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EVERY CLOUD HAS A SILVER LINING.
THE SOVEREIGN CRISIS AND ITALIAN POTENTIAL OUTPUT

by Andrea Gerali, Alberto Locarno, Alessandro Notarpietro and Massimiliano Pisani*

Abstract

This paper evaluates the direct and indirect effects of the sovereign debt crisis on Italy's potential output. The direct effects are captured by the increase in the interest rate paid by Italian borrowers in the second half of 2011, the indirect effects by the policy responses to the crisis (fiscal consolidation and structural reforms). Using a New Keynesian dynamic general equilibrium model, we compute potential output as the "natural" level of output in the absence of nominal price and wage rigidities. The evaluation posits a no-crisis scenario in line with the pre-2011 potential output projections and government budget rules. We find first that the fiscal and financial shocks that caused the 2011-2013 recession subtracted 1.6 percentage points from potential output growth, while the structural reforms in 2013 have limited the reduction in output capacity to about 1.4 points; second, that the structural reforms have a long-run growth-enhancing impact on potential output of around 3 points from now to 2030; and third, that once budget balance is achieved in the medium term, reductions in either labor or capital income taxes would boost potential output growth by about 0.2 points per year.

JEL Classification: C51, E31, E52.
Keywords: sovereign risk, fiscal policy, potential output.

Contents

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1 Introduction[1]

The 2011 sovereign debt crisis and the related policy responses will have a long-lasting impact on the Italian economy. For the remaining part of the decade (and possibly for longer) the record-level tax pressure, the higher cost of borrowing, and the gradual shift to the reformed setting in the labour market and services sector are expected to be key drivers of economic activity.[2] While structural reforms will give a permanent boost to the level of potential output, drags from taxes and financing costs are likely to be long-lasting but transitory. Risk premia and taxes are expected to return to normal (lower) levels as soon as public finances are in order and the debt-to-gross domestic product (GDP) ratio follows a decreasing path towards the 60 percent target. Exactly because of their persistence and size, the three drivers are likely to affect not only aggregate demand, but also the supply side of the Italian economy, through their effects on the accumulation of productive factors.

This paper evaluates the impact on Italian potential output over the 2011–2030 period of the sovereign debt crisis and its aftermath, making use of a calibrated New Keynesian dynamic general equilibrium model. The model is large and structural. It features nominal price and wage rigidities and real frictions, such as adjustment costs on investment and habits in consumption. Private-sector spending decisions are affected by fiscal measures, sovereign spreads and structural reforms. Potential output is defined in terms of "natural" output. It is the output obtained by simulating the model under the assumptions that nominal prices and wages are fully flexible (i.e. nominal rigidities are absent) and (net) markups are greater than zero. We use natural output because we simulate a scenario where the degree of monopolistic competition in the service sector is exogenously reduced, to capture the effects of pro-competition reforms.[3]

We initially assess, over the 2011–2013 period, the impact on Italian potential out-

[1]The views expressed in this paper are those of the authors and should not be attributed to the Bank of Italy. We thank Gianni Amisano, Guido Bulligan, Giuseppe Ferrero, Massimiliano Marcellino, Stefano Siviero and two anonymous referees for useful comments. All errors are ours.

[2]The current draft was finalized before the announcement of the launch of the Extended Asset Purchase Program of the Eurosystem in January 2015.

A firm downward trend in the sovereign risk premium started only in July 2012, when the President of the European Central Bank Draghi announced (and then launched) the Outright Monetary Transactions (OMT) program, which dissipated the fears of a EA break-up and eased financial market tensions.

Therefore, in the following we do not consider the possible effects on sovereign spreads of the purchase of long-term sovereign bonds on secondary markets. To be sure, such effects are expected to be non-negligible and indeed sovereign spreads fell substantially in the first days after the launch of the program in March 2015.

[3]Justiniano *et al.* (2013) also use the natural output to estaimte US potential output.

put of (i) the observed increase in sovereign risk, measured by the yield spread of Italian Treasury bonds with respect to the German ones (henceforth just spread); (ii) the implemented fiscal consolidation measures and (iii) structural (competition-friendly) reform packages. We then evaluate, for the period 2014–2018, the impact of fiscal measures that will bring indebtedness of the General Government to zero, so triggering the progressive reduction of the debt-to-GDP ratio and hence of the spread. For the 2019–2030 period, we assume a permanently balanced public-sector budget and assess the contribution to potential output growth of the joint decrease of financing costs and taxation (either on labor or on capital), made possible by apportioning the resources made available by the lower debt burden to reducing distortionary taxation.

The main findings of the paper are the following. First, fiscal and sovereign-risk shocks, responsible for the 2011–2013 recession, subtract -1.6pp to potential output growth. The largest negative contribution is attributed to fiscal consolidation, while spread plays a relatively minor role. The 2013 structural reforms limit the reduction in supply capacity, to about 1.4pp. Second, the growth-enhancing impact of structural reforms over the 2011-2030 period is around 3pp, less than estimated by International Monetary Fund (IMF) and Organization for Economic Co-operation and Development (OECD). Third, in 2019–2030, the reductions in either labor or capital income taxes would boost potential output growth by nearly 0.1–0.3pp per year.

The structural model-based approach we use in this paper should be considered as complementary to "standard" statistical approaches. Its advantage relies on its theoretical foundations. Households and firms are forward-looking and their (optimal) decisions derive of explicit maximization problems, that factor-in current and future (anticipated) economic conditions, affected by policy decisions. This allows us to condition the potential output dynamics on the main exogenous sources of fluctuations in an internally consistent way. Our contribution adds to the existing literature that tries to evaluate potential output by using the New Keynesian framework, so as to understand its implications for the policy analysis. Among the others, Levin *et al.* (2005), Andres *et al.* (2005), Edge *et al.* (2008), Justiniano *et al.* (2013), Sala *et al.* (2008) estimate the US potential output. Vetlov *et al.* (2011) estimate EA potential output. Different from these contributions, we use the New Keynesian model to evaluate the impact of the recent financial crisis on Italian potential output.

The paper is organized as follows. Section 2 presents the model used. Section 3 illustrates the calibration of the model and the simulated scenarios. Section 4 shows the results. Section 5 concludes.

2 The model

The model represents a world economy composed of three regions: Italy, rest of the euro area (REA) and rest of the world (RW). In each region there is a continuum of symmetric households and symmetric firms. Italian households are indexed by $j \in [0; s]$, households in the REA by $j^* \in (s; S]$, households in the RW by $j^{**} \in (S; 1]$.[4]

Italy and the REA share the currency and the monetary authority, that sets the nominal interest rate according to euro area (EA)-wide variables. The presence of the RW outside the EA allows to assess the role of the nominal exchange rate and extra-EA trade in transmitting the shocks. Households consume a final good, which is a composite of intermediate nontradable and tradable goods. The latter are domestically produced or imported. Households trade a one-period nominal bond, denominated in euro. They also own domestic firms and use another final good (different from the final consumption good) to invest in physical capital. The latter is rented to domestic firms in a perfectly competitive market. All households supply differentiated labor services to domestic firms and act as wage setters in monopolistically competitive labor markets by charging a markup over their marginal rate of substitution between consumption and leisure.

On the production side, there are perfectly competitive firms that produce the two final goods (consumption and investment goods) and monopolistic firms that produce the intermediate goods. The two final goods are sold domestically and are produced combining all available intermediate goods using a constant-elasticity-of-substitution (CES) production function. The two resulting bundles can have different composition. Intermediate tradable and nontradable goods are produced combining domestic capital and labor, that are assumed to be mobile across sectors. Intermediate tradable goods can be sold domestically and abroad. Because intermediate goods are differentiated, firms have market power and restrict output to create excess profits. We also assume that markets for tradable goods are segmented, so that firms can set three different prices, one for each market. Similarly to other models of the EA (see, among the others, Christoffel *et al.* 2008 and Gomes *et al.* 2010), we include adjustment costs on real and nominal variables, ensuring that, in response to a shock, consumption, production and prices react in a gradual way. On the real side, habit preferences and quadratic costs prolong the adjustment of households consumption and investment, respectively. On the

[4]The parameter s is the size of the Italian population, which is also equal to the number of firms in each Italian sector (final nontradable, intermediate tradable and intermediate nontradable). Similar assumptions holds for REA and RW.

nominal side, quadratic costs make wages and prices sticky.[5]

In the following sections we describe, for the case of Italy, the fiscal policy setup, the monopolistic competition regime in the intermediate nontradable sector and the households' problem. Similar equations, not reported to save on space, hold for other regions. The only exception is the equation of the sovereign spread, that holds for Italy only.[6]

2.1 Fiscal authority

Fiscal policy is set at the regional level. The government budget constraint is

$$\frac{B_{t+1}^g}{R_t^H} - B_t^g = (1+\tau_t^c)P_{N,t}C_t^g + Tr_t - T_t, \tag{1}$$

where $B_t^g \geq 0$ is nominal public debt. It is a one-period nominal bond issued in the domestic market that pays the gross nominal interest rate R_t^H. The latter is determined as a spread over the EA risk-free nominal interest rate:

$$R_t^H \equiv R_t * spread_t^H, \tag{2}$$

where R_t is the (gross) risk-free nominal interest rate, where the spread is proportional to the public debt, as in Corsetti *et al.* (2012).

For other variables in the budget constraint, C_t^g represents government purchases of goods and services, $Tr_t > 0$ (< 0) are lump-sum transfers (taxes) to households. Consistent with the empirical evidence, C_t^g is fully biased towards the intermediate nontradable good. Hence it is multiplied by the corresponding price index $P_{N,t}$.[7] We assume that the same tax rates apply to every household. Total government revenues T_t from distortionary taxation are given by the following identity:

$$T_t \equiv \int_0^s \left(\tau_t^\ell W_t(j) L_t(j) + \tau_t^k \left(R_t^k K_{t-1}(j) + \Pi_t^P(j)\right) + \tau_t^c P_t C_t(j)\right) dj - \tau_t^c P_{N,t} C_t^g, \tag{3}$$

where τ_t^ℓ is the tax rate on individual labor income $W_t(j) L_t(j)$, τ_t^k on capital income $R_t^k K_{t-1}(j) + \Pi_t^P(j)$ and τ_t^c on consumption $C_t(j)$. The variable $W_t(j)$ represents the individual nominal wage, $L_t(j)$ is individual amount of hours worked, R_t^k is the rental rate of existing physical capital stock $K_{t-1}(j)$, $\Pi_t^P(j)$ stands for dividends from

[5] See Rotemberg (1982).

[6] In the Appendix we lay down the rest of the model.

[7] See Corsetti and Mueller (2006, 2008).

ownership of domestic monopolistic firms (they are equally shared across households) and P_t is the price of the consumption bundle.

The tax rates and public expenditure are appropriately adjusted to capture the different fiscal regimes considered in the simulations (the 2011-2013 consolidation packages, the 2014–2018 pursuit of a balanced budget and, in both no-crisis and crisis scenarios, the 2019–2030 reduction of tax rates.

Some remarks are in order. While sovereign default risk affects consumption and investment decisions by creating a wedge between the risk-free rate and the government bonds yield, we do not consider here the ex-post consequences of an actual default. As in Corsetti *et al.* (2012), the model does not allow for a strategic default, that would result from an explicit decision of the policymaker, comparing costs and benefits of the default. Thus, the premium is not microfounded. This is a deliberate choice, to make the model tractable. The link between sovereign risk premium and the expected path of public debt is imposed, (1) building on the result (from the literature on strategic default) that in equilibrium the probability of default increases in the level of debt, and (2) implicitly assuming that there are limits to credible commitment on the part of fiscal policymakers.

Equivalently, as in Corsetti *et al.* (2012), we assume that the government can make use of non-distortionary taxation (lump-sum transfers) so that, in case of a sovereign default, government bond holders would be compensated for their loss. Hence, while actual ex-post default is neutral, the ex-ante probability of default is crucial for the pricing of government debt and has real effects.

2.2 Monopolistic competition and structural reforms in the service sector

Monopolistic competition introduced as follows. In both tradable and nontradable sectors there is a large number of firms offering a continuum of different brands that are imperfect substitutes. Each product is made by one monopolistic firm, which sets price to maximize profits. In the long-run (flexible-price) steady state of the New Keynesian model, in each sector a first order condition for price setting like the following one holds:

$$\frac{P_{Y,i}}{P} = \frac{\theta_i}{\theta_i - 1} \frac{MC_i}{P}, \ \theta_i > 1, \tag{4}$$

where $P_{Y,i}/P$ is the relative price of the "representative" brand Y_i produced in the sector and MC_i/P is the real marginal cost (with $i = T, N$ in the tradable and non-

tradable sector, respectively). The markup is $\theta_i/(\theta_i - 1)$ and depends negatively on the elasticity of substitution between different varieties, θ_i. The higher the degree of substitutability, the lower the implied markup and prices, the higher the production level. As such, the markup reflects imperfect competition. When simulating structural reforms, we permanently increase the elasticity of substitution among intermediate nontradable goods (our proxy for services) to augment the degree of competition in that sector. Note that in the New Keynesian model a modified version of equation (4) holds in the short run, as the markup depends not only on the elasticity of substitution, but also on nominal rigidities (formalized as quadratic costs that firms have to pay for adjusting their prices).[8] The above equation holds in both short- and long-run when nominal rigidities are switched off, as it is the case when computing the natural output. We add, as a caveat, that, as with any macroeconomic model, our analysis has limitations. The model can only approximate the scope of the reforms, as the model is restricted to two sectors, tradable and non-tradable goods. This makes the direct analysis of specific reforms, such as a reduction of professional services costs, or a cut in entry barriers, only approximate.

2.3 Households

Households' preferences are additively separable in consumption and labor effort. The generic Italian household j receives utility from consumption C and disutility from labor L. The expected value of the lifetime utility is

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\frac{\left(C_t\left(j\right) - hC_{t-1}\right)^{1-\sigma}}{\left(1-\sigma\right)} - \frac{L_t\left(j\right)^{1+\tau}}{1+\tau} \right] \right\}, \tag{5}$$

where E_0 denotes the expectation conditional on information set at date 0, β is the discount factor ($0 < \beta < 1$), $1/\sigma$ is the elasticity of intertemporal substitution ($\sigma > 0$) and $1/\tau$ is the labor Frisch elasticity ($\tau > 0$). The parameter h ($0 < h < 1$) represents external habit formation in consumption.

[8] See the Appendix for more details.

The budget constraint of household j is

$$\begin{aligned} & \frac{B_t(j)}{\left(1+R_t^B\right)} - B_{t-1}(j) + \frac{B_t^g(j)}{\left(1+R_t^H\right)} - B_{t-1}^g(j) \\ \leq\ & (1-\tau_t^k)\left(R_t^K K_{t-1}(j) + \Pi_t^P(j)\right) + \\ & +(1-\tau_t^\ell) W_t(j) L_t(j) - (1+\tau_t^c) P_t C_t(j) - P_t^I I_t(j) \\ & +Tr_t(j) - AC_t^W(j). \end{aligned}$$

Italian households hold a one-period nominal bond, B_t, denominated in euro ($B_t > 0$ is a lending position) and traded internationally with REA and RW households. The short-term nominal rate R_t^B is paid at the beginning of period t and is known at time t.[9] Moreover, Italian households hold the Italian government bond B_t^g, paying the interest rate R_t^H, which includes the sovereign spread as illustrated above. An increase in the sovereign risk spread implies a rise in the return of the government bond and, by a no-arbitrage condition, an increase in all the interest rates paid by Italian households. In this way, we introduce the rapid and complete pass-through of the sovereign spread to the private-sector, in line with empirical evidence reported by Albertazzi *et al.* (2012). Similarly, the higher spread increases the user cost of capital. Overall, the higher the spread, the higher the interest rate R_t^H and the larger the incentive for Italian households to postpone consumption and investment. Italian households accumulate physical capital K_t and rent it to domestic firms at the nominal rate R_t^k. The law of motion of capital accumulation is

$$K_t(j) = (1-\delta) K_{t-1}(j) + \left(1 - AC_t^I(j)\right) I_t(j), \ 0 < \delta < 1, \tag{6}$$

where δ is a parameter (the depreciation rate). Adjustment cost on investment AC_t^I is

$$AC_t^I(j) \equiv \frac{\phi_I}{2}\left(\frac{I_t(j)}{I_{t-1}(j)} - 1\right)^2, \ \phi_I > 0, \tag{7}$$

where ϕ_I is a parameter. Households own all domestic firms and there is no international trade in claims on firms' profits. The variable Π_t^P includes profits accruing to the Italian households. The variable I_t is the investment bundle in physical capital and P_t^I is its price index, which is different from the price index of consumption because the two bundles have different composition.[10] Finally, Italian households act as wage setters in a

[9] A financial friction μ_t is introduced to guarantee that net asset positions follow a stationary process and the economy converge to a steady state. See Benigno and Thoenissen (2008).

[10] See the Appendix for more details.

monopolistic competitive labor market. Each household j sets its nominal wage taking into account labor demand and quadratic adjustment costs AC_t^W on the nominal wage $W_t(j)$:

$$AC_t^W(j) \equiv \frac{\kappa_W}{2}\left(\frac{W_t(j)}{W_{t-1}(j)} - 1\right)^2 W_t(j), \ \kappa_W > 0. \tag{8}$$

where κ_W is the adjustment cost scale parameter. Similar relations hold in the REA and in the RW.

It is assumed that the "private" bond traded by households is in worldwide zero net supply. The implied market clearing condition is:

$$\int_0^s B_t(j)\,dj + \int_s^S B_t(j^*)\,dj^* + \int_S^1 B_t(j^{**})\,dj^{**} = 0, \tag{9}$$

where $B_t(j^*)$ and $B_t^{**}(j^{**})$ are respectively the per-capita bond positions of households in REA and in RW.

Finally, two remarks are due.

First, we are excluding the possible transmission of sovereign risk to REA (and RW). The country-specific nature of both Home interest rates R_t^B and R_t^H, can be interpreted as the result of a high degree of diversification in REA and RW, which allows households to isolate their income from idiosyncratic risk factors. So it is the riskless interest rate that appears in the corresponding REA and RW Euler equations. This is consistent with common practice in the New Keynesian open economy literature, which assumes, as we do, that the financial revenues from a country-specific risk premium are rebated in a lump-sum way to foreign households (REA households in our case).[11] As our main goal is an assessment of the effects of the Italian sovereign spread on the Italian potential output, these assumptions allow to focus the analysis.

The second point is that we stick to the New Keynesian framework and assume a representative household. Our estimate of the decline of households' consumption in correspondence of the increase in the spread should be considered as representing an upper bound. The expenditure decisions of indebted households and firms are negatively affected by the increase in spreads. However, households that do not have debt positions are likely to reduce to a lower extent, or not to reduce at all, their consumption expenditure in correspondence of the increase in the spread. This depends, for example, on the degree of substitutability between risk-free financial assets and sovereign bonds. The larger this substitutability, the larger the incentive, for a given income, to reduce

[11] See Benigno and Thoenissen (2008).

consumption and increase savings.

2.4 Monetary authority

The monetary authority sets the (short-term) policy rate R_t according to a Taylor rule of the form

$$\left(\frac{R_t}{\bar{R}}\right) = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho_R} (\Pi_{EA,t})^{(1-\rho_R)\rho_\pi} \left(\frac{GDP_{EA,t}}{GDP_{EA,t-1}}\right)^{(1-\rho_R)\rho_{GDP}}. \tag{10}$$

The parameter ρ_R $(0 < \rho_R < 1)$ captures inertia in interest-rate setting, while the term $\bar{R}$ represents the steady-state gross nominal policy rate. The parameters ρ_π and ρ_{GDP} are respectively the weights of EA CPI inflation rate $(\Pi_{EA,t})$ and GDP $(GDP_{EA,t})$. The CPI inflation rate is a geometric average of Italian and REA inflation rates, with weights equal to the correspondent (steady-state) regional GDP (as a share of the EA steady-state GDP). EA GDP is the sum of Italian and REA GDPs.

2.5 Calibration

The model is calibrated at quarterly frequency. We set some parameter values so that steady-state ratios are consistent with 2012 national account data, which are the most recent and complete available data. For remaining parameters we resort to previous studies and estimates available in the literature.[12]

Table 1 contains parameters that regulate preferences and technology. Parameters with "$*$" and "$**$" are related to the REA and the RW, respectively. Throughout we assume perfect symmetry between the REA and the RW, unless differently specified. We assume that discount rates and elasticities of substitution have the same value across the three regions. The discount factor β is set to 0.9927, so that the steady state real interest rate is equal to 3.0 per cent on an annual basis. The value for the intertemporal elasticity of substitution, $1/\sigma$, is 1 (logarithmic utility function in consumption). The Frisch labor elasticity is set to 0.5. The depreciation rate of capital δ is set to 0.025. Habit is set to 0.6.

In the production functions of tradables and nontradables, the elasticity of substitution between labor and capital is set to 0.93. To match investment-to-GDP ratios, the bias towards capital in the production function of tradables is set to 0.56 in Italy and, in the REA and in the RW, to 0.46. The corresponding value in the production

[12] Among others, see Forni *et al.* (2010a, 2010b).

function of nontradables is set to 0.53 in Italy and 0.43 in the REA and RW. In the final consumption and investment goods the elasticity of substitution between domestic and imported tradable is set to 1.5, while the elasticity of substitution between tradables and nontradables to 0.5, as empirical evidence suggests that it is harder to substitute tradables for nontradables than to substitute across tradables. The biases towards the domestically produced good and composite tradable good are chosen to match the Italy and REA import-to-GDP ratios. In the consumption bundle the bias towards the domestic tradeable is 0.68 in Italy, 0.59 in the REA and 0.90 in the RW. The bias towards the composite tradeable is set to 0.68 in Italy, to 0.5 in the REA and the RW. For the investment basket, the bias towards the domestic tradeable is 0.50 in Italy, 0.49 in the REA and 0.90 in the RW. The bias towards the composite tradable is 0.78 in Italy, 0.70 in the REA and in the RW.

Table 2 reports gross markup values, that represent updated estimates of those reported in Forni *et al.* (2010a). In the Italian tradable and nontradable sectors and in the Italian labor market the markup is set to 1.08, 1.29 and 1.60, respectively (the corresponding elasticities of substitution across varieties are set to 13.32, 4.44 and 2.65). In the REA tradable and nontradable sectors and in the REA labor market the gross markups are respectively set to 1.11, 1.24 and 1.33 (the corresponding elasticities are set to 10.15, 5.19 and 4.00). Similar values are chosen for the corresponding parameters in the RW.

Table 3 contains parameters that regulate the dynamics. The parameters are calibrated to generate dynamic adjustments for the EA similar to those obtained with the New Area Wide Model (NAWM, see Christoffel *et al.* 2008) and Euro Area and Global Economy Model (EAGLE, see Gomes *et al.* 2010, 2013). Adjustment costs on investment change are set to 1.0, so as to match the investment response to fiscal and financial shocks during the crisis as estimated by Busetti and Cova (2013). Nominal wage quadratic adjustment costs are set to 200. In the tradable sector, we set the nominal adjustment cost parameter to 300 for Italian tradable goods sold domestically and in the REA; for Italian goods sold in the RW, the corresponding parameter is set to 50. The same parameterization is adopted for the REA, while for the RW we set the adjustment cost on goods exported to Italy and the REA to 50. Nominal price adjustment costs are set to 500 in the nontradable sector. The two parameters regulating the adjustment cost paid by the private agents on their net financial position are set to 0.00055 so that they do not greatly affect the model dynamics.

The central bank of the EA (see Table 4) targets the contemporaneous EA wide

consumer price inflation (the corresponding parameter is set to 1.7) and the output growth (the parameter is set to 0.1). Interest rate is set in an inertial way and hence its previous-period value enters the rule with a weight equal to 0.87. Same values hold for the corresponding parameters of the Taylor rule in the RW.

Table 5 reports the actual great ratios which are matched in the model steady state under our baseline calibration. We assume a zero steady state net foreign asset position of each region. The size of Italian and REA GDP, as a share of world GDP, are set to 3 percent and to 17 percent, respectively.

As for fiscal policy variables, the public consumption-to-GDP ratio is set to 0.20. The tax rate on wage income τ^{ℓ} is set to 42.6 per cent in Italy and to 34.6 in the REA. The tax rate on physical capital income τ^{k} is set to 34.9 in Italy and 25.9 in the REA, while the tax rate on consumption τ^{c} is equal to 16.8 in Italy and to 20.3 in the REA. The public debt-to-yearly GDP ratio is calibrated to 129 percent for Italy and to 0.79 for the REA. Variables of the RW are set to values equal to those of corresponding REA variables.

3 The simulated scenarios

The overall simulation period is 2011–2030. We initially describe the baseline no-crisis scenario, thereafter the crisis scenario.

3.1 The no-crisis scenario (baseline)

We assess the impact on potential output of the financial and fiscal shocks with respect to the baseline scenario, in which the sovereign debt crisis did not take place ("no-crisis" scenario). The potential output is set according to data and forecasts for the 2011–2013 period of Italian (actual) GDP as formulated in mid 2011, before the outbreak of the sovereign crisis, and reported in the July 2011 Economic Bulletin of the Bank of Italy.[13] We maintain the presumption that for Italy the 2008–2009 recession, although unprecedented in its harshness, was mainly due to foreign demand shocks and, hence, did not substantially affect the supply capacity of the economy. From 2014 onwards, Italian potential output growth rate is assumed to be 1.1%.[14]

For the spread, it is set in line with its before-crisis average value, equal to 100bp.

[13] See Bank of Italy (2011).

[14] The model features an exogenous steady-state growth rate and does not allow for endogenous growth.

For fiscal measures, the deficit vanishes in 2025 as it is assumed that: (1) government spending is projected to increase in line with the pre-2007 period, namely outpacing nominal GDP growth by 0.5 per year; (2) no discretionary measure is assumed to be taken. Once the deficit vanishes, in 2025, it is assumed that the financial resources that become available are entirely used to reduce taxes on labour or capital.

This fiscal framework formalizes the assumption that the European Union (EU) fiscal governance would have been left unchanged had the sovereign debt crisis not occurred. To the opposite, because of the crisis the EU fiscal governance was modified by the introduction of the Six-pack, Fiscal compact and Two-pack. EA fiscal rules have become stricter and easier to enforce. Three changes in particular are worth mentioning. First, the Six-pack operationalises the debt criterion, so that an Excessive Deficit Procedure may also be launched on the basis of a debt ratio above 60% of GDP which would not diminish towards the Treaty reference value at a satisfactory pace (and not only on the basis of a deficit above 3% of GDP, which was the case up to 2011). Second, the Six-pack ensures stricter application of the fiscal rules by defining quantitatively what a "significant deviation" from the Medium-Term budgetary Objective (MTO) or the adjustment path towards it means in the context of the preventive arm of the Stability and Growth Pact (SGP). In addition, by introducing reverse qualified majority voting for most sanctions, it increases their likelihood for EA Member States.[15] The combination of these two prescriptions makes much more difficult for Member States not to comply with the rule demanding a 0.5% improvement in the structural budget deficit when it is too high. Third, the Six-pack imposes the compliance with an expenditure benchmark, aimed at keeping expenditure on a stable sustainable path over the cycle: government spending (net of interest payments, outlays on EU programmes fully matched by EU funds revenue, and non-discretionary changes in unemployment benefit expenditure) is to grow in line with medium-term potential GDP. Member States that have not yet reached their MTO should take steps to achieve it over the cycle; the adjustment efforts should attach a pivotal role to spending cuts, as the growth rate of expenditure in relation to that of medium-term potential GDP should be expected to yield an annual improvement in the government balance in cyclically adjusted terms net of one-offs and other temporary measures of 0.5% of GDP.

[15]Reverse qualified majority voting implies that a recommendation or a proposal of the Commission is considered adopted in the Council unless a qualified majority of Member States votes against it.

3.2 The crisis

The crisis scenario is characterized by three "shocks": sovereign spread, fiscal policy measures, structural reforms. We describe each in turn.

3.2.1 Spread

We focus on the excess return on 10-year Italian over German government bonds.

From 2011 to 2013, the spread is exogenously set to match its historical path. A series of upward shocks increases its level relative to the baseline. The spread, equals to approximately 100bp before the crisis, increases to: (i) 200bp in 2011Q1; (ii) 300bp in 2011Q3; (iii) 450bp in 2011Q4; (iv) 400bp during the first three quarters of 2012; (v) 300bp from 2012Q4 to 2013Q3 and, finally, (vi) 250bp in 2013Q4. The reversal of the upward trend occurs after the announcement of the ECB President Draghi of the launch of the Outright Monetary Transaction (OMT) program, which dissipated the fears of a EA break-up.

From 2014 to 2018 the spread falls by 50bp in 2014–2015, it keeps declining afterwards to 100bp (level achieved and the end of 2015), it further declines to zero in 2018. The reduction is obtained by calibrating to the Italian case the elasticity of sovereign spread to the public debt, as suggested by Corsetti *et al.* (2012).

Specifically, the following polynomial form is used to interpolate the exponential relation between government debt and sovereign spreads portraied in Figure 2 of Corsetti *et al.* (2012):

$$spread_t = 0.00087\left(\frac{B_t^g}{GDP_t}\right)^3 - 0.1014\left(\frac{B_t^g}{GDP_t}\right)^2 + 3.90941\left(\frac{B_t^g}{GDP_t}\right) - 454.492. \quad (11)$$

Consistent with empirical evidence, it is assumed that the increase in spread is quickly and fully passed-through to the financing conditions of the private sector ("sovereign risk channel").[16]

Table 6 reports the impact of the spread increase on the growth rate of Italian actual real GDP and its components over the 2011-2013 period. GDP, consumption and investment decrease. The spread increase induces a fall in GDP by 1.2% over the 2011-2012 period. A similar value is reported by Busetti and Cova (2013), that estimate the impact of the financial crisis and 2012-2013 Italian fiscal consolidation by simulating the Bank of Italy Quarterly Model.

[16] See Albertazzi *et al.* (2012).

3.2.2 Fiscal policy

In the simulations, up to 2013 fiscal variables replicate historical developments: for the 2011–2012 period we implement the consolidation packages, amounting to almost 5pp of GDP and consisting of higher taxes, mostly on consumption and real estates, for about 3/4 and public spending cuts for the remaining part.[17] We approximate the increase in real estate taxes by appropriately increasing consumption and labour income taxes. This directly follows from the model specification. Ideally, fixed or quasi-fixed factors (such as land or structures) should be included in the model. For the sake of tractability, we keep a relatively standard production function in capital and labor and a standard utility function and approximate the taxation of real estate wealth by equally splitting the tax base into consumption and labour income.

From 2014 to 2018, the fiscal variables dynamics is assumed to be consistent with the EU fiscal framework and with budget policies already passed into law or under discussion. It ensures a 0.5pp yearly improvement in the Italian deficit from the current value of 3% of GDP up to 0% percent in 2018. The measures that are implemented mainly consist of (mild) public spending cuts. Finally, from 2019 to 2030, public-sector net indebtedness is kept constant and equal to zero in every year. The budget savings allowed by the decrease in interest payments are exploited to gradually reduce the labor income tax rate or, alternatively, the capital income tax rate (by approximately 4pp in 10 years).

Table 6 reports the contributions of the fiscal consolidation to the growth rate of Italian actual GDP and its components over the 2012-2013 period.[18] GDP, consumption and investment decrease. GDP decrease is 1.6% over the 2012-2013 period, a value not extremely different from the decrease reported by Busetti and Cova (2013), equal to 2.3%.

3.2.3 Structural reforms

The Italian Parliament also enacted two laws, addressing the malfunctions of the labour market and the services sector, and inscribed in the Constitution a commitment to stabilize public finances (the EU "fiscal compact"). We do not consider labour market reforms, as the lack of reliable quantitative data does not allow for a complete characterization of the legal changes in terms of model variables and parameters. We concentrate

[17] See Ministero dell'Economia e delle Finanze (2012).

[18] See Locarno *et al.* (2013) for a model-based analysis of Italian fiscal multipliers.

instead on liberalization measures in the service sector (e.g. liberalizations in some professions, unbundling measures for energy supply and pro-competition measures in the retail sector), which represent the lion share of the 2012 reform packages. We assume that the reforms achieve a 10pp reduction in the average gross markup of the Italian services sector, which accordingly falls from 1.29 to 1.19. The reforms are gradually implemented over a 10-year horizon, starting from 2013. The quantification of the effects of the reform on the degree of concentration in the services sector necessarily involves some arbitrariness. However, they are not implausible. Lusinyan and Muir (2013) document that the overall OECD Product Market Regulation (PMR) indicator for Italy has improved from 1.3 in 2008 to 1.2 in 2012, becoming less restrictive than the 2008 EU and OECD averages. In our simulations, the markup in the services sector ends up being lower in Italy than in the REA by 2022. Moreover, the same authors, when simulating the effect of reforming the Italian service sector, assume that the markup reduction is equal to 15 pp. Reforms in the Italian service sector are also evaluated in Ministero dell'Economia (2012), by simulating the DSGE model QUEST. Reforms are formalized as the combination of lower markups and lower entry barriers. The assumed markup reduction is -1.9pp; it is lower than in our case (10pp), but we do not simulate the reduction in the entry barriers, as the latter are not formalized in the our model. Our results are similar to theirs. They report a long-run (cumulated) effect on Italian GDP equal to 2.0% (it is 3% if administrative duties reduction is also included). According to our results, reported in the next section, the long-run impact on Italian potential output is 3.0%, while Lusinyan and Muir (2013) report a long-run increase equal to 7%.

Table 6 reports the contribution of the structural reforms on actual GDP. It is slightly negative, as the investment decreases. GDP returns to positive values already from the second year (not reported to save on space).

4 Results

We gauge the impact of the crisis on potential output by shocking financial and fiscal variables in the way described in the previous section. Potential output is defined as the level of GDP obtained from the model under the assumption that prices and wages are fully flexible. As such, the dynamics of output is not "distorted" by nominal frictions. We include only one distortion by assuming that steady-state markups are different from zero, thus implicitly accounting for a suboptimal level of production. Such assumption is motivated by the necessity to design an exogenous reduction in the degree of monopolistic

competition in the service sector, to capture the effects of pro-competition reforms.

Results are reported distinguishing among the following periods: 1. the peak of the crisis (2011–2013); 2. the interim period (2014–15) and the pursuit of a balanced budget (2016–2018); 3. the balanced budget (2019–2030).

4.1 The peak of the crisis (2011–2013)

In 2011–2013 period the Italian economy was hit by a severe financial shock that triggered a fiscal policy response – aimed at reassuring markets about the sustainability of public debt – and accelerated the process of repairing the working of the Italian economy. Table 7 reports the estimated impact of those three factors on potential GDP: in the first two columns, it shows potential output in the no-crisis and crisis scenarios; in the following three, it shows separately the contribution of each factor. For fiscal policy, Table 7 refers to the case in which the savings allowed by the reduction in the cost of servicing the debt from 2019 onwards are used to cut the labor income tax rate.

The impact of the spread on potential output growth is reported in the column labelled "Spread". The increase in financing costs for households has a negative influence on aggregate demand for consumption and investment. Firms reduce employment in response to lower demand. The implied deceleration in the accumulation of labour and capital curbs the supply capacity of the economy and, hence, negatively affects potential output.

The Italian economy was also affected by fiscal shocks, as policymakers faced the challenges posed by the sovereign-debt crisis by trying and putting public finances in order. The adopted measures – mostly revenue-based – were estimated to reduce ex-ante the budget deficit by some 5pp of GDP in three years. The column labelled "Fiscal policy" shows the effects of the budget tightening on Italian potential output. As for the case of spread shocks, fiscal policy is estimated to exert a negative impulse on the supply side of the economy, decreasing potential output in 2011–2013 by about 1.2pp on aggregate.

At the peak of the crisis, the Italian government also decided to pass laws promoting competition in the services sectors. The reform, which will permanently reduce oligopoly rents for incumbent firms, is assumed to be gradually implemented over a 10-year horizon, starting from 2013Q1. The column "Structural reforms" reports the results. The increase in competition induces firms to permanently reduce the prices of the services they provide. Lower prices have a positive income effect on households, which increases their demand not only for services, but also for manufacturing goods, as the two types

of goods are complements rather than substitutes (the elasticity of substitution between manufacturing goods and services is calibrated to 0.5, a relatively low value). The permanent increase in aggregate demand for services and goods induces firms to increase production and hence the demand for labour and capital.

The last column reports the evolution of the output gap, computed as the difference between actual and potential GDP in the "crisis scenario", divided by potential GDP (the ratio is expressed in percentage points). The output gap widens during the crisis because of the drop in effective GDP, which outweighs the drop in potential output. It is equal to -3.8%, -5.9%, -6.7% in 2012, 2013, 2014, respectively.

Figure 1 reports a graphical representation of the three contributions (spread, fiscal policy and reforms). All in all, the Italian potential output is estimated to decrease by about 1.4pp relative to the no-crisis scenario over the 2011–2013 period. The largest negative contribution is attributable to the impact of the fiscal consolidation measures.

4.2 The interim period (2014–2015) and the pursuit of a balanced budget (2016–2018)

The 2014–2015 period is characterized by non-negligible improvements in financial conditions and steps ahead in the implementation of structural reforms. As the most severe phase of the sovereign-debt crisis is over, households and firms start reaping the benefits of financial stabilization. The spread falls by 50bp in 2014-2015, to 100bp. Concerning budget policies, differently from the 2011–2012 episode, the measures adopted in 2014–2015 period mainly consist of permanent reductions in public spending, which amount to 0.4pp of GDP per year and whose impact on potential output is limited, as public spending, especially if wasteful, does not directly affect supply capacity. The more favourable financial conditions allow households and firms to borrow, fostering private-sector spending; firms increase production to match the acceleration of aggregate demand; the ensued increase in employment and capital accumulation benefits potential output.

For the 2016–2018 period, the spread gradually declines to zero, in 2018. The evolution of fiscal policy in the second half of the current decade is consistent with the EU fiscal framework, which dictates a 0.5pp annual improvement in the (structural) deficit. From the 2013 value of 3% of GDP, indebtedness gradually falls to 0% in six years. Such pattern reflects the downward trend of the public debt-to-GDP ratio due to (i) the positive effects of previous fiscal consolidation efforts and (ii) the return of the economy to more sustained growth performances.[19]

[19]The simulated growth rate of Italian GDP in the average of this period is in line with that projected

Compared with the no-crisis scenario, potential output increases by 0.1pp in 2014–2015 and by 1.0pp in 2016–2018, favored by the reforms and the improved financial conditions, while fiscal policy continues to be a drag.

During this period, potential output grows on average at about 1.0% per year, about two decimal points per year more than in the no-crisis scenario.

4.3 The balanced budget (2019–2030)

With zero indebtedness maintained for the whole decade, the savings generated by the lower cost of servicing public debt are used to reduce distortionary taxes. Two alternative scenarios are considered: in the first, taxes on labour income are reduced; in the second, the tax pressure on capital is mitigated. Table 6 reports results referring to the case of a reduction in labor income taxes. Reforms and tax reduction exert a positive impact on supply capacity. Table 8 compares the impact on potential output growth of both strategies of tax cuts. If labor income taxes and capital income taxes are reduced, potential output respectively grows on average about 0.1 and 0.3pp more than in the no-crisis scenario, in which the taxes are reduced only from 2025, reflecting less external pressure for fiscal consolidation.

5 Conclusions

This paper provides an assessment of the effects on Italian potential output of both the sovereign debt crisis and the policy responses that it triggered, i.e. the fiscal consolidation effort undertaken in order to dissipate investors' fears on the sustainability of Italian public debt and the acceleration of the program of reforming the economy. The main findings of the paper are the following. First, fiscal and sovereign-risk shocks, responsible for the 2011–2013 recession, subtract -1.6pp to potential output growth. The largest negative contribution is attributed to fiscal consolidation, while spread plays a relatively minor role. Second, taking into account the positive impact of 2013 structural reforms, the reduction in supply capacity falls to about 1.4pp. Third, the growth-enhancing impact of structural reforms over the 2011-2030 period is around 3pp, less than estimated by IMF and OECD. Fourth, in 2019–2030, the reductions in either labor or capital income taxes would boost potential output growth by nearly 0.1–0.3pp per year.

by the International Monetary Fund in 2013. See IMF (2013).

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Table 1. Parameterization of Italy, REA and RW

Parameter	IT	REA	RW
Discount rate β	0.9927	0.9927	0.9927
Intertemporal elasticity of substitution $1/\sigma$	1.0	1.0	1.0
Inverse of Frisch Elasticity of Labor Supply τ	2.0	2.0	2.0
Habit h	0.6	0.6	0.6
Depreciation rate of (private and public) capital δ	0.025	0.025	0.025
Tradable Intermediate Goods			
Substitution between factors of production ξ_T	0.93	0.93	0.93
Bias towards capital $\alpha_T, \alpha_T^*, \alpha_T^{**}$	0.56	0.46	0.46
Nontradable Intermediate Goods			
Substitution between factors of production ξ_N	0.93	0.93	0.93
Bias towards capital $\alpha_N, \alpha_N^*, \alpha_N^{**}$	0.53	0.43	0.43
Final consumption goods			
Substitution between domestic and imported goods ϕ_A	1.50	1.50	1.50
Bias towards domestic tradable goods a_H, a_G^*, a_F^{**}	0.68	0.59	0.90
Substitution between domestic tradables and nontradables ρ_A	0.50	0.50	0.50
Bias towards tradable goods a_T, a_T^*, a_T^{**}	0.68	0.50	0.50
Final investment goods			
Substitution between domestic and imported goods ϕ_E	1.50	1.50	1.50
Bias towards domestic tradable goods $\upsilon_H, \upsilon_G, \upsilon_F^{**}$	0.50	0.49	0.90
Substitution between domestic tradables and nontradables ρ_E	0.50	0.50	0.50
Bias towards tradable goods $\upsilon_T, \upsilon_T^*, \upsilon_T^{**}$	0.78	0.70	0.70

Note: IT=Italy; REA=Rest of the euro area; RW= Rest of the world.

Table 2. Gross markups

Markups and Elasticities of Substitution			
	Tradables	Non-tradables	Wages
IT	1.08 ($\theta_T = 13.32$)	1.29 ($\theta_N = 4.44$)	1.60 ($\psi = 2.65$)
REA	1.11 ($\theta_T^* = 10.15$)	1.24 ($\theta_N^* = 5.19$)	1.33 ($\psi^* = 4$)
RW	1.11 ($\theta_T^{**} = 10.15$)	1.24 ($\theta_N^{**} = 5.19$)	1.33 ($\psi^{**} = 4$)

Note: IT=Italy; REA=rest of the euro area; RW= rest of the world; source: OECD (2012).

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Table 3. Real and nominal adjustment costs

Parameter ("*" refers to rest of the Euro area)	IT	REA	RW
Real Adjustment Costs			
Investment ϕ_I, ϕ_I^*, ϕ_I^{**}	1.00	1.00	1.00
Households' financial net position ϕ_{b1}, ϕ_{b2}	0.00055, 0.00055	-	0.00055, 0.00055
Nominal Adjustment Costs			
Wages κ_W, κ_W^*, κ_W^{**}	200	200	200
Italian produced tradables κ_H, k_H^* k_H^{**}	300	300	50
REA produced tradables κ_G, k_G^* k_G^{**}	300	300	50
RW produced tradables κ_F, k_F^* k_F^{**}	50	50	300
Nontradables κ_N, κ_N^*, κ_N^{**}	500	500	500

Note: IT=Italy; REA=rest of the euro area; RW= rest of the world.

Table 4. Monetary policy rules

Parameter	IT	REA	EA	RW
	-	-		
Lagged interest rate at t-1 ρ_R, ρ_R^{**}	-	-	0.87	0.87
Inflation ρ_Π, ρ_Π^{**}	-	-	1.70	1.70
GDP growth $\rho_{GDP}, \rho_{GDP}^{**}$	-	-	0.10	0.10

Note: IT=Italy; REA=rest of the euro area; EA= euro area; RW= rest of the world.

Table 5. Main macroeconomic variables (ratio to GDP) and tax rates

	IT	REA	RW
Macroeconomic variables			
Private consumption	61.0	57.1	64.0
Private Investment	18.0	16.0	20.0
Public purchases	20.0	20.0	20.0
Imports	29.0	24.3	4.25
Net Foreign Asset Position	0.0	0.0	0.0
GDP (share of world GDP)	0.03	0.17	0.80

Note: IT= Italy; REA= Rest of the euro area; RW= Rest of the world. Sources: European Commission (2012).

Table 6. Italian actual GDP and inflation. Contributions of crisis factors

	τ^{ℓ}		τ^{c}		Fiscal consolidation		Spread		Reforms
	2012	2013	2012	2013	2012	2013	2011	2012	2013
GDP	0.0	-0.1	-1.3	-0.2	-1.3	-0.3	-0.8	-0.4	-0.5
Consumption	0.0	-0.1	-2.8	-1.0	-2.8	-1.0	-1.0	-0.5	-1.2
Investment	0.2	-0.1	-4.6	-1.1	-4.4	-1.3	-4.5	-1.8	-2.4
Export	-0.1	-0.1	1.3	0.8	1.2	0.7	0.4	0.1	0.6
Import	0.1	0.0	-3.6	-1.4	-3.4	-1.4	-2.1	-0.9	-1.7
Inflation	0.0	0.0	-0.2	-0.3	-0.2	-0.2	0.0	0.0	-0.2

Note: annual growth rates (% points). τ^{ℓ}: increase in labor taxes; τ^{c}: increase in consumption tax rate

Table 7. Italian potential output. Contributions of crisis factors

	Potential output		Contributions			Output gap
	No crisis	Crisis	Spread	Fiscal policy	Structural reforms	
2011	0.3	0.3	0.0	0.0	0.0	-2.2
2012	0.4	-0.7	-0.2	-0.9	0.0	-3.8
2013	0.5	0.3	-0.2	-0.3	0.2	-5.9
2014	0.6	0.5	0.0	-0.1	0.1	-6.7
2015	0.7	0.9	0.1	-0.1	0.1	
2016	0.8	1.1	0.1	0.0	0.2	
2017	1.0	1.3	0.1	0.0	0.2	
2018	1.0	1.4	0.1	0.0	0.3	
2019	1.0	1.5	0.0	0.1	0.3	
2020	1.0	1.4	0.0	0.1	0.3	
2021	1.0	1.4	0.0	0.1	0.3	
2022	1.0	1.5	0.0	0.1	0.3	
2023	1.0	1.4	0.0	0.1	0.2	
2024	1.0	1.3	0.0	0.2	0.2	
2025	1.0	1.3	0.0	0.2	0.1	
2026	1.1	1.3	0.0	0.2	0.1	
2027	1.1	1.3	0.0	0.2	0.0	
2028	1.1	1.3	0.0	0.2	0.1	
2029	1.1	1.2	0.0	0.1	0.2	
2030	1.1	1.2	0.0	0.1	0.2	

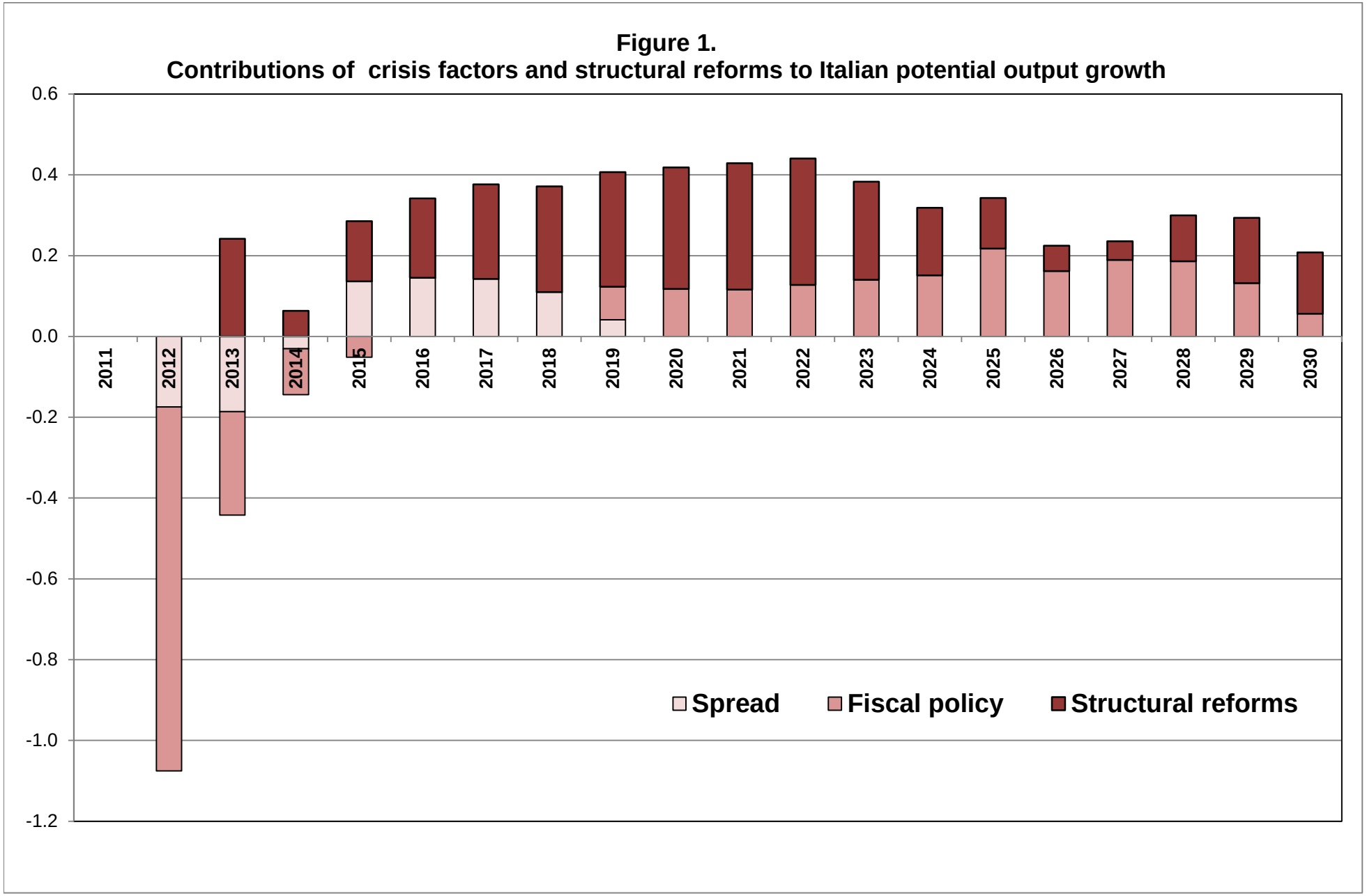
Note: annual growth rates (% points). Scenarios "Spread", "Fiscal policy"and "Structural reforms"are expressed as pp deviations from the scenario "No crisis". Output gap: actual GDP/potential output-1, %

Table 8. Italian potential output: contributions of alternative tax reductions

	No crisis labor inc. tax reduction potential output	Labor inc. tax reduction	No crisis capital inc. tax reduction potential output	Capital inc. tax reduction
2019	1.0	0.1	1.0	0.3
2020	1.0	0.1	1.0	0.2
2021	1.0	0.1	1.0	0.3
2022	1.0	0.1	1.0	0.3
2023	1.0	0.1	1.0	0.3
2024	1.0	0.2	1.0	0.3
2025	1.0	0.2	1.2	0.3
2026	1.1	0.2	1.2	0.3
2027	1.1	0.2	1.3	0.3
2028	1.1	0.2	1.3	0.2
2029	1.1	0.1	1.3	0.2
2030	1.1	0.1	1.3	0.1
Average		0.1		0.3

Note: annual growth rates (% points). Scenarios "Labor income tax reduction"and "Capital income tax reduction"are expressed as pp deviations from the "No crisis labor inc. tax reduction" and No crisis capital inc. tax reduction.

Figure 1.
Contributions of crisis factors and structural reforms to Italian potential output growth



Appendix

In this Appendix we report a detailed description of the model, excluding the fiscal and monetary policy part and the description of the households optimization problem that are reported in the main text.[20]

There are three countries, Italy, the rest of the euro area (REA) and the rest of the world (RW). They have different sizes. Italy and the REA share the currency and the monetary authority. In each region there are households and firms. Each household consumes a final composite good made of non-tradable, domestic tradable and imported intermediate goods. Households have access to financial markets and smooth consumption by trading a risk-free one-period nominal bond, denominated in euro. They also own domestic firms and capital stock, which is rent to domestic firms in a perfectly competitive market. Households supply differentiated labor services to domestic firms and act as wage setters in monopolistically competitive markets by charging a markup over their marginal rate of substitution.

On the production side, there are perfectly competitive firms that produce the final goods and monopolistic firms that produce the intermediate goods. Two final goods (private consumption and private investment) are produced combining all available intermediate goods according to constant-elasticity-of-substitution bundle. The public consumption good is a bundle of intermediate non-tradable goods.

Tradable and non-tradable intermediate goods are produced combining capital and labor in the same way. Tradable intermediate goods can be sold domestically or abroad. Because intermediate goods are differentiated, firms have market power and restrict output to create excess profits. We assume that goods markets are internationally segmented and the law of one price for tradables does not hold. Hence, each firm producing a tradable good sets three prices, one for the domestic market and the other two for the export market (one for each region). Since the firm faces the same marginal costs regardless of the scale of production in each market, the different price-setting problems are independent of each other.

To capture the empirical persistence of the aggregate data and generate realistic dynamics, we include adjustment costs on real and nominal variables, ensuring that, in response to a shock, consumption and production react in a gradual way. On the real side, quadratic costs and habit prolong the adjustment of the investment and consump-

[20]For a detailed description of the main features of the model see also Bayoumi (2004) and Pesenti (2008).

tion. On the nominal side, quadratic costs make wage and prices sticky.

In what follows we illustrate the Italian economy. The structure of each of the other two regions (REA and the RW) is similar and to save on space we do not report it.

5.1 Final consumption and investment goods

There is a continuum of symmetric Italian firms producing final non-tradable consumption under perfect competition. Each firm producing the consumption good is indexed by $x \in (0, s]$, where the parameter $0 < s < 1$ measures the size of Italy. Firms in the REA and in the RW are indexed by $x^* \in (s, S]$ and $x^{**} \in (S, 1]$, respectively (the size of the world economy is normalized to 1). The CES production technology used by the generic firm x is:

$$A_t(x) \equiv \left(a_T^{\frac{1}{\phi_A}} \left(\begin{array}{c} a_H^{\frac{1}{\rho_A}} Q_{HA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} \\ + a_G^{\frac{1}{\rho_A}} Q_{GA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} (1 - a_H - a_G)^{\frac{1}{\rho_A}} Q_{FA,t}(x)^{\frac{\rho_A - 1}{\rho_A}} \\ + (1 - a_T)^{\frac{1}{\phi_A}} Q_{NA,t}(x)^{\frac{\phi_A - 1}{\phi_A}} \end{array} \right)^{\frac{\rho_A}{\rho_A - 1} \frac{\phi_A - 1}{\phi_A}} \right)^{\frac{\phi_A}{\phi_A - 1}}$$

where Q_{HA}, Q_{GA}, Q_{FA} and Q_{NA} are bundles of respectively intermediate tradables produced in Italy, intermediate tradables produced in the REA, intermediate tradables produced in the RW and intermediate non-tradables produced in Italy. The parameter $\rho_A > 0$ is the elasticity of substitution between tradables and $\phi_A > 0$ is the elasticity of substitution between tradable and non-tradable goods. The parameter a_H $(0 < a_H < 1)$ is the weight of the Italian tradable, the parameter a_G $(0 < a_G < 1)$ the weight of tradables imported from the REA, a_T $(0 < a_T < 1)$ the weight of tradable goods.

The production of investment good is similar. There are symmetric Italian firms under perfect competition indexed by $y \in (0, s]$. Firms in the REA and in the RW are indexed by $y^* \in (s, S]$ and $y^{**} \in (S, 1]$. Output of the generic Italian firm y is:

$$E_t(y) \equiv \left(v_T^{\frac{1}{\phi_E}} \left(\begin{array}{c} v_H^{\frac{1}{\rho_E}} Q_{HE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} + v_G^{\frac{1}{\rho_E}} Q_{GE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} \\ + (1 - v_H - v_G)^{\frac{1}{\rho_E}} Q_{FE,t}(y)^{\frac{\rho_E - 1}{\rho_E}} \\ + (1 - v_T)^{\frac{1}{\phi_E}} Q_{NE,t}(y)^{\frac{\phi_E - 1}{\phi_E}} \end{array} \right)^{\frac{\rho_E}{\rho_E - 1} \frac{\phi_E - 1}{\phi_E}} \right)^{\frac{\phi_E}{\phi_E - 1}}$$

Finally, we assume that public expenditure C^g is composed by intermediate non-tradable goods only.

5.2 Intermediate goods

5.2.1 Demand

Bundles used to produce the final consumption goods are CES indexes of differentiated intermediate goods, each produced by a single firm under conditions of monopolistic competition:

$$Q_{HA}(x) \equiv \left[\left(\frac{1}{s}\right)^{\theta_T} \int_0^s Q(h,x)^{\frac{\theta_T-1}{\theta_T}}\, dh\right]^{\frac{\theta_T}{\theta_T-1}} \tag{12}$$

$$Q_{GA}(x) \equiv \left[\left(\frac{1}{S-s}\right)^{\theta_T} \int_s^S Q(g,x)^{\frac{\theta_T-1}{\theta_T}}\, dg\right]^{\frac{\theta_T}{\theta_T-1}} \tag{13}$$

$$Q_{FA}(x) \equiv \left[\left(\frac{1}{1-S}\right)^{\theta_T} \int_S^1 Q(f,x)^{\frac{\theta_T-1}{\theta_T}}\, df\right]^{\frac{\theta_T}{\theta_T-1}} \tag{14}$$

$$Q_{NA}(x) \equiv \left[\left(\frac{1}{s}\right)^{\theta_N} \int_0^s Q(n,x)^{\frac{\theta_N-1}{\theta_N}}\, dn\right]^{\frac{\theta_N}{\theta_T-1}} \tag{15}$$

where firms in the Italian intermediate tradable and non-tradable sectors are respectively indexed by $h \in (0,s)$ and $n \in (0,s)$, firms in the REA by $g \in (s,S]$ and firms in the RW by $f \in (S,1]$. Parameters θ_T, $\theta_N > 1$ are respectively the elasticity of substitution across brands in the tradable and non-tradable sector. The prices of the intermediate non-tradable goods are denoted $p(n)$. Each firm x takes these prices as given when minimizing production costs of the final good. The resulting demand for intermediate non-tradable input n is:

$$Q_{A,t}(n,x) = \left(\frac{1}{s}\right)\left(\frac{P_t(n)}{P_{N,t}}\right)^{-\theta_N} Q_{NA,t}(x) \tag{16}$$

where $P_{N,t}$ is the cost-minimizing price of one basket of local intermediates:

$$P_{N,t} = \left[\int_0^s P_t(n)^{1-\theta_N}\, dn\right]^{\frac{1}{1-\theta_N}} \tag{17}$$

We can derive $Q_A(h,x)$, $Q_A(f,x)$, $C_A^g(h,x)$, $C_A^g(f,x)$, P_H and P_F in a similar way. Firms y producing the final investment goods have similar demand curves. Aggregating over x and y, it can be shown that total demand for intermediate non-tradable good n

is:

$$\begin{aligned} & \int_0^s Q_{A,t}(n,x)\,dx + \int_0^s Q_{E,t}(n,y)\,dy + \int_0^s C_t^g(n,x)\,dx \\ = & \left(\frac{P_t(n)}{P_{N,t}}\right)^{-\theta_N}\left(Q_{NA,t} + Q_{NE,t} + C_{N,t}^g\right) \end{aligned}$$

where C_N^g is public sector consumption. Italy demands for (intermediate) domestic and imported tradable goods can be derived in a similar way.

5.2.2 Supply

The supply of each Italian intermediate non-tradable good n is denoted by $N^S(n)$:

$$N_t^S(n) = \left((1-\alpha_N)^{\frac{1}{\xi_N}} L_{N,t}(n)^{\frac{\xi_N-1}{\xi_N}} + \alpha^{\frac{1}{\xi_N}} K_{N,t}(n)^{\frac{\xi_N-1}{\xi_N}}\right)^{\frac{\xi_N}{\xi_N-1}} \tag{18}$$

Firm n uses labor $L_{N,t}^p(n)$ and capital $K_{N,t}(n)$ with constant elasticity of input substitution $\xi_N > 0$ and capital weight $0 < \alpha_N < 1$. Firms producing intermediate goods take the prices of labor inputs and capital as given. Denoting W_t the nominal wage index and R_t^K the nominal rental price of capital, cost minimization implies:

$$L_{N,t}(n) = (1-\alpha_N)\left(\frac{W_t}{MC_{N,t}(n)}\right)^{-\xi_N} N_t^S(n) \tag{19}$$

$$K_{N,t}(n) = \alpha\left(\frac{R_t^K}{MC_{N,t}(n)}\right)^{-\xi_N} N_t^S(n)$$

where $MC_{N,t}(n)$ is the nominal marginal cost:

$$MC_{N,t}(n) = \left((1-\alpha)W_t^{1-\xi_N} + \alpha\left(R_t^K\right)^{1-\xi_N}\right)^{\frac{1}{1-\xi_N}} \tag{20}$$

The productions of each Italian tradable good, $T^S(h)$, is similarly characterized.

5.2.3 Price setting in the intermediate sector

Consider now profit maximization in the Italian intermediate non-tradable sector. Each firm n sets the price $p_t(n)$ by maximizing the present discounted value of profits subject

to the demand constraint and the quadratic adjustment costs:

$$AC_{N,t}^{p}(n) \equiv \frac{\kappa_N^p}{2}\left(\frac{P_t(n)}{P_{t-1}(n)}-1\right)^2 Q_{N,t} \quad \kappa_N^p \geq 0$$

paid in unit of sectorial product $Q_{N,t}$ and where κ_N^p measures the degree of price stickiness. The resulting first-order condition, expressed in terms of domestic consumption, is:

$$p_t(n) = \frac{\theta_N}{\theta_N - 1} mc_t(n) - \frac{A_t(n)}{\theta_N - 1} \tag{21}$$

where $mc_t(n)$ is the real marginal cost and $A(n)$ contains terms related to the presence of price adjustment costs:

$$\begin{aligned} A_t(n) \quad \approx \quad & \kappa_N^p \frac{P_t(n)}{P_{t-1}(n)}\left(\frac{P_t(n)}{P_{t-1}(n)}-1\right) \\ & -\beta\kappa_N^p \frac{P_{t+1}(n)}{P_t(n)}\left(\frac{P_{t+1}(n)}{P_t(n)}-1\right)\frac{Q_{N,t+1}}{Q_{N,t}} \end{aligned}$$

The above equations clarify the link between imperfect competition and nominal rigidities. As emphasized by Bayoumi *et al.* (2004), when the elasticity of substitution θ_N is very large and hence the competition in the sector is high, prices closely follow marginal costs, even though adjustment costs are large. To the contrary, it may be optimal to maintain stable prices and accommodate changes in demand through supply adjustments when the average markup over marginal costs is relatively high. If prices were flexible, optimal pricing would collapse to the standard pricing rule of constant markup over marginal costs (expressed in units of domestic consumption):

$$p_t(n) = \frac{\theta_N}{\theta_N - 1} mc_{N,t}(n) \tag{22}$$

Firms operating in the intermediate tradable sector solve a similar problem. We assume that there is market segmentation. Hence the firm producing the brand h chooses $p_t(h)$ in the Italian market,a price $p_t^*(h)$ in the REA and a price $p_t^{**}(h)$ in the RW to maximize the expected flow of profits (in terms of domestic consumption units):

$$E_t \sum_{\tau=t}^{\infty} \Lambda_{t,\tau} \left[\begin{array}{c} p_\tau(h) y_\tau(h) + p_\tau^*(h) y_\tau^*(h) + p_\tau^{**}(h) y_\tau^{**}(h) \\ -mc_{H,\tau}(h)\left(y_\tau(h) + y_\tau^*(h) + y_\tau^{**}(h)\right) \end{array} \right]$$

subject to quadratic price adjustment costs similar to those considered for non-tradables and standard demand constraints. The term E_t denotes the expectation operator condi-

tional on the information set at time t, $\Lambda_{t,\tau}$ is the appropriate discount rate and $mc_{H,t}(h)$ is the real marginal cost. The first order conditions with respect to $p_t(h)$, $p_t^*(h)$ and $p_t^{**}(h)$ are:

$$p_t(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t(h)}{\theta_T - 1} \tag{23}$$

$$p_t^*(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t^*(h)}{\theta_T - 1} \tag{24}$$

$$p_t^{**}(h) = \frac{\theta_T}{\theta_T - 1} mc_t(h) - \frac{A_t^{**}(h)}{\theta_T - 1} \tag{25}$$

where θ_T is the elasticity of substitution of intermediate tradable goods, while $A(h)$ and $A^*(h)$ involve terms related to the presence of price adjustment costs:

$$\begin{aligned}
A_t(h) &\approx \kappa_H^p \frac{P_t(h)}{P_{t-1}(h)} \left(\frac{P_t(h)}{P_{t-1}(h)} - 1 \right) \\
&\quad -\beta \kappa_H^p \frac{P_{t+1}(h)}{P_t(h)} \left(\frac{P_{t+1}(h)}{P_t(h)} - 1 \right) \frac{Q_{H,t+1}}{Q_{H,t}} \\
A_t^*(h) &\approx \theta_T - 1 + \kappa_H^p \frac{P_t^*(h)}{P_{t-1}^*(h)} \left(\frac{P_t^*(h)}{P_{t-1}^*(h)} - 1 \right) \\
&\quad -\beta \kappa_H^p \frac{P_{t+1}^*(h)}{P_t^*(h)} \left(\frac{P_{t+1}^*(h)}{P_t^*(h)} - 1 \right) \frac{Q_{H,t+1}^*}{Q_{H,t}^*} \\
A_t^{**}(h) &\approx \theta_T - 1 + \kappa_H^p \frac{P_t^{**}(h)}{P_{t-1}^{**}(h)} \left(\frac{P_t^{**}(h)}{P_{t-1}^{**}(h)} - 1 \right) \\
&\quad -\beta \kappa_H^p \frac{P_{t+1}^{**}(h)}{P_t^{**}(h)} \left(\frac{P_{t+1}^{**}(h)}{P_t^{**}(h)} - 1 \right) \frac{Q_{H,t+1}^{**}}{Q_{H,t}^{**}}
\end{aligned}$$

where κ_H^p,$\kappa_H^{p\,*}$,$\kappa_H^{p\,**} > 0$ respectively measure the degree of nominal rigidity in Italy, in the REA and in the RW. If nominal rigidities in the (domestic) export market are highly relevant (that is, if is relatively large), the degree of inertia of Italian goods prices in the foreign markets will be high. If prices were flexible ($\kappa_H^p = \kappa_H^{p*} = \kappa_H^{p**} = 0$) then optimal price setting would be consistent with the cross-border law of one price (prices of the same tradable goods would be equal when denominated in the same currency).

5.3 Labor Market

In the case of firms in the intermediate non-tradable sector, the labor input $L_N(n)$ is a CES combination of differentiated labor inputs supplied by domestic agents and defined

over a continuum of mass equal to the country size ($j \in [0, s]$):

$$L_{N,t}(n) \equiv \left(\frac{1}{s}\right)^{\frac{1}{\psi}} \left[\int_0^s L_t(n,j)^{\frac{\psi-1}{\psi}} dj\right]^{\frac{\psi}{\psi-1}} \tag{26}$$

where $L(n,j)$ is the demand of the labor input of type j by the producer of good n and $\psi > 1$ is the elasticity of substitution among labor inputs. Cost minimization implies:

$$L_t(n,j) = \left(\frac{1}{s}\right) \left(\frac{W_t(j)}{W_t}\right)^{-\psi} L_{N,t}(j), \tag{27}$$

where $W(j)$ is the nominal wage of labor input j and the wage index W is:

$$W_t = \left[\left(\frac{1}{s}\right) \int_0^s W_t(h)^{1-\psi} dj\right]^{\frac{1}{1-\psi}}. \tag{28}$$

Similar equations hold for firms producing intermediate tradable goods. Each household is the monopolistic supplier of a labor input j and sets the nominal wage facing a downward-sloping demand, obtained by aggregating demand across Italian firms. The wage adjustment is sluggish because of quadratic costs paid in terms of the total wage bill:

$$AC_t^W = \frac{\kappa_W}{2} \left(\frac{W_t}{W_{t-1}} - 1\right)^2 W_t L_t \tag{29}$$

where the parameter $\kappa_W > 0$ measures the degree of nominal wage rigidity and L is the total amount of labor in the Italian economy.

5.4 The equilibrium

We find a symmetric equilibrium of the model. In each country there is a representative agent and four representative sectorial firms (in the intermediate tradable sector, intermediate non-tradable sector, consumption production sector and investment production sector). The equilibrium is a sequence of allocations and prices such that, given initial conditions and the sequence of exogenous shocks, each private agent and firm satisfy the correspondent first order conditions, the private and public sector budget constraints and market clearing conditions for goods, labor, capital and bond hold.

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