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ORIGINAL PAPER

The Barcelona initiative and the importance of NTBs: a dynamic CGE-analysis for Syria

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Abstract The Barcelona Initiative is the central element of the EU's Mediterranean policy. We study the implementation of this policy with respect to Syria using a dynamic general equilibrium model with credit constraints and capital market imperfections. Dismantling formal tariffs has only limited effects on the Syrian economy, while reducing non-tariff barriers produces by far larger results. EU association promises broadly positive effects for factor incomes and sectoral outputs, with some temporarily negative effects in agricultural sectors. Nevertheless, we find evidence of severe trade distorting effects making preferential trade policy clearly welfare inferior to multilateral trade liberalization within the WTO framework.

Keywords Euro-Mediterranean partnership · Barcelona initiative · Syria · Non-Tariff-Barriers (NTBs) · Dynamic CGE

JEL Classification E32 · O11

1 Introduction

In 1995, the European Union (EU) launched the Barcelona Initiative (officially: Euro-Mediterranean Partnership) which aims at strengthening economic and political ties between the Common Market and most Southern Mediterranean Countries. A cornerstone of the Barcelona Initiative is the gradual creation of a free trade area between the EU and its Mediterranean Partners (basically all Mediterranean non-EU countries, plus Jordan, except Libya). In line with its hub-and-spoke preferential trade policy, the EU suggested to negotiate bilateral Association Agreements between the EU and each partner country. In exchange for opening up their fairly

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protected markets, the Mediterranean Partners were to receive financial and technical assistance for modernizing their governmental, economic and social structures (the so-called MEDA-program).

This policy aims at increasing the speed at which the Mediterranean Partners integrate into the world economy. According to a World Bank (2003a) study for the post-1985 period, no other region in the world has been as slow as the Middle-East and North-Africa (MENA) in responding and adjusting to globalization. Given the geographic proximity to Europe, this fact is particularly challenging for the EU, since the MENA region is a large developing market with more than 400 million customers (about the size of the EU25). Both economic potential and the threat of political instability due to a wealthy EU and a poor southern neighboring region motivate the EU to encourage economic development of the Mediterranean Partners.

Syria is a particularly interesting case. The country is relatively rich in natural resources (limited availability of oil, rich reserves in gas, plenty of arable land). The quality of its infrastructure and the education of the population matches the standards of e. g. Jordan (a country which has no oil, no gas, and virtually no arable land. Yet Jordan's per capita GDP (all data PPP-adjusted) is about 4,500 US-$, while Syria's GDP per head is merely about 3,400 US-$ (75% of Jordan's). By all accounts, Syria seems to do much worse than it could. In fact, due to its relatively large size, one could hope that an economic take-off of Syria would generate positive spillovers to other countries in the region.

To date, Syria is the only Mediterranean partner country which has not yet signed an Association Agreement (AA) with the EU. While the negotiations are finished and a text for the agreement has in principle been approved by both sides, discussions on political issues like weapons of mass destruction seem to at least postpone ratification of the agreement. This is most unfortunate for the Syrian people, as a stimulus for economic reform is widely expected from trade liberalization and EU assistance in reshaping Syria's governmental structures. Many economists agree that Syria greatly needs economic reform, see Sukkar (2001) or Chemingui and Dessus (2004).

Nashashibi (2002), in a study for the International Monetary Fund, claims that Syria is the least open country to international trade among all MENA countries. Yet opening Syria's economy may be easier said than done, since much of the protection is not in the form of formal tariffs but through non-tariff barriers (NTBs), cf. Lucke (2001) and World Bank (2003b). Chemingui and Dessus (2004) have computed tariff-equivalents of Syrian NTBs for a large number of commodity classifications by comparing world market and domestic prices net of formal tariffs. They find that on average, NTBs add a 22.1% premium on world prices, while formal tariffs just account for 8.2%. As tariffs and NTBs fluctuate widely across commodities, the NTB-surcharge on some products is actually much larger.

Thus, in order to quantify the prospects of the aspired free trade area with respect to Syria, it is necessary to take NTBs properly into account. It is also necessary to allow for slow adjustments: On the one hand, the tariff dismantling schedule (in principle) agreed upon by Syria and the EU extends over 12 years before free trade is accomplished. (This schedule is similar for all Mediterranean partners). On the

other hand, capital accumulation and improvements in Syria's creditworthiness on international financial markets set in only gradually.[1]

We use a dynamic computable general equilibrium (CGE) model to illustrate Syria's economic potential from trade liberalization as well as its likely development under EU association and diminishing oil exports. The model is based on a standard neoclassical CGE model, but allows for differential domestic credit conditions (government industries may borrow at more favorable interest rates than private industries) and for borrowing constraints on international capital markets. As for the latter, we follow Cohen and Sachs (1986) and Barro et al. (1995) in assuming that foreign debt requires collateral. Collateral is modeled as a function of the physical capital stock so that capital accumulation also enhances the possibilities of foreign borrowing. See also Penalver (2000).

The sequel of the paper is organized as follows: "A dynamic CGE model with debt constraints" describes the model. "Data issues" discusses data issues. "Syria's policy options in international trade" describes various simulations relating to Syria's policy options in international trade. "Conclusions" concludes.

2 A dynamic CGE model with debt constraints

The general setup of the model is laid out in the well-known paper by Devarajan and Go (1988). However, we amend the model in various ways to make it applicable to the Syrian economy. Below, we give a formal description of the model with particular focus on our modifications vis-à-vis Devarajan and Go. For the sake of completeness, the remaining (and fairly standard) equations can be found in the Appendix.

As our most important modification, we allow for international borrowing and lending. Since perfect capital mobility would, unrealistically, imply infinitely fast adjustment to the steady state, we model debt constraints by collateral requirements. By doing so we can dispose of any ad-hoc adjustment costs specification to slow down capital stock growth. To incorporate debt constraints, we follow the work of Barro et al. (1995) and Penalver (2000) where productive capital is used as collateral for debt. Apart from (constrained) foreign borrowing and lending, the representative agent follows a standard Ramsey savings plan.

Moreover, we allow for a non-competitive financial sector. It is widely known that government enterprises in Syria receive more favorable credit conditions than private enterprises. Therefore, we model an interest premium of 3% for all private sectors of the economy. That is to say, in equilibrium all private firms have the same interest rate, but this is three percentage points higher than the interest rate at which government firms can borrow. This feature (which is very close to official banking policy in Syria) is clearly a weak form of capital immobility. We have run simulations in which we considered "financial liberalization" by abolishing this type of discrimination against private business. However, in order to save space, financial

[1] In addition, we also allow for an exogenous development: The foreseeable depletion of Syria's oil reserves along with an expansion of gas production which may partially compensate for the decrease in oil.

liberalization scenarios are not reported in this paper, but they are available on request.

Other extensions relate to data issues. For instance, while the Syrian Central Bureau of Statistics provides sectoral output data classified according to the International Standard Industrial Classification (ISIC), foreign trade data is classified following the Standard International Trade Classification (SITC) system. Most sectors in the (basically two-digit) ISIC classification (henceforth "activities") produce more than just one good of the (basically two-digit) SITC classification (henceforth "commodities"). Therefore, the social accounting matrix employed here distinguishes a use-matrix (input–output matrix) and a make-matrix. The use-matrix describes how much the various activities spend on different commodities as intermediate inputs. The make-matrix indicates the amount of commodities produced by each activity. Hence, firms do in general produce more than one type of commodity—as explained below. A non-diagonal make matrix makes the sectoral interrelations highly complex.

The model is programmed in Gauss and solved using the backward integration method, cf. Brunner and Strulik (2002). In this method, the algorithm sets off in an arbitrarily small neighborhood of the post-shock steady state and iterates backwards on the saddle path. Since time is reversed in this method, all instable trajectories become stable in the sense that they converge to the true saddle path. Hence, choosing a starting value arbitrarily close to the post-shock steady state gives excellent approximations to the true saddle path. Moreover, all future developments are properly taken into account, i. e. the solution algorithm implements a time-consistent and completely rational forward looking behavior.

Formally, the most important features of the model are given as follows:

2.1 Firms

2.1.1 Producers

In the following, activities are indexed $n=1,...,N$ and commodities are indexed $m=1,...,M$. Activity output Y_t^n employs physical capital K_t^n, labor services $L_t^n \Omega_t$, (where L_t^n is the number of per-capita hours worked in sector n during period t and Ω_t is total population in period t), land La_t^n (in the case of agriculture) and M intermediate inputs according to a constant returns to scale Leontief fixed coefficients' production function as follows:

$$Y_t^n = min\left\{A_t^n\left(K_t^n\right)^{b_k^n}\cdot\left(L_t^n\Omega_t^n\right)^{b_l^n}\cdot\left(La_t^n\right)^{b_{la}^n}, \frac{x_t^{1,n}}{a^{1,n}}, \ldots, \frac{x_t^{M,n}}{a^{M,n}}\right\}, \quad n = 1,2,\ldots N, \quad (1)$$

where A_t^n is the exogenous sector specific total factor productivity, $0 < b_j^n < 1$ are share parameters. $x_t^{m,n}$ denotes the intermediate input m used by activity n and $a_{m,n}$ is the corresponding fixed input requirement. Each intermediate commodity is an Armington (1969) aggregate of domestic and foreign goods.

Firms minimize costs for a given amount of activity output Y_t^n. To minimize cost each firm sets $Y_t^n = \frac{x_t^{1,n}}{a^{1,n}} = ... = \frac{x_t^{M,n}}{a^{M,n}}$ and solves the cost minimization problem,

$$P_t^{V,n} Y_t^n \equiv \min_{K_t^n, L_t^n, La_t^n} \left(P_t^I r_t^n \cdot K_t^n + w_t \cdot L_t^n \Omega_t + P_t^{La} \cdot La_t^n \right) \tag{2}$$

subject to

$$Y_t^n = A_t^n \left(K_t^n \right)^{b_k^n} \cdot \left(L_t^n \Omega_t^n \right)^{b_l^n} \cdot \left(La_t^n \right)^{b_{la}^n} \tag{3}$$

where P_t^I is the price of capital (or investment good). w_t and P_t^{La} are, respectively, the labor wage rate and rental rate of land. r_t^n is a sector specific interest rate, which expresses the phenomenon that in state-controlled Syrian banking government industries receive more favorable credit conditions than private enterprises.[2] $P_t^{V,n} Y_t^n$ equals value added and $P_t^{V,n}$ is the value added price of activity n.

Each activity n pays indirect taxes to the government and decides on its optimal commodity supply of commodity $mYs_t^{n,m}$ given a system of prices $P_t^{n,m}$—the price of commodity m produced by activity n. To do so, firm n maximizes (for a given activity output Y_t^n) the value of its sales subject to a CET-restriction which describes how activity output is transformed into commodity supply.

2.1.2 Intermediaries

We assume the existence of m intermediaries (also operating under zero-profit conditions). Intermediary m purchases at prices $P_t^{n,m}$ all goods of category m produced by each activity. This constitutes the demand $Yd_t^{n,m}$ for the NxM differentiated commodities in the make-matrix. Intermediary m then "produces" aggregate commodity m (Q_t^m) from the (at most) N different brands. Each intermediary m supplies commodity m which can either be exported or sold in the domestic market. In addition exports are a composite of exports to countries or regions index by q. The export price to region q of good m equals $P_t^{E,m,q} = (1 - s^{E,m,q}) P_t^{WE,m,q}$ where $P_t^{WE,m,q}$ is the world export price of region q and $s^{E,m,q}$is a corresponding export subsidy.

2.2 Consumers

Apart from NTBs, modeling households is standard. Households maximize lifetime utility by choosing between consumption and leisure. The lifetime utility function of the representative agent is given by:

$$U_0 = \sum_{t=0}^{\infty} \left(\frac{1}{1+\rho} \right)^t \left[(1-\eta) \frac{(c_t)^{1-\alpha} - 1}{1-\alpha} + \eta \frac{(1-L_t)^{1-\beta} - 1}{1-\beta} \right] \cdot \Omega_t, \tag{4}$$

where c_t denotes per-capita consumption at time t and L_t is the fraction of time spent working. Parameter $\alpha > 0$ ($\beta > 0$) is the inverse of the elasticity of substitution between consumption (leisure) at any two points of time, η is the leisure share parameter and $\rho > 0$ is the representative consumer's rate of time preference.

[2] Specifically, we assume that due to institutional provisions, i. e. a government controlled banking sector, government industries enjoy an interest advantage of three percentage points.

Households' assets are ownership claims on two types of durables, productive capital K_t and land La_t. Households have liabilities in the form of net external debt D_t, a nominal variable. Productive capital serves as a (imperfect) collateral for debt, i. e. households' external borrowing is constrained to be a fraction of the existing physical capital, cf. Barro et al. (1995) and Penalver (2000). Thus, the value of external debt must not exceed a fraction v of the value of the domestic capital stock:

$$D_t \leq vP_t^I K_t \; with \; 0 \leq v \leq 1. \tag{5}$$

We assume that this constraint is always binding, because the marginal product of capital is higher in Syria than on the world market.

Households behave competitively, taking as given the domestic interest rate r_t, the price of capital goods P_t^I and the labor wage rate w_t. r_t is a weighted average of the sectoral rates of return r_t^n. Aggregate factor income consists of labor income, $w_t L_t \Omega_t$, and asset income. The latter is the sum of capital rents, $P_t^I r_t \cdot K_t$, land rents, $P_t^{La} \cdot La_t$ minus interest income paid on external debt (if $D_t>0$) or received on external wealth (if $D_t<0$). In addition, households receive net lump sum transfers T_t^G from the government, foreign remittances T_t^W and revenues from NTBs. Total disposable income is given by:

$$\begin{aligned} Y_t^{disp} \equiv (1-\tau)\left[(1-\tau^L)w_t \cdot L_t \Omega_t + (1-\tau^K)P_t^I r_t \cdot K_t + (1-\tau^{La})P_t^{La} \cdot La_t\right] + \\ + T_t^G + T_t^W + \sum_{m=1}^{M}\sum_{q=1}^{Q}((1+t_{IM}^{m,q})ntb^{m,q})P_t^{WIM,m,q} IM_t^{m,q} - \bar{r}D_t \end{aligned}, \tag{6}$$

where τ is a general income tax rate and τ^L, τ^K, τ^{La} are factor income tax rates on labor, capital, and land income, respectively. $t_{IM}^{m,q}$ is the import tariff rate on commodity m imported from country q, $ntb^{m,q}$ is the non-tariff barrier tariff rate equivalent on commodity m imported from country q. $P_t^{WIM,m,q}$ denotes the world price of commodity m from region q and $IM_t^{m,q}$ is the quantity of imports of good m originating from country q. Thus, $P_t^{WIM,m,q} IM_t^{m,q}$ is the import value.

Net income is allocated between consumption and savings as follows

$$\Omega_t \cdot P_t^C c_t + S_t = Y_t^{disp} \tag{7}$$

where P_t^C is the price of the aggregate consumption bundle.

In period t the consumer decides on the level of physical capital K_{t+1} and debt D_{t+1}, i. e. her net savings are

$$S_t - \delta P_t^I K_t = P_t^I (K_{t+1} - K_t) - (D_{t+1} - D_t) \tag{8}$$

where $\delta>0$ is the constant rate of capital depreciation and $\delta P_t^I K_t$ is the value of capital lost due to depreciation.

The consumption good c_t is an aggregate of m commodities in the conventional fashion. In each period t, households choose among a variety of domestic and imported goods. We assume that consumers perceive as imperfect substitutes the domestically produced and imported goods. Each consumption good is, therefore, an Armington aggregate of domestic and imported goods. In turn aggregate imports of commodity m is an Armington composite of imported commodities originating from country or region q.

Imports of commodity m originating from country q are purchased at the after tariff ($t^{IM,m,q}$) and NTB's tariff equivalent ($ntb^{m,q}$) price $P_t^{IM,m,q} \equiv P_t^{WIM,m,q}(1+t^{IM,m,q})(1+ntb^{m,q})$. The consumer, therefore, pays price $P_t^{IM,m,q}$ when she purchases commodity m originating from country q and pays the domestic price, denoted $P_t^{D,m}$, when she purchases good m produced in the Syrian economy.

2.3 Investor

Aggregate capital stock follows from the standard neoclassical capital accumulation equation:

$$K_{t+1} = I_t + (1-\delta)K_t, \tag{9}$$

Here I_t is aggregate investment. I_t has a structure similar to the consumption composite: It is a CES composite of m Armington goods. This CES composite has price P_t^I. Investments are financed through private savings, S_t, and the change in net foreign debt, $D_{t+1} - D_t$, which is subject to collateral requirements.

$$P_t^I I_t = S_t + D_{t+1} - D_t. \tag{10}$$

2.4 Government

As for the government, public revenues include general income taxes and single factor taxes on labor, capital and land income. Additionally, the government collects indirect taxes from activity output and raises import tariffs on imports of good m from country q. Government outlays consist of purchases of consumption goods and services, (exogenous) payments abroad, (endogenous) direct lump transfers to consumers, and export subsidies. A balanced budget requires government outlays to be equal to government revenues.

Government consumption is a composite similar to the one of the consumers i. e. aggregate government consumption is a CES-composite of all commodities.

2.5 Trade

International linkages of the domestic economy encompass trade as well as financial flows. Trade relations are modeled taking into account import tariffs, NTBs tariff equivalents.

Imports from Q different trading partners are modeled as follows: World market prices $P_t^{WIM,m,q}$ may be different across origins. Imports of commodity m originating from country q are purchased at the after tariff and NTB's price $P_t^{IM,m,q} := P_t^{WIM,m,q}(1+t_{IM}^{m,q})(1+ntb^{m,q})$.

Non-tariff barriers take the form of technical barriers to trade, quantitative restrictions, intransparent and slow Customs Department procedures etc., cf. World Bank (2003b) and Chemingui and Dessus (2004). Few people doubt that the most promising way to get around these difficulties is to pay bribes to Customs Department officials—according to private sources within Syria, the Customs

Department is the most corrupt authority within Syria. We, thus, model NTBs as a tariff-equivalent surcharge on imported commodities, the proceeds of which accrue to private households.

2.6 Market clearing

The rental rate of capital, labor wage rate and rental price of land, respectively, clear the capital, labor and rental land markets.

The prices $P_t^{n,m}$ at which producers and intermediaries trade are determined by setting each producer's (activity) supply equal to each intermediate's demand. The final goods market clearing endogenously determines the price of each commodity m produced in the domestic economy.

Walras' Law, finally, implies the equilibrium of the balance of payments, i. e. financial inflows, due to exports and transfer payments from the rest of the world as well as from new foreign debt, equal financial outflows due to imports, government payments abroad, and foreign debt principal and interest.

For a detailed list of parameters, values and equations please refer to the Appendix.

3 Data issues

The first social accounting matrix for Syria was constructed by Lucke (2001). Later, Chemingui and Dessus (2004) introduced NTBs into this SAM. Data availability and data quality is not always satisfactory in Syria, although it has improved in recent years. Partially, the SAM has to rely on guestimates or imported coefficients. The latter is in particular true for the use- and make-matrix. There is no recent input–output data available for Syria, with the exception of an input–output-table in Penson (1979), which is heavily focused on the agricultural sector. Most available SAMs thus use Leontief coefficients imported from the Jordanian use- and make-matrix, where, however, adjustments have been made to make the implied usage of intermediates match the published totals of each Syrian industry. This is also true for the SAM due to Chemingui and Dessus which is used in this work.

The SAM distinguishes 23 activities, among them agriculture, mining, various manufacturing and services activities. For manufacturing we distinguish between government and private activities. Each activity can produce more than one of a total of 23 types of commodities, i. e. the make-matrix is non-diagonal. The commodity classification follows the SITC system, modified to allow for the various lists of permitted, restricted and prohibited import goods used by the Syrian customs administration.

Most parameters in the above model can be calibrated from the SAM. This works as follows: The model consists of equations formulated in variables and parameters. The SAM provides information on the value of the variables in a certain base period—where prices are typically normalized to one by appropriate choice of units. Thus, for given values of the variables, the model can be solved for the parameters. This solution has the property that the model, properly parameterized, exactly reproduces the SAM, i. e. all variables assume their SAM-values.

One of the key parameters obtained in this way is the coefficient v, which expresses how much of the physical capital stock can actually be used as collateral. More specifically, v can be calibrated by substituting Eqs. 5, 7 and 8 into Eq. 6. Let γ^{Ω} denote the exogenous population rate of growth and let $\gamma_K \equiv 1 + \gamma^{\Omega}$. Assuming that all prices equal one at the benchmark we obtain

$$v = \left(\begin{array}{l} (1-\tau)[(1-\tau_L)\cdot L_t \Omega_t + (1-\tau_K) r_t \cdot K_t + (1-\tau_{La})\cdot La_t] + \\ + T_t^G + T_t^W + \sum_{m=1}^{M} \sum_{q=1}^{Q} ((1+t_{IM}^{m,q}) ntb^{m,q}) P_t^{WIM,m,q} IM_t^{m,q} - \Omega_t \cdot c_t \\ + K_t(1-\gamma_K-\delta) \end{array} \right) \Big/ (K_t(1+\overline{r_t}-\gamma_K)) \tag{11}$$

Income from each factor of production, transfer payments from NTBs and consumption expenditure can directly be obtained from the SAM. Taxes can also be calibrated in a standard manner. The capital stock is calibrated by using estimates of the real rate of return and capital income data. Finally, the depreciation rate of capital (δ) is calibrated from Eq. 9.

The resulting value is v=0.09, which implies that less than 10% of Syria's physical capital stock can serve as collateral for foreign debt or —equivalently—that Syria needs a large amount of physical capital to attract a unit of foreign credit. One apparent reason may be that international donors do not have too much trust in the property-rights protection or, in general, the enforcement of law in Syria. For example, the analogous calculations for highly indebted Lebanon results in a coefficient of v=0.39. While this value is still quite far off the maximum value of v=1 (which would correspond to perfect capital mobility), it expresses much more confidence of international capital markets in the Lebanese economy than in the Syrian economy.

As it is well known some parameters cannot be calibrated from the SAM. Some of these are elasticities of substitution and transformation. Here we resort to a World Bank study by Devarajan et al. (1999), in which modern time series methods are used to estimate elasticities of substitution between domestically and internationally produced goods for Syria and many other countries. Where point estimates for Syria are not available, we use averages of point estimates from other Arabic States. As Devarajan, Go and Li estimates refer to aggregates, we use their values uniform across disaggregated magnitudes. Following standard practices in trade policy analysis we assume a high elasticity of substitution for imports of the same commodity from different countries of origin. This elasticity was set to four across all trading partners in our simulations. The world real interest rate, which can also not be inferred from the SAM, is exogenously fixed at 4%.

For tax and tariff rates, we often have contradictory information, because the legally fixed value is not in accord with the factual value implied from observed tax revenues and tax bases. We have always used the effective tax rates in such cases.

For tariff equivalents of non-tariff barriers we use the estimates that have been calculated by Chemingui and Dessus (2004). They use the so-called price gap or price impact methodology, cf. Stanton (1994). According to this approach, the tariff equivalent of NTBs is the percentage by which the domestic price exceeds the cif-world market price plus any tariffs imposed by the importing country. Hence NTBs may differ across trading partners, since some trading partners may have preferential

access to the Syrian market. For instance, Arabic countries benefit from reduced (and still decreasing) tariff rates agreed upon in the Greater Arab Free Trade Agreement (GAFTA). Note that the EU currently does not have preferential access to Syria, even though Syrian manufactures do enjoy essentially free market access to the EU already since a Cooperation Agreement signed in 1977.

For the purpose of this study, the European Union is defined as the EU 15. This is due to data limitations—currently, no annual data is yet available for the EU 25. For the trade patterns, we have, however, made crude adjustments by rearranging data between the formerly socialist block of countries and the EU 15 to reflect the accession of the Eastern European countries to the EU in May 2004. Except for the EU and the formerly socialist countries we also consider a block of Arabic countries, Iran, Turkey, and the rest of the world. Iran and Turkey are considered as single countries since Syria has signed or intends to sign free trade agreements with these countries not included in GAFTA.

4 Syria's policy options in international trade

The negotiated text of Syria's Association Agreement with the European Union stipulates the Syrian immediate abolishment of NTBs and the gradual reduction to zero of ad-valorem tariff rates. So the first simulation (the AA-simulation) computes the quantitative effects of these measures. It is important to note that the design of the simulations is determined by the text of the Agreement—it does in no way express the opinion that NTBs can or will be reduced significantly faster than formal tariff rates. Hence, the AA-simulation must be viewed as an ideal scenario which will probably not be matched in reality. It is nevertheless useful as a benchmark. We organize the discussion of our simulation results around the lessons drawn from this benchmark simulation, which is, therefore, documented in some detail.

Figure 1 displays the responses of the main aggregates GDP, consumption and investment. We show the growth factors relative to the benchmark year prior to the implementation of the AA. (The growth factor of a variable is defined as one plus the percentage change of the variable.) The last value of the trajectories is the new steady state value. We depict the trajectories over 250 years (!), nevertheless, convergence to the new steady state is still less than complete after such a long time span. (Thus, be aware that the time axis of Fig. 1 has a discontinuity at the last observation).

Why does the model have such a slow speed of convergence? We traced the cause of this unusual phenomenon to the capital share in the mining sector. The Syrian mining sector (which basically comprises oil and gas production) is very capital intensive. The production elasticity of capital is calibrated to be 0.98, i. e. a value very close to one. As is well-known from e. g. the *AK*-model, a unitary production elasticity of capital (in the aggregate) would imply no convergence at all. While in the Syrian SAM not all sectors have similarly high capital shares, it is suggestive to conjecture that even a single sectoral capital share close to one may significantly slow down convergence. For a counterfactual test, we changed the SAM by decreasing the capital share in mining to one third (and increasing the labor share correspondingly). As a result, convergence occurred after less than 70 years. Hence,

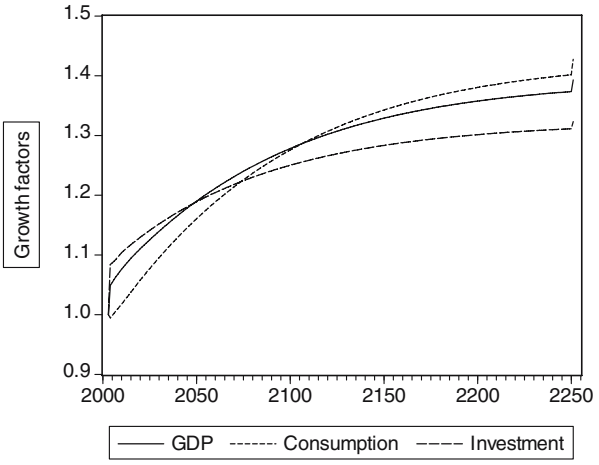

Fig. 1 Main aggregates

it is clearly the capital share in mining which causes slow convergence. (Coincidentally, slow economic adjustment is quite a realistic feature of the Syrian economy!).

Obviously, few policymakers will be impressed by projections which promise benefits after 250 years or longer. We will instead focus on the effect after 25 years. This is still a long time span, but given that the schedule for tariff dismantling extends over 12 years, 25 years is a useful interval to look at. In fact, some variables react in a non-monotonic way to changes in the economic environment, but the non-monotonicity typically fades in the first 10 years or so. Such non-monotonicities (a very tiny occurrence is visible in the consumption trajectory in Fig. 1) are among the most interesting features of CGE-results.

The trajectories in Fig. 1 underpin the importance of a dynamic analysis. While investment increases instantaneously by 8%, consumption actually falls slightly (−0.5%). However, in the (very) long run, consumption increases more than investment: After 250 years, consumption has increased by 40%, whereas investment has increased by 31% relative to their benchmark values. This is to say that the economy sacrifices consumption possibilities now for investment and is rewarded by increased consumption possibilities (due to accumulated physical capital) in the future. The initial loss of consumption (−0.5%) is cut to less than a third in the second year (−0.15%) and changes sign in the third year (+0.2%) with further increases in each subsequent year. Hence, it seems that trade liberalization as set out in the Association Agreement is politically feasible, since detrimental effects on the population's consumption possibilities are limited.

This impression is also supported by looking at factor prices, cf. Fig. 2. The real interest rate initially rises by less than half a percentage point before converging to a level slightly lower than in the benchmark. It is clearly the possibility of (constrained) international borrowing and lending which helps prevent more pronounced fluctuations in the real rate. The real wage increases monotonically over the whole horizon with a sizable increase of 12% in the first 25 years. This is obviously due to capital stock growth which induces a higher marginal product of

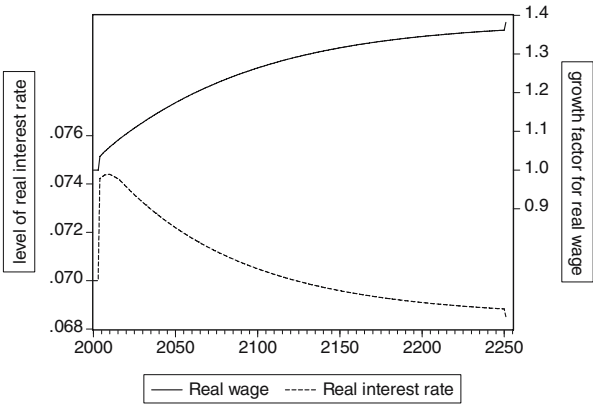

Fig. 2 Factor prices

labor. So, at least for the first hundred years or so, factor owners benefit from EU-association.

However, aggregate effects do not provide information about the political feasibility of reform since certain sectors could experience crises, while others benefit. Looking at sectoral outputs, the instantaneous effect on production is positive for almost all Syrian manufacturing sectors.[3] However, in agriculture, the short-run effect is negative (−1.4%). Figure 3 displays the growth factors over 25 years for outputs in agriculture and the two largest manufacturing sectors, government-owned chemical industries and private textile production. There are strong positive short-run effects in textile and chemicals production (and—not depicted—similarly strong positive effects in exports), presumably because intermediates for these industries enter Syria cheaper under the Association Agreement than before. Agriculture, however, does not benefit initially. This seems plausible, since the most important intermediates for agriculture (fertilizers, fuel and agricultural inputs) are produced within Syria. Hence, at constant factor input, the profitability (measured by the return to capital) of agriculture decreases relative to the manufacturing sectors. Therefore, production factors (labor and capital usage) shift towards manufacturing and manufacturing output increases.[4]

Looking at the output levels across all sectors 25 years from now, the AA-scenario would suggest that activities are very differently affected by the increased openness. Food, chemical and metal industries (both government and privately

[3] The one exception being government-controlled wood processing industries—a very minor and actually the smallest sector we consider.

[4] Note that this statement is about *relative* profitability at constant factor input. In absolute terms, even agriculture benefits from reduced input prices, albeit to a lesser extent. This is evident from agricultural exports (which are sold at constant prices): Agricultural exports increase by about 2% in the first year. However, agricultural imports increase even stronger (about 3% in the first year), although tariffs for agricultural products are not liberalized. Thus, increased imports make up for reduced agricultural production and higher exports. (Note that this discussion just gives the general line—the model actually considers four types of tradable agricultural commodities which differ in their reaction to trade liberalization).

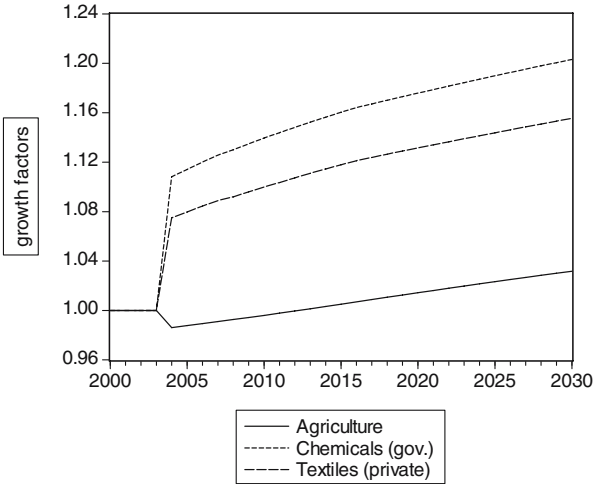

Fig. 3 Selected sectoral outputs

owned) benefit most, whereas service industries (which use little imported intermediates) and agriculture come last, but still with positive effects.

So far, our results are fairly promising, as trade liberalization seems to be associated with broadly positive developments in the Syrian economy (Table 1). But

Table 1 Sectoral effects of trade liberalization

Sectoral effects of trade liberalization		
Sector	Benchmark output value in Syrian Pounds	Increase after 25 years (%)
Agriculture	303,495	3.0
Wood (gov.)	410	5.5
Government services	94,651	5.7
Finance	37,676	5.7
Textiles (gov.)	14,467	7.3
Trade	164,238	7.6
Utilities	35,360	7.9
Non-metals (gov.)	9,480	8.4
Transport	159,793	8.5
Other manufactures (priv.)	39,812	8.9
Construction	72,889	9.6
Social services	38,038	10.1
Other manufactures (gov.)	6,948	11.5
Mining	149,576	12.9
Food (gov.)	39,160	13.3
Food (priv.)	50,126	13.7
Non-metals (priv.)	23,935	15.0
Textiles (priv.)	50,245	15.3
Chemicals (priv.)	11,570	16.6
Wood products (priv.)	15,452	17.6
Chemicals (gov.)	71,919	20.1
Metals (priv.)	36,094	23.2
Metals (gov.)	9,303	25.0

Table 2 Effects of trade liberalization after 25 years

(per capita variables)	Tariff-scenario	NTB-scenario	Combined effect
Welfare	0.16%	0.48%	0.33%
	25 year effects		
GDP	1.6%	9.9%	13.7%
Consumption	1.2%	7.6%	9.2%
Investment	2.0%	11.8%	15.1%
	steady-state effects		
GDP	4.7%	29.1%	39.3%
Consumption	5.3%	33.2%	42.8%
Investment	4.1%	24.8%	32.3%

we have to bear in mind that the immediate and complete dismantling of NTBs seems fairly unrealistic. We, therefore, decompose the benchmark scenario into a tariff-scenario with just the gradual tariff dismantling (NTBs constant) and an NTB-scenario with just immediate NTB dismantling (formal tariffs constant).[5] Since formal tariff dismantling sets in gradually and extends over 12 years, there is no point in short-run comparisons with the effects of immediate NTB dismantling. We, therefore, focus on the effect after 25 years and on the (very distant) steady state effect, where the latter is approximately proportional to the former, cf. Table 2. Using the full aggregate consumption trajectory, we also calculate the appropriate welfare effects.

Note that the welfare increase from the combined measures is smaller than from removing only the NTBs. This takes place because the combined scenario induces more investment and hence less consumption in the short-run. In the long run, of course, this effect reverses, but due to discounting under slow convergence, this is not sufficient to make the combined scenario welfare-superior.

Looking at the measures in isolation, removing NTBs causes effects which are about six times larger than reducing tariffs. Why is this the case?

The Syrian tariff structure is quite typical for an import-substituting economy. Basically, consumption goods carry high tariff rates,[6] while intermediates and investment goods benefit from low tariff rates—unless there is a domestic industry to be protected (as with fertilizers). However, this structure is not necessarily reflected in NTBs. As Table 3 shows, some important intermediates or investment goods categories are subject to substantial non-tariff barriers to trade.

It is not completely clear why some non-tariff barriers seem to run counter to the intended structure of the formal tariffs. But it is suggestive to hypothesize that the non-tariff barriers are not the results of deliberate economic policy. Rather, it may be the case that an uncoordinated accumulation of regulations over time, inefficient structures and habits have created NTBs not actively controlled by the government. While it may go too far to say that these NTBs are factually beyond the control of

[5] Note that this decomposition does not imply that the two scenarios add up to the scenario with the combined policy. The model is highly nonlinear and so are the results. Table 2 clearly shows that the combined policy has larger effects than the sum of the two policies in isolation.

[6] E. g. 19% for fish, 43% for fruits, 27% for beverages and tobacco, 104% for leather products, 47% for textiles and 21% for plastics.

Table 3 Tariff and non-tariff barriers for intermediates and investment goods

	Tariff rate (%)	Tariff equivalent of NTB (%)
Fats and waxes	6.6	31.8
Textile fibers	2.3	8.3
Crude materials (except fuels[a])	5.5	4.9
Fertilizers	31.8	6.3
Other chemicals	4.9	35.1
Steel	8.7	9.2
Transport equipment	16.3	55.5
Other machinery	16.2	124.2

[a] There are virtually no imports of fuel, since Syria still is affluent in oil and provides mineral fuels at very low prices domestically.

the government, the observed quality of government institutions in Syria suggests that it may be very difficult to remove NTBs. In particular, since NTBs give rise to sizable rents they will likely be defended by those currently benefiting from them. As such, the analysis reveals that formal trade liberalization as set out in the Association Agreement may have relatively small effects on economic welfare, even if the abolishment of NTBs is (on paper) codified in the Agreement. However, the Agreement along with active technical help in reforming institutions (as intended in the MEDA program) may realize a much larger potential for economic growth in Syria.

There is one other reason why the removal of NTBs creates sizable effects on GDP and other macro aggregates. Note that the simulation results just refer to the removal of NTBs for products of European origin. Imports from Europe (EU 25 concept) constitute about 40% of total Syrian imports. However, it is common in such analyses to assume that the elasticity of substitution for imports of the same commodity but from different countries of origin is fairly high. For instance, this elasticity was set to four across all trading partners in our simulations. Thus, removing NTBs for the EU but not for other trading partners gives European suppliers the chance to make large inroads into other Syrian trading partners' market shares. Thus, the share of liberalized trade is sizably larger than the current share of EU trade.

In our simulations, the removal of NTBs for EU products (as the only change to the status quo) causes an increase in imports from the EU after 25 years of more than 25%, while imports of other trading partners decrease by roughly 15–20%. The sole exception to this are the Arabic trading partners, whose exports to Syria decrease by less than 5% after 25 years. This is so because many Arabic countries are also Mediterranean Partners which can take advantage from a specific NTB-removal: The EU applies to all Mediterranean Partners the so-called Palermo-rules of origin, which allow for diagonal cumulation rather than bilateral cumulation as in the status quo, cf. Augier et al. (2005). Thus intermediates imported from other partner countries will be considered as equivalent to domestically produced intermediates when exporting to the EU, and therefore, trade with Arabic countries becomes more favorable for Syrian importers than before the Association Agreement. However, this positive stimulus is not sufficient to compensate for the competitive edge European suppliers gain through the removal of NTBs.

Syrian trade policy, however, is not exclusively oriented towards the EU. Besides the agreement on the Greater Arab Free Trade Area (GAFTA) Syria concluded a free trade agreement with Turkey and is in talks about such an agreement with Iran. The effects of these latter FTAs on GDP are small (and not reported here), since both countries have only minor shares in trade with Syria. Of much higher importance is Syria's application for WTO membership. The next simulation (called WTO-simulation) will quantify its likely effects. We also provide a simulation for a trade policy which implements the most favored nation (MFN) principle, the MFN-simulation.

Under WTO rules, Syria would have to follow a tariffication process for the remaining NTBs, i. e. NTBs would have to be transformed into formal tariff barriers. After tariffication, tariffs of agricultural goods would have to be dismantled based on the Agricultural Goods Agreement for Developing Countries established in the Uruguay Round. This consists in a total 24% decrease in agricultural tariffs during a 10-year period. For the rest of the commodities (all non-agricultural goods) tariff reductions are to be negotiated with the WTO. Not knowing the results of these negotiations we presumed that after tariffication import tariffs of all non-agricultural commodities are instantaneously reduced by 50%. Note that this essentially implies that only 50% of current NTBs will be dismantled—but this refers to the NTBs for all trading partners.

For an MFN-policy, the crucial question is to which tariff system the MFN rule refers. If there is a preferential trading agreement under which the tariff rates for a single trading partner are reduced to zero, then obviously MFN implies that all trading partners will enjoy tariff rates of zero. If, however, all trading partners are confronted with positive tariff rates then, obviously, MFN will just ensure that each trading partner can import goods into Syria at the minimum tariff rate applicable to a single country. We will here simulate an MFN-policy with reference to the status quo tariff structure, i. e. not taking into account future tariff reductions under preferential trading agreements.

The results are given in Table 4. The effects of WTO accession are much bigger than those of MFN adoption. In fact, the MFN rule seems hardly effective, unless there is accompanying trade liberalization—either in the form of preferential agreements or in the form of multilateral trade liberalization under the auspices of the WTO.

Table 4 Results of WTO accession and MFN adoption

(per capita variables)	WTO-scenario	MFN-scenario
Welfare	1.35%	0.20%
	25 year effects	
GDP	5.7%	1.4%
Consumption	7.4%	0.6%
Investment	3.2%	2.2%
	steady-state effects	
GDP	21.1%	2.9%
Consumption	28.6%	2.7%
Investment	13.2%	3.2%

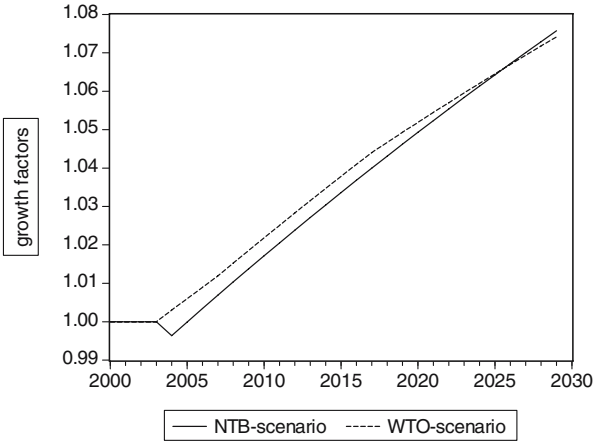

Fig. 4 Alternative consumption trajectories

The long-run effects of WTO membership on GDP, consumption and investment are somewhat smaller than in the NTB-scenario—which once again underlines the importance of NTB removal under the Barcelona Initiative. But note that the effect on welfare is substantially larger for the WTO-scenario than for the NTB-scenario, cf. Fig. 4. This is so, because the WTO scenario implies a higher level of consumption during the first 20 years or so. Only in the long run does NTB removal lead to higher consumption levels, however, long-run consumption levels are highly discounted.

Digging deeper, we can single out trade diversion effects as the likely source of relatively small welfare effects under preferential trade liberalization. Table 5 gives the growth rates of Syrian imports by country for the NTB- and WTO-scenarios. (The NTB-scenario is typical for the other scenarios with preferential trade liberalization, while the WTO-scenario is a good representative of other multilateral trade liberalization settings). It is obvious that the NTB-scenario is more strongly trade-creating than the WTO-scenario, because export growth is much stronger in the former. But, it is equally obvious that preferential trade liberalization has severe trade distorting effects in favor of the European Union (the positive effect for formerly socialist states is due to the fact that we anticipated the Eastern enlargement of the EU by decreasing some NTBs for these states, too). By contrast, imports grow rather evenly across trading partners in the WTO-scenario. Hence we may conclude that preferential trade liberalization leads in many cases to the replacement of goods from non-European countries by possibly more expensive European goods, thereby creating inefficient trade structures.

From a policy point of view, the above results suggest that the EU-association offers a promising and politically feasible way for Syria to stimulate its economy. Despite a non-trivially interrelated commodity production and intermediate consumption structure there are clearly discernible benefits for almost all manufacturing sectors of the economy. There may be a certain depression in agriculture, though, so the Syrian government might be well advised to press the

Table 5 Growth rates of Syrian imports by country

25-year-effects: growth rates of imports from	NTB-scenario (%)	WTO-scenario (%)
Arabic countries	−4.01	3.77
EU 15	26.7	4.31
Formerly socialist countries	8.57	4.17
Turkey	−14.8	3.86
Iran	−21.7	4.61
Rest of the world	−14.0	4.11
Total imports	3.05	4.14
Total exports	10.6	4.23

European Union to open its agricultural markets more to Syrian products than they actually do. In fact, Syria has already obtained such concessions from the European Commission, and probably more so than any other Mediterranean Partner Country.

With some temporary shrinking in agriculture, there will be layoffs in rural areas. These are typically unqualified workers flowing into the few industrial centers of Syria. While from a labor market perspective this excess supply of workers might well be absorbed by the expanding industries (many industry jobs in Syria require little qualification), the increased rural–urban migration is a deplorable phenomenon, in particular for over-crowded Damascus. It is henceforth suggestive to discuss setting up tax incentives for newly founded industrial settlements in Syria's less developed regions. The economic stimulus from trade liberalization may be the appropriate window of opportunity to do so.

Nevertheless, the simulations also show, that preferential trade liberalization through EU association is probably at most second-best. It seems that trade flows may be severely distorted if Syria dismantles both its formal tariffs and its NTBs for European suppliers. This trade distortion is clearly not in the interest of the Syrian people, so the Syrian Government would be well advised to go ahead with WTO accession and multilateral trade liberalization. While such a policy (according to our simulations) does not necessarily dominate EU association in terms of GDP or long-run consumption growth, it clearly dominates in welfare, i. e. it provides higher consumption levels sooner than does mere EU-association.

This is important, since Syria faces grave problems elsewhere in its economy. The most important economic challenge is the foreseeable decrease in oil production. Known reserves are expected to be depleted in about 10 years' time and intensive exploration in recent years has, so far, not resulted in significant new discoveries. Running out of oil would hurt Syria seriously, since almost two thirds of total export receipts are currently due to crude oil and related products. Although exports may be stabilized a bit by substituting gas (of which Syria has plenty) for oil in domestic electricity generation and thus freeing oil for exports, it is widely acknowledged that Syria is faced with a problem which may result in a serious depression of economic activity. Any positive impetus through trade liberalization and in particular any support for consumer welfare will therefore be highly welcome for a population which is already today by about 25% poorer than neighboring Jordan's—let alone Lebanon.

5 Conclusions

The Barcelona Initiative is the central element of the EU's Mediterranean policy. Trade liberalization figures prominently on the agenda of this initiative, possibly because it is the origin of the EU's own success story. In fact, the economic success of the European Union widens the gap between EU and MENA countries and may reinforce problematic developments like illegal immigration. It is therefore in the own interest of the EU to promote economic growth and the development of modern institutions in the MENA countries.

Syria is a country whose backwardness is particularly noticeable, even among MENA countries. As this seems to be at least partially attributable to suboptimal domestic policies, it is interesting to analyse what kind of growth impulses the country may obtain from what kind of policy changes. Successful economic development in Syria may have far-reaching consequences not only through spillovers to neighboring countries like Jordan and Lebanon, but also for the peace process with Israel.

The results of a fully specified dynamic general equilibrium model calibrated to Syrian data deliver a fairly clear message: Dismantling formal tariffs has only very limited effects on the Syrian economy, while a dismantling of non-tariff barriers produces by far larger results. This suggests two things: First, unfreezing the Syrian growth potential may be quite difficult, both politically and administratively, as it seems that Syrian NTBs are not fully controlled by the government. Second, it seems that the EU was well advised to include institution-building elements like the MEDA program into the Association Agreement, rather than limit the agreement to a typical free trade agreement. If anything succeeds in reducing NTBs, then this is likely to be a reformed institution rather than a good-will declaration on paper. The ubiquituous complaints about the implementation of the GAFTA agreement teach an important lesson about the perspectives of a free trade agreement handled in the present governmental structures.

Beyond EU-association, WTO accession or, in general, multilateral trade liberalization promises further benefits, since trade distorting effects will be reduced. But this, again, may be easier said than done, since WTO accession also requires NTB dismantling—at least in the form of tariffication. If it is true that the Syrian government may not be able to accomplish this task on its own, the institution-building component of the Mediterranean Partnership Program may be a helpful device also for a trade policy devoted to the most MFN principle.

Of course, there are various other economic policy measures the Syrian government may wish to consider: Privatization, deregulation, financial liberalization, improved property rights and so forth. Such reforms would surely increase Syria's creditworthyness on international capital markets, so that it would be interesting to study gradual changes in credit constraints as Lucke et al. (2007) and Lucke and Zotti (2006) have done for Lebanon. Such an analysis, however, is left for future research.

Acknowledgement We thank Salam Said for her very helpful research assistance, specifically for requesting and translating documents from the Syrian government. She also collaborated with the computation of tariff reductions and worked on data collection.

Appendix

Glossary

$a^{m,n}$	activity n intermediate good m fixed input Leontief coefficient
A_t^n	activity n total factor productivity
B_t^G	government payments abroad
$b^{K,n}$	activity n capital production elasticity
$b^{L,n}$	activity n labor production elasticity
$b^{La,n}$	activity n land production elasticity
c_t	per-capita private consumption composite
$c_t^{D,m}$	per-capita private consumption of domestic commodity m (in Armington)
$c_t^{IM,m}$	per-capita private consumption composite of imports of commodity m (in Armington)
$c_t^{IM,m,q}$	per-capita private consumption of imported good m originating from country q
c_t^m	per-capita private consumption of good m (Armington)
D_t	stock of foreign debt
D_t^m	domestic supply of domestic commodity m
E_t^m	export supply of commodity m
G_t	government consumption composite
$G_t^{D,m}$	government consumption of domestic commodity m
$G_t^{IM,m,q}$	government consumption of imported good m originating from country q
I_t	Investment
$I_t^{D,m}$	domestic commodity m used in the production of the investment good
$I_t^{IM,m,q}$	imported good m originating from country q used in the production of the investment good
$IM_t^{m,q}$	Aggregate imports of good m originating from country q
K_t	physical capital stock
K_t^n	physical capital employed by activity n
L_t	total per-capita working time
L_t^n	per-capita working time employed by activity n
La_t	land endowment
La_t^n	land employed by activity n
m	index for commodities
M	number of commodities
n	index for activities
N	number of activities
$ntb^{m,q}$	non-tariff-barrier rate equivalent of commodity m originating from region q
O_t	government outlays
$P_t^{A,m}$	Armington demand price of commodity m
P_t^C	price of private consumption composite
$P_t^{D,m}$	domestic price of commodity m
$P_t^{E,m}$	intermediary composite price of exports of commodity m
$P_t^{E,m,q}$	export price of commodity m to region q
P_t^G	government consumption composite price
P_t^I	investment good composite price
$P_t^{IM,m}$	composite price of imports of commodity m
$P_t^{IM,m,q}$	import price of good m originating form country q
P_t^{La}	rental price of land
$P_t^{n,m}$	price of commodity m sold by activity n
$P_t^{WE,m,q}$	world price of exports of commodity m of country q
$P_t^{WIM,m,q}$	world price of imports of commodity m from country q
$P_t^{Q,m}$	intermediary-m supply price composite
$P_t^{Y,n}$	supply price composite of activity n
$P_t^{V,n}$	value added price of activity n
$P_t^{V,n} Y_t^n$	activity n value added
$Pd_t^{Q,m}$	demand composite price of intermediary m

Q_t^m	aggregate supply of commodity m
Qd_t^m	production (CES) composite of intermediary m
r_t	weighted average rental rate of capital
$\bar{r}$	world interest rate
r_t^n	activity n rental rate of capital
R_t	government revenues
S_t	private' savings
$s^{E,m,q}$	export subsidy of commodity m to country q
$t^{IM,m,q}$	import tariff rate on commodity m originating from country q
T_t^G	consumer's net lump transfer from government
T_t^W	foreign remittances to consumers
U_0	lifetime utility
U_t	instantaneous utility
w_t	labor wage rate
$x_t^{D,m,n}$	activity n intermediate demand of domestic good m
$x_t^{IM,m,n,q}$	activity n intermediate demand of imported good m originating from country q
$x_t^{m,n}$	activity n intermediate demand of good m
Y_t^n	activity n aggregate production
Y_t^{disp}	disposable income
$Yd_t^{n,m}$	intermediary m purchases of good m from activity n
$Ys_t^{n,m}$	Activity n supply of commodity m
α	inverse of the elasticity of intertemporal substitution for consumption in the instantaneous utility function
β	inverse of the elasticity of intertemporal substitution for leisure in the instantaneous utility function
$\chi^{E,m}$	scale parameter of intermediaries export composite distinguishing between exports to regions.
$\chi^{I,m}$	scale parameter of intermediaries m in supply composite (distinguishing between domestic sales and exports of good m)
χ^n	scale parameter of activity n in CET supply composite
δ	capital depreciation rate
ε^E	export elasticity of transformation between goods of type m to regions q.
ε^I	intermediary m the elasticity of transformation between domestically produced goods and exports.
ε^m	elasticity of transformation between goods of type m produced by activity n
$\phi^{E,m,q}$	share parameter of good m exported to region q in intermediaries export composite distinguishing between exports to regions.
$\phi^{I,m}$	share parameter of domestic supply of good m of intermediary m in supply composite(distinguishing between domestic sales and exports of good m)
$\phi^{n,m}$	commodity m produced by activity n share parameter in CET supply composite
γ^{Ω}	population growth rate
η	leisure share parameter
κ^m	elasticity of substitution between goods m in consumption composite
κ^A	elasticity of substitution between domestically produced and imported goods in Armington
$\kappa^{I,m}$	elasticity of substitution between goods of type m produced by each of the N activities in intermediary m CES demand composite
κ^{IM}	elasticity of substitution between goods of type m originating from regions q in Armington
λ^E	substitution parameter in intermediaries export composite distinguishing between exports to regions q
λ^I	substitution parameter of intermediaries in supply composite (distinguishing between domestic sales and exports of good m)
λ^m	substitution parameter of activity n across commodities M in CET supply composite
ν_t	fraction of foreign debt to domestic capital
ρ	consumer's rate of time preference
σ^m	substitution parameter of goods m in consumption composite
σ^A	substitution parameter (in Armington distinguishing between domestic and imported goods)
$\sigma^{I,m}$	substitution parameter in intermediary m CES demand composite
σ^{IM}	substitution parameter (in Armington distinguishing between goods of type m originating from regions q)
τ	general income tax rate

τ^{L}	labor income tax rate
τ^{K}	capital income tax rate
τ^{La}	land income tax rate
$\tau^{n,ind}$	indirect tax rate on production of activity n
Ω_t	population at time t
$\psi^{C,m}$	private composite consumption commodity-m's share parameter
$\psi^{C,A,m}$	private consumption domestic commodity-m's share parameter in Armington (distinguishing between domestic and imported goods) of good m
$\psi^{C,IM,m,q}$	private consumption commodity-m's originating from region q share parameter inimport Armington (distinguishing between goods of type m originating from regions q) of good m
$\psi^{I,n,m}$	share of good m produced by activity n in intermediary m CES demand composite
ζ^{C}	private composite consumption scale parameter
$\zeta^{C,A,m}$	private consumption scale parameter in Armington of good m
$\zeta^{C,IM,m}$	private consumption scale parameter in import Armington of good m
$\zeta^{I,m}$	scale parameter in intermediary m CES demand composite

Equations

Firms (Activities)

Intermediate demand

$$x_t^{m,n} = a^{m,n} Y_t^n, \quad m = 1, ..., M, \quad n = 1, ..., N. \tag{12}$$

Value added price

$$P_t^{V,n} = \frac{\left(P_t^I r_t^n\right)^{b^{K,n}} (w_t)^{b^{L,n}} \left(P_t^{La}\right)^{b^{La,n}}}{\left(b^{K,n}\right)^{b^{K,n}} \left(b^{L,n}\right)^{b^{L,n}} \left(b^{La,n}\right)^{b^{La,n}} A_t^n}. \tag{13}$$

Activity n value added

$$P_t^{V,n} \cdot Y_t^n = \frac{\left(P_t^I r_t^n\right)^{b^{K,n}} (w_t)^{b^{L,n}} \left(P_t^{La}\right)^{b^{La,n}}}{\left(b^{K,n}\right)^{b^{K,n}} \left(b^{L,n}\right)^{b^{L,n}} \left(b^{La,n}\right)^{b^{La,n}} A_t^n} \cdot Y_t^n \tag{14}$$

Factor demands

$$K_t^n = \frac{b^{K,n}}{P_t^I r_t^n} P_t^{V,n} \cdot Y_t^n, \tag{15}$$

$$L_t^n \Omega_t^n = \frac{b^{L,n}}{w_t} P_t^{V,n} \cdot Y_t^n, \tag{16}$$

$$La_t^n = \frac{b^{La,n}}{P_t^{La}} P_t^{V,n} \cdot Y_t^n. \tag{17}$$

Activity n zero profits condition

$$P_t^{Y,n} = \left(\sum_{m=1}^{M} a^{m,n} P_t^{A,m} + P_t^{V,n}\right) \Big/ \left(1 - \tau^{n,ind}\right). \tag{18}$$

Activity revenue (supply) maximization problem

$$\begin{aligned} &P_t^{Y,n} Y_t^n \equiv \max_{\left\{ys_t^{n,m}\right\}_{m=1\ldots M}} \left(\sum_{m=1}^{M} P_t^{n,m} Ys_t^{n,m} \right), \\ &s.t. \\ &Y_t^n = \chi^n \left(\sum_{m=1}^{M} \phi^{n,m} \left(Ys_t^{n,m}\right)^{\lambda^m} \right)^{\frac{1}{\lambda^m}}, \quad \chi^n > 0, \quad 0 < \phi^{n,m} < 1, \quad \sum_{m=1}^{M} \phi^{n,m} = 1, \quad \lambda^m > 1, \end{aligned} \tag{19}$$

and $\varepsilon^m = \frac{1}{\lambda^m - 1}$.

Activity n supply of commodity m

$$Ys_t^{n,m} = \left(\chi^n\right)^{\varepsilon^m - 1} \left(\frac{P_t^{Y,n}}{P_t^{n,m}} \phi_s^{n,m} \right)^{\varepsilon^m} Y_t^n. \tag{20}$$

Intermediaries

Intermediary m cost minimization problem

$$\begin{aligned} &Pd_t^{Q,m} Qd_t^m \equiv \min_{\left\{yd_t^{n,m}\right\}_{n=1\ldots N}} \left(\sum_{n=1}^{N} P_t^{n,m} Yd_t^{n,m} \right), \\ &s.t. \\ &Qd_t^m = \zeta^{I,m} \cdot \left[\sum_{n=1}^{N} \psi^{I,n,m} \cdot \left(Yd_t^{n,m}\right)^{\sigma^{I,m}} \right]^{\frac{1}{\sigma^{I,m}}}, \quad \zeta^{I,m} > 0, \quad 0 \le \psi^{I,n,m} \le 1, \quad \sum_{m=1}^{M} \psi^{I,n,m} = 1, \quad \sigma^{I,m} < 1 \end{aligned} \tag{21}$$

and $\kappa^{I,m} = \frac{1}{1 - \sigma^{I,m}}$.

Intermediary's m demand of commodity m from activity n

$$Yd_t^{n,m} = \left(\zeta^{I,m}\right)^{\kappa^{I,m} - 1} \left(\psi^{I,n,m} \frac{Pd_t^{Q,m}}{P_t^{n,m}} \right)^{\kappa^{I,m}} Qd_t^m \tag{22}$$

Intermediary's m revenue maximization problem

$$\begin{aligned} &P_t^{Q,m} \cdot Q_t^m \equiv \max_{D_t^m, E_t^m} \left(P_t^{D,m} \cdot D_t^m + P_t^{E,m} \cdot E_t^m \right), \\ &s.t. \\ &Q_t^m = \chi^{I,m} \left[\phi^{I,m} \left(D_t^m\right)^{\lambda^I} + \left(1 - \phi^{I,m}\right) \left(E_t^m\right)^{\lambda^I} \right]^{\frac{1}{\lambda^I}}, \quad 0 \le \phi^{I,m} \le 1, \quad \lambda^I > 1 \end{aligned} \tag{23}$$

and $\varepsilon^I = \frac{1}{\lambda^I - 1}$.

Domestic supply of commodity m

$$D_t^m = \left(\chi^{I,m}\right)^{\varepsilon^I - 1} \left(\phi^{I,m} \frac{P_t^{Q,m}}{P_t^{D,m}} \right)^{\varepsilon^I} Q_t^m. \tag{24}$$

Armington composite of exports of commodity m

$$E_t^m = \left(\phi^{I,m}\right)^{\varepsilon^I - 1}\left(\left(1-\alpha^{I,m}\right)\frac{P_t^{Q,m}}{P_t^{E,m}}\right)^{\varepsilon^I} Q_t^m. \tag{25}$$

Also

$$P_t^{E,m}E_t^m \equiv \max_{\left\{E_t^{m,q}\right\}_{q=1\ldots Q}}\left(\sum_{q=1}^{Q} P_t^{E,m,q}E_t^{m,q}\right),$$

$$s.t.$$

$$E_t^m = \chi_E^{E,m}\left(\sum_{q=1}^{Q}\phi^{E,m,q}\left(E_t^{m,q}\right)^{\lambda^E}\right)^{\frac{1}{\lambda^E}}, \quad \chi_E^m > 0, \quad \varphi^{E,m,q} > 0, \quad \sum_{q=1}^{Q}\varphi^{E,m,q} = 1, \quad \lambda^E > 1 \tag{26}$$

where $P_t^{E,m,q} \equiv P_t^{WE,m,q}\left(1+s^{E,m}\right)$ and $\varepsilon^E = \frac{1}{\lambda^E - 1}$

Exports of commodity m to country q

$$E_t^{m,q} = \left(\chi^{E,m}\right)^{\varepsilon^E - 1}\left(\phi^{E,m,q}\frac{P_t^{E,m}}{P_t^{E,m,q}}\right)^{\varepsilon^E} E_t^m. \tag{27}$$

Intermediary zero profit condition

$$P_t^{Q,m}\cdot Q_t^m = Pd_t^{Q,m}Qd_t^m. \tag{28}$$

Consumer

Necessary conditions for the consumer's intertemporal-maximization problem are given by

$$\frac{\left(1-L_t\right)^{\beta}}{c_t^{\alpha}} = \left(\frac{\eta}{1-\eta}\right)\frac{P_t^C}{(1-\tau)(1-\tau_L)w_t}, \tag{29}$$

$$\left(\frac{c_{t+1}}{c_t}\right)^{\alpha} = \frac{\nu_t P_{t+1}^I}{\left(P_t^I - \nu_t P_{t+1}^I\right)} \times \frac{P_t^C}{P_{t+1}^C}\left(\left(\frac{1+(1-\tau)(1-\tau_K)r_{t+1}-\delta}{1+\rho}\right)\frac{1}{\nu_t} + \left(\frac{1+\overline{r}}{1+\rho}\right)\right). \tag{30}$$

Consumption composite

$$c_t = \zeta^C\cdot\left[\sum_{m=1}^{M}\psi^{C,m}\cdot\left(c_t^m\right)^{\sigma^m}\right]^{\frac{1}{\sigma^m}}, \quad 0 \le \psi^{C,m} \le 1, \quad \sum_{m=1}^{M}\psi^{C,m} = 1, \quad \sigma^m < 1 \tag{31}$$

and $\kappa^m \equiv \frac{1}{1-\sigma^m}$.

Armington consumption composite of domestic and imported goods

$$c_t^m = \zeta^{C,A,m}\left[\psi^{C,A,m}\left(c_t^{D,m}\right)^{\sigma^A} + \left(1-\psi^{C,A,m}\right)\left(c_t^{IM,m}\right)^{\sigma^A}\right]^{\frac{1}{\sigma^A}}, \quad \zeta^{C,A,m} > 0,$$
$$0 \le \psi^{C,A,m} \le 1, \quad \sigma^A < 1 \tag{32}$$

and $\kappa^A \equiv \frac{1}{1-\sigma^A}$.

Armington consumption composite of imports of commodity m from regions q

$$c_t^{IM,m} = \zeta^{C,IM,m}\left(\sum_{q=1}^{Q}\psi^{C,IM,mq}\left(c_t^{IM,m,q}\right)^{\sigma^{IM}}\right)^{\frac{1}{\sigma^{IM}}}, \quad \zeta^{C,IM,m} > 0,$$
$$0 \le \psi^{C,IM,mq} \le 1 \quad \sum_{q=1}^{Q}\psi^{C,IM,mq} = 1, \quad \sigma^{IM} < 1 \tag{33}$$

and $\kappa^{IM} \equiv \frac{1}{1-\sigma^{IM}}$.

Consumer's demand of commodity m

$$c_t^m = \left(\zeta^C\right)^{(\kappa^m-1)}\left(\frac{\psi^{C,m}}{P_t^{A,m}}P_t^C\right)^{\kappa^m} c_t. \tag{34}$$

Consumer's demand of domestic commodity m

$$c_t^{D,m} = \left(\zeta^{C,A,m}\right)^{\kappa^A-1}\left(\frac{\psi^{C,A,m}P_t^{A,m}}{P_t^{D,m}}\right)^{\kappa^A} c_t^m. \tag{35}$$

Consumer's composite demand of imports of commodity m

$$c_t^{IM,m} = \left(\zeta^{C,A,m}\right)^{\kappa^A-1}\left(\frac{\left(1-\psi^{C,A,m}\right)P_t^{A,m}}{P_t^{IM,m}}\right)^{\kappa^A} c_t^m. \tag{36}$$

Consumer's demand of commodity domestic commodity m originating from region q

Government

$$c_t^{IM,m,q} = \left(\zeta^{C,IM,m}\right)^{\kappa^{IM}-1}\left(\frac{\psi^{C,IM,mq}P_t^{IM,m}}{P_t^{IM,m,q}}\right)^{\kappa^{IM}} c_t^{IM,m}. \tag{37}$$

$$\begin{aligned} R_t = \tau\big[&(1-\tau_L)w_t\cdot L_t\Omega_t + (1-\tau_K)P_t^I r_t\cdot K_t + (1-\tau_{La})P_t^{La}\cdot La_t\big] + \\ &+\tau_L\left(w_t\cdot L_t\Omega_t\right) + \tau_K\left(P_t^I r_t\cdot K_t\right) + \tau_{La}\left(P_t^{La}\cdot La_t\right) + \\ &+\sum_{n=1}^{N}\tau^{n,ind}P_t^{Y,n}Y_t^n + \sum_{m=1}^{M}\sum_{q=1}^{Q}t_{IM}^{m,q}P_t^{WIM,m,q}IM_t^{m,q} \end{aligned}, \tag{38}$$

$$O_t = P_t^G G_t + B_t^G + T_t^G + \sum_{m=1}^{M}\sum_{q=1}^{Q} s^{E,m,q} P_t^{WE,m,q} E_t^{m,q}. \tag{39}$$

Balanced government budget

$$O_t = R_t. \tag{40}$$

Market clearing conditions

Factors market clearing conditions

$$K_t = \sum_{n=1}^{N} K_t^n, \qquad L_t = \sum_{n=1}^{N} L_t^n, \qquad La_t = \sum_{n=1}^{N} La_t^n. \tag{41}$$

Good m produced by activity n market clearing condition (between activities and intermediaries)

$$Ys_t^{n,m} = Yd_t^{n,m}. \tag{42}$$

Market clearing condition for domestic products

$$D_t^m = c_t^{D,m}\Omega_t + I_t^{D,m} + G_t^{D,m} + \sum_{n=1}^{N} x_t^{D,m,n} \tag{43}$$

Total imports from country q

$$IM_t^{m,q} = c_t^{IM,m,q}\Omega_t + I_t^{IM,m,q} + G_t^{IM,m,q} + \sum_{n=1}^{N} x_t^{IM,m,n,q}. \tag{44}$$

Balance of payments

$$-(D_{t+1} - D_t) = \sum_{m=1}^{M}\sum_{q=1}^{Q}\left(P_t^{WE,m,q} E_t^{m,q} - P_t^{WIM,m,q} IM_t^{m,q}\right) - \bar{r} D_t + \left(T_t^W - B_t^G\right). \tag{45}$$

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