T\right)^{1-\eta} + \left(p_i^N\right)^{1-\eta}} L_i \text{ and } L_i^T = \frac{\left(p_i^T\right)^{1-\eta}}{\left(p_i^T\right)^{1-\eta} + \left(p_i^N\right)^{1-\eta}} L_i \end{aligned}$$

By aggregating across industries the quantities $q_i^m(j)$, we can find:

$Q_i^m = \int q_i^m(j)\, dj = \int z_i^m(j)\, L_i^m(j)\, dj = \frac{\int \left[z_i^N(j)\right]^{\sigma} dj}{\int \left[z_i^N(j)\right]^{\sigma-1} dj} L_i^m = A^m L_i^m$, $\forall m = T, N$. Thus:

$$\begin{aligned} Q_i^N &= A_i^N L_i^N \text{ and } Q_i^T = A_i^T L_i^T \\ A_i^m &= \frac{\int \left[z_i^m(j)\right]^{\sigma} dj}{\int \left[z_i^m(j)\right]^{\sigma-1} dj}, \ \forall m = T, N \end{aligned}$$

---

[82] It is easy to check that: $\left\{ \int \left[p_i^m(j)\right]^{1-\sigma} dj \right\}^{\frac{1}{1-\sigma}} = \left(c_i^m\right)^{-1} \int p_i^m(j)\, c_i^m(j)\, dj$, $\forall m = T, N$. In other words, the price index defined in the first step is the same as the one defined in the second step.

Note also that aggregate production and real GDP are:[83]

$$\begin{aligned} Q_i &= Q_i^N + Q_i^T = A_i^N L_i^N + A_i^T L_i^T \\ \frac{Q_i}{L_i} &= A_i^N \frac{L_i^N}{L_i^T + L_i^N} + A_i^T \frac{L_i^T}{L_i^T + L_i^N} \end{aligned}$$

Similarly, we can compute the real wage as:

$$\frac{w_i}{p_i} = \left[\left(\left\{ \int \left[z_i^N (j) \right]^{\sigma-1} dj \right\}^{\frac{1}{1-\sigma}} \right)^{1-\eta} + \left(\left\{ \int \left[z_i^T (j) \right]^{\sigma-1} dj \right\}^{\frac{1}{1-\sigma}} \right)^{1-\eta} \right]^{1/(\eta-1)}.$$

Key equations. Summing up, the main equations of the autarky equilibrium are:

$$\frac{p_i^T}{p_i^N} = \left[\frac{\int \left[z_i^N (j) \right]^{\sigma-1} dj}{\int \left[z_i^T (j) \right]^{\sigma-1} dj} \right]^{\frac{1}{\sigma-1}} \tag{36}$$

$$\frac{L_i^N}{L_i^T} = \left(\frac{p_i^T}{p_i^N} \right)^{\eta-1} \tag{37}$$

$$\frac{c_i^N}{c_i^T} = \left(\frac{p_i^T}{p_i^N} \right)^{\eta} \tag{38}$$

$$\frac{A_i^N}{A_i^T} = \frac{\int \left[z_i^N (j) \right]^{\sigma} dj}{\int \left[z_i^N (j) \right]^{\sigma-1} dj} \left(\frac{\int \left[z_i^T (j) \right]^{\sigma} dj}{\int \left[z_i^T (j) \right]^{\sigma-1} dj} \right)^{-1} \tag{39}$$

$$Q_i = A_i^N L_i^N + A_i^T L_i^T \tag{40}$$

$$\frac{w_i}{p_i} = \left[\left(\left\{ \int \left[z_i^N (j) \right]^{\sigma-1} dj \right\}^{\frac{1}{1-\sigma}} \right)^{1-\eta} + \left(\left\{ \int \left[z_i^T (j) \right]^{\sigma-1} dj \right\}^{\frac{1}{1-\sigma}} \right)^{1-\eta} \right]^{1/(\eta-1)} \tag{41}$$

With the assumption that efficiencies are Fréchet distributed, equations (36)-(41) immediately turn into the equations (4)-(9) reported in Section 3.1.1.

B.2 Open economy

We start by computing demand and supply for each non-tradeable and tradeable good. From the first order conditions and the budget constraint we obtain demand:

$$\begin{aligned} c_i^N (j) &= \frac{\left(p_i^N \right)^{\sigma-1}}{\left[p_i^N (j) \right]^{\sigma}} w_i L_i^N \\ c_i^T (j) &= \frac{\left(p_i^T \right)^{\sigma-1}}{\left[p_i^T (j) \right]^{\sigma}} w_i L_i^T \end{aligned}$$

By imposing that prices are equal to marginal costs, we can solve for the resource constraint.

[83] We can sum the quantities of non-tradeable and tradeable goods as long as they show up symmetrically into the utility function. In this case, the different goods are formally equivalent to different varieties of the same good. The key to this computation is to define physical units in the same way as they enter the utility function, so that we are summing up quantities measured in the same "efficiency units" (for more on this point see Demidova and Rodríguez-Clare, 2009).

1. For a non-tradeable good j we have:

$c_i^N(j) = q_i^N(j) \Leftrightarrow \frac{(p_i^T)^{\sigma-1}}{[p_i^T(j)]^{\sigma}} \frac{(p_i^T)^{1-\eta}}{(p_i^T)^{1-\eta}+(p_i^N)^{1-\eta}} w_i L_i = z_i^N(j) L_i^N(j)$; therefore: $L_i^N(j) = \frac{[z_i^N(j)]^{\sigma-1}}{\int [z_i^N(j)]^{\sigma-1} dF_{i.o}^N(j)} L_i^N$

where $F_{i.o}^N = F_i^N$ that is: the productivity distributions for non-tradeable goods of the open and the autarky economy are identical.

2. If the good j is sold only domestically (which happens if $w_i/z_i^T(j) < w_n d_{in}/z_n^T(j)$), then:

$L_i^T(j) = \frac{[z_i^T(j)]^{\sigma-1}}{\int [z_i^T(j)]^{\sigma-1} F_{i,o}^T(j)} L_i^T$

where, as mentioned, $F_{i.o}^T \neq F_i^T$ that is: the productivity distributions for tradeable goods of the open and the autarky economy are different (in particular, we can show that $F_{i.o}^T < F_i^T$; in other words: $F_{i.o}^T$ first-order stochastically dominates F_i^T).

3. If the good j is sold both at home and abroad (which happens if $w_i d_{ni}/z_i^T(j) < w_n/z_n^T(j)$), then:

$c_i^T(j) + c_n^T(j) = q_i^T(j) \Leftrightarrow \frac{(p_i^T)^{\sigma-1}}{[p_i^T(j)]^{\sigma}} w_i L_i^T + \frac{(p_n^T)^{\sigma-1}}{[p_{ni}^T(j)]^{\sigma}} w_n L_n^T = z_i^T(j) L_i^T(j)$

$\Leftrightarrow \frac{[z_i^T(j)]^{\sigma}}{\int [z_i^T(j)]^{\sigma-1} F_{i,o}^T(j)} L_i^T + \frac{[z_i^T(j)]^{\sigma}}{w_i^{\sigma} d_{ni}^{\sigma}} \frac{w_n^{\sigma-1}}{\int [z_n^T(j)]^{\sigma-1} F_{n,o}^T(j)} w_n L_n^T = z_i^T(j) L_i^T(j)$

$\Leftrightarrow L_i^T(j) = \frac{[z_i^T(j)]^{\sigma-1}}{\int [z_i^T(j)]^{\sigma-1} F_{i,o}^T(j)} L_i^T + \frac{[z_i^T(j)]^{\sigma-1}}{\int [z_n^T(j)]^{\sigma-1} F_{n,o}^T(j)} \left(\frac{w_n}{w_i d_{ni}}\right)^{\sigma} L_n^T$

where the second addendum represents the extra demand coming from abroad. Thus, we have:

$$
\begin{aligned}
L_i^N(j) &= \frac{[z_i^N(j)]^{\sigma-1}}{\int [z_i^N(j)]^{\sigma-1} dF_{i.o}^N(j)} L_i^N \\
L_i^T(j) &= \frac{[z_i^T(j)]^{\sigma-1}}{\int [z_i^T(j)]^{\sigma-1} F_{i,o}^T(j)} L_i^T \text{ , if } j \text{ is sold only domestically} \\
L_i^T(j) &= \frac{[z_i^T(j)]^{\sigma-1}}{\int [z_i^T(j)]^{\sigma-1} F_{i,o}^T(j)} L_i^T + \frac{[z_i^T(j)]^{\sigma-1}}{\int [z_n^T(j)]^{\sigma-1} F_{n,o}^T(j)} \left(\frac{w_n}{w_i d_{ni}}\right)^{\sigma} L_n^T \text{ , if } j \text{ is exported}
\end{aligned}
$$

Aggregate production is $Q_i = A_{i,o}^N L_i^N + A_{i,o}^T L_i^T$. However, while productivity for non-tradeable goods is still given by $A_{i,o}^N = A_i^N = E\left[(Z_i^N)^{\sigma}\right] / E\left[(Z_i^N)^{\sigma-1}\right]$, the expression of $A_{i,o}^T$ is given by:

$$A_{i,o} = \frac{E\left(Z_{i,o}^{\sigma}\right) + bE\left(Z_{i,e}^{\sigma}\right)}{E\left(Z_{i,o}^{\sigma-1}\right) + bE\left(Z_{i,o}^{\sigma-1}\right)}$$

$$\text{where: } b = \frac{\pi_{ni}}{1-\pi_{ii}} \left(\frac{\Phi_i}{\Phi_n}\right)^{1+\frac{1}{\theta}(\sigma-1)} d_{in}^{-(\theta+\sigma)} .$$

C Trade equilibrium with increasing returns to scale

We can rearrange the conditions under which good j is: exported (i.e. sold at home and abroad using a pure pricing strategy), sold at home and abroad using a mixed pricing strategy, sold only domestically, or imported.

Country i exports good j if and only if the following two conditions hold:

$$\frac{z_i^T(j)}{z_n^T(j)} \geq \frac{w_i}{w_n} \frac{q_i^T(j) + d_{ni} q_n^T(j)}{d_{in} q_i^T(j) + q_n^T(j)} \tag{42}$$

$$\frac{z_i^T(j)}{z_n^T(j)} \geq \frac{w_i d_{ni}}{w_n} \frac{A_j \left[q_n^T(j)\right]}{A_j \left[\tilde{q}^T(j)\right]} \tag{43}$$

Country i sells good j at home and abroad using a mixed strategy if and only if: (i) inequality (42) holds; (ii) inequality (43) does not hold; and (iii):

$$\frac{z_i^T(j)}{z_n^T(j)} \geq \frac{w_i}{w_n} \left[\frac{c_i(j) + c_n(j) d_{ni}}{A_j \left[\tilde{c}^T(j)\right]}\right] \cdot \left[\frac{c_n(j)}{A_j \left[c_i^T(j)\right]} + \frac{c_i(j)}{A_j \left[c_n^T(j)\right]}\right] \tag{44}$$

Country i sells good j only at home if and only if: (i) inequality (42) holds; (ii) inequality (43) does not hold; and (iii) inequality (44) does not hold. In this case, also firms in country n adopt a pure pricing strategy and sell their goods only in their domestic market.

Country i imports good j if and only if: (i) inequality (42) does not hold; and (ii)

$$\frac{z_i^T(j)}{z_n^T(j)} \leq \frac{w_i}{w_n d_{in}} \frac{A_j \left[\tilde{q}^T(j)\right]}{A_j \left[q_i^T(j)\right]} \tag{45}$$

Let us consider the initial impact (before wages keep rising) of a depreciation. Suppose that for the firm of country i that produces good j, inequality (43) is fulfilled, while the LHS of (42) is equal to the RHS (i.e. (42) holds with an equality). Thus, this firm does not export its good because the constraint (42) is not fulfilled. Now consider a rise of d_{in} to $d'_{in} = \delta d_{in}$ and a decline of d_{ni} to $d'_{ni} = d_{in}/\delta$ ($\delta > 1$). It is straightforward to check that inequality (42) now holds, while inequality (43) keeps holding. In other words, this firm (and, possibly, others) can now export its good to country n. For what concerns imports, one can verify, using the same approach, that if inequality (45) held before the depreciation, it keeps holding also after the depreciation; on the other hand, if the reciprocal (42) was such that, for a good j' the LHS was equal to the RHS, then this equation is now violated. In other words, the good j' is no longer imported.

We now turn to case in which wages rise from w_i to $w'_i = \delta w_i$ (for simplicity, normalize $w_n = 1$). Again, it is easy to check that both inequalities (42) and (43) keep holding for the "marginal good" j. Hence, despite the rise in wages (for an amount offsetting the depreciation), the firm of country i that produces good j keeps exporting in country n. Note also that, due to the rise in the quantity produced and the presence of increasing returns to scale, the decline in the average cost of this firm is higher than δ%, which is the extent of the depreciation. Therefore, the rise in wages by δ% is not enough to offset the decline in average costs. By the same token, the "marginal" good j' that was imported before the depreciation and made domestically after the depreciation, keeps being produced at home also after the rise in wages.

What happens in the labor market? The tradeable-goods sector is demanding more workers, because of the newly exported goods and the goods that are produced at home and no longer imported. The domestic price of tradeable goods, then, increases relative to the price of non-tradeable goods, because both the newly produced goods and the goods that the country keeps importing are more expensive. On the other hand, recall that $L_i^T/L_i^N = \left(p_i^T/p_i^N\right)^{1-\eta}$. Hence, under the standard assumption that $\eta < 1$, the non-tradeable-goods sector releases workers.

Notice that we cannot asses whether the rise in w_i to $w_i' = \delta w_i$ is necessary or sufficient to restore equilibrium. It could exceed or fall short of the necessary adjustment. Suppose, for instance, that at $w_i' = \delta w_i$ there is an excess demand of workers in the tradeable sector. Then, wages keep rising until equilibrium is restored. As wages rise, some exporters will be crowded out as well as some firms that produced only for the domestic market. In any case, the equilibrium is no longer the same as the one before the depreciation. Some firms that previously produced or exported their goods can no longer do it, due to the higher wages. Some other domestic firms that have been able to enter the domestic or the foreign market remain in these markets. These are the firms that had the largest cost gains from increasing returns to scale.

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