ASSESSING ECONOMIC AND FISCAL REFORMS IN LEBANON.
A DYNAMIC CGE ANALYSIS WITH DEBT CONSTRAINTS

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Abstract
Since the early nineties, Lebanon has undertaken a number of economic reforms, covering in particular international trade and internal fiscal policy issues. Simultaneously, debt has been skyrocketing, partially justified by reconstruction needs after the end of the civil war. Fostering economic growth seems to be the only way out of the debt trap, but reforms intended to stimulate growth may well have adverse short run effects on public and external deficits. We construct a dynamic open economy CGE model with debt constraints in the sense that external debt requires physical capital as collateral. This model allows us to study the effects of a number of important economic policy issues (fiscal policy reform, WTO membership, FDI) in a multisectoral dynamic setting under the realistic assumption that debt constraints relax when the economy starts growing. In particular, this paper, reports results on scenarios of trade liberalization and political stabilization.

Key words: dynamic CGE, Lebanon, trade liberalization, FDI, political stability

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Introduction

Lebanon has taken major steps towards integration in the world trading system. On the one hand, an Association Agreement\(^1\) with the European Union was signed in 2002. On the other hand, an observer status at the WTO was granted since 1999. Both decisions constitute important achievements towards trade liberalization and further opening up to foreign capital flows. Besides, Lebanon has been a member of the GAFTA\(^2\) since its creation in 1997 and joined the Agadir Agreement in 2004. A number of bilateral treaties with the OECD as well as other world countries are intended to further promote the free exchange of goods, services and capital.

 Preferential as well as non-discriminatory trade liberalization processes take place in the immediate aftermath of the introduction of a number of internal fiscal policy reform measures. These were undertaken with the primary goal of addressing fiscal imbalances, which had been steadily growing since the mid Nineties. Important modernization steps involved the introduction of a VAT in 2002 and of a General Income Tax in 2003. This was preceded (in 2002) by the introduction of a new system for the deduction at source of the income tax on salaries and wages. Such measures, broadening and consolidating the tax base, are also expected to counteract the negative impacts of trade liberalization on public revenues.

 Note that a common concern in studies on trade liberalization is inappropriate fiscal responses to rising deficits, i.e. lost tariff revenues, cf. Diao, Roe and Yeldan (1999). In the case of Lebanon, fiscal reform preceded major steps in trade liberalization, but it anteceded steps of tariff harmonization. In that sense, fiscal reform was embedded in trade reform: Lebanon implemented a tariff system reform in 1993 which brought about a simplification of the tariff structure, but left the protection level still somewhat high compared to other developing countries (Haddad (2004)). Also, government revenues continued to be highly reliant on tariff proceeds, cf. Nashashibi (2002).

 Therefore, one of the main objectives of the 2001-2003 tax reform was broadening the tax base. The reform also included a cut in tariff rates, but Dessus and Ghaleb (2004) report that even after the cut tariff proceeds amount to about one quarter of government revenues. The major trade liberalizing steps were still ahead in 2001, namely EU-association and WTO membership.

 As Go (1994, p. 229) has pointed out, the intertemporal trade-offs of tariff-reform may involve “the need for complementary measures to ease macro imbalances and short-term dislocations of the protected sector”. This suggests that fiscal policy reacts to perturbations caused by trade liberalization, cf. Harrison et al. (1997). However, the Lebanese example shows that policy need not be designed like this. Quite to the contrary, the government may try to set fiscal policy straight before liberalizing trade.

\(^1\) Henceforth “the Agreement”.
\(^2\) Greater Arab Free Trade Agreement.
While this does not preclude later adjustments, the ex-ante position of the government may be that trade liberalization does not require further changes in fiscal policy if appropriate measures have been taken in advance.

We adopt this position in our analysis. We assume that fiscal policy reform has preceded tariff dismantling and hence compute the effects of trade liberalization under the assumption of a neutral response of the government, i.e. changes in lump-sum transfers. This seems to match the intentions of the Lebanese government as there are currently no fiscal policy adjustments on the agenda which should be viewed as reactions to imbalances caused by trade liberalization. Besides, it allows a clear distinction between the possibly positive effects of trade liberalization and the possibly negative effects of distorting tax increases.

The urgency of fiscal responses to imbalances caused by trade liberalization depends decisively on the speed of adjustment in the economy, i.e. on the speed by which new capital is accumulated. Dynamic CGE models typically specify adjustment costs technologies to control this speed, see e.g. Keuschnigg and Kohler (1994), Dissou (2002). The disadvantage of this approach lies in the fact that the speed of adjustment is chosen arbitrarily, since adjustment cost parameters cannot be calibrated from a Social Accounting Matrix (SAM). Hence the speed of adjustment depends on the priors of the researcher – and so does the necessity of fiscal policy responses.

In this paper, we adopt a novel approach to model transitional dynamics. In a small open economy setting the speed of adjustment depends decisively on the degree to which the economy is integrated in the world capital market. Adjustment can be slow if there are constraints to international borrowing and lending. We thus model Lebanon’s integration in the world trading system under constrained capability of international borrowing. Specifically, we follow Barro, Mankiw and Sala-i-Martin (1995) in assuming that external debt requires collateral. Due to lack of data, however, we do not consider human capital as the limiting factor in capital demand, but rather adopt the approach of Cohen and Sachs (1986), who postulate that at most a fraction $\nu$ of the actual capital stock may be used as collateral. Unlike in adjustment costs settings, the parameter $\nu$ can be calibrated from the SAM. Thus the speed of adjustment in our model is data determined rather than arbitrary

To the best of our knowledge, ours is the first intertemporal CGE model applied to Lebanon. Previous studies were confined to static models which ignore welfare effects due to productive investment and sectoral reallocation of capital. Most of them suggest only limited gains in consumer welfare through trade creation, lower import prices or increased competition in the

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3 Incidentally, Diao, Rattsø and Stokke (2005) discuss possibilities to create interesting adjustment dynamics. They conclude by recommending to “look into constraints and risks at international capital markets [as] a future challenge for this kind of models”.
domestic economy. See, e. g., Martin (1996, 2000) who studies the impact of the implementation of the Association Agreement by means of a simple static CGE model. In his study, losses from trade diversion are found to exceed the gains from trade creation, resulting in a net loss of 0.3% of GDP. This is due to the high share of Lebanon’s imports from the EU (around of 50%) and to the broadly poor export performance. Similar results are obtained by Dessus and Ghaleb (2004) under the assumption, however, of a non-discriminatory trade liberalization. They quantify the loss of public revenues at about 17% with only a negligible increase in GDP (0.1%). Somewhat larger benefits (GDP growth of 0.4%) are achieved by introducing further reforms, in particular by removing regulations with anticompetitive effect.

We calibrate our dynamic model on the most recent National Accounts’ data (MOET⁴, 2003). Our simulations confirm that positive effects of trade liberalization on aggregate economic activity in Lebanon are tiny even in a long-term perspective. On the other hand, positive developments in political stability raise the reliability of Lebanon as a debtor on the world capital market and thus lower the collateral requirements. We show that progress along these lines, for instance the Syrian withdrawal from Lebanon or peaceful settlement of ethnic or religious disputes, may be economically more important than all efforts of trade liberalization. However, it should be borne in mind that trade liberalization and political stabilization are by no means rival. Quite to the contrary, they may positively influence each other and the EU’s Association Agreement is actually intended to make progress along both lines.

The sequel of the paper is organized as follows. Section 2 provides an overview on main agreements on trade and investments involving Lebanon. Section 3 describes the structure of the CGE model that we use to quantify the effects. Section 4 briefly presents main calibration issues and the solution technique. Simulations of gradual non-discriminatory tariff reductions and economic benefits of political stability are carried out in Section 5. The main conclusions are summarized in the final section of this paper.

⁴ Ministry of Economy and Trade of the Republic of Lebanon.
Main agreements on trade and investments

Lebanon’s integration process in the global economy is based on several trade agreements and various treaties. The former include multilateral agreements (as in the case of WTO) and agreements at regional and bilateral level. Main regional agreements are the Euro-Mediterranean Agreement, enhancing north-south integration as well as the GAFTA and the Agadir Agreement promoting south-south integration. Bilateral agreements have been signed with, Syria (1993), Kuwait (1996), Egypt (1998) and the United Arab Emirates (2000). The Agreement for an Economic Free Trade Zone with Jordan (signed in 1992) is expected to be ratified before long. The latter involves a number of treaties on investments promotion and protection as well as on double taxation.

The Euro-Mediterranean Agreement is part of a wider programme, known as the Euro-Mediterranean Barcelona Process, involving a number of Mediterranean Countries. This follows the 1977 Cooperation Agreement which grants Lebanese industrial exports duty-free access to EU markets (after satisfying strict rules of origin). The Agreement covers several areas of cooperation, including the progressive liberalization of trade in goods through a gradual phasing out of tariff and non-tariff barriers, with the ultimate goal of establishing a Mediterranean Free Trade Area. In addition, the Agreement seeks to liberalize trade in services and the rights of establishment, while widening the FDI potential in Lebanon.

The ratification by all parties being a compulsory condition for the Association Agreement to enter into force, Lebanon and the European Community signed a bilateral Interim Agreement. This reproduces the provisions contained in the Agreement on trade and trade-related matters. From the fifth year onward, customs duties on industrial imports from the EU will be gradually reduced by 12% per year until they reach zero in year 12. The phasing of tariff elimination will take into account the extent to which such imports compete with domestic production. Reductions in tariffs on agricultural products, fisheries and processed agricultural products are scheduled in a single shot in the fifth year. Customs duties on processed agricultural products are to fall by a maximum of 30% of the original duty, provided that imports currently subject to a 5% tariff will be fully liberalized. Lebanon’s exports of industrial products to the EU will continue to be allowed free of customs duties (with the exception of certain listed sensitive agricultural and agro-industrial imports) as already granted in the Cooperation Agreement.

The GAFTA deals essentially with trade in goods. Tariffs are to be reduced by 10% per year over a period of 10 years, beginning in 1998. Lebanon (as well as each other partner) was allowed to set up a list of products to be excluded from the tariff reduction scheme for the first three years to allow industry restructuring. The trade liberalization process has been accelerated in 2002 and is expected to achieve full reduction by 2005.

\[5\] Lebanon ratified the Agreement in December 2002.

\[6\] March 2003.
The Agadir Agreement was signed in May 2001 by two Maghreb Countries (Morocco and Tunisia) and two Mashreq Countries (Egypt and Jordan) in order to establish a free trade area open to the other Maghreb\(^7\) and Mashreq\(^8\) Countries. According to Hamoudeh (2002) the process for achieving the free trade area should start in 2003 with a 65% reduction in tariffs, followed by a further 15% in 2004, and a 10% in 2005 and 2006. Agadir Member Countries are allowed to cumulate the Agadir rules of origin with those of the Euro-Mediterranean Agreement, while granting their exports an easier access to the EU markets.

In February 1999 Lebanon submitted its application for accession to the WTO and two months later (April 1999) was granted observer status. A National Committee on Accession to the WTO was established in May 1999 with the task of investigating the existing legal framework in order to ensure conformity of Lebanon’s foreign trade regime to the WTO requirements. Following the submission of its Memorandum on the Foreign Trade Regime in May 2001, the first round of negotiations was held in October 2002 and a second round in December 2003. The WTO membership will eventually contribute to a stable and conducive investment environment. The investors’ perceived commercial risk in investing in Lebanon will decrease, thus attracting new FDI.

Further trade and investment promotion is sought through a number of treaties with Armenia, Australia, Austria, Azerbaijan, Belarus, Benelux, Bulgaria, Canada, Chile, China, Croatia, Cuba, Cyprus, Czech Republic, Egypt, Finland, France, Gabon, Germany, Greece, Hungary, Iran, Italy, Kuwait, Malaysia, Morocco, the OPEC Fund, Pakistan, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Syria, Tunisia, Ukraine, Uruguay, the United Arab Emirates, the United Kingdom and Yemen. Treaties for the avoidance of double taxation have already been ratified with 20 countries and signed with eight additional countries.

3 \textit{A dynamic CGE Model}

The Lebanese economy is modeled as a dynamic small open economy (cf. Devarajan and Go (1998)), i.e. the domestic country is a price taker on international markets. International borrowing is constrained by the requirement of collateral, adopting ideas of Cohen and Sachs (1986) and Barro, Mankiw and Sala-i-Martin (1995). Specifically, external debt requires collateral and only a fraction \( \nu_t \), \( 0 < \nu_t < 1 \), of physical capital can serve this purpose.

The model is formulated in discrete time. In each period \( t \) a population of \( \Omega_t \) identical individuals grows at a constant exogenous rate of \( \gamma^\Omega \). The

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\(^7\) Algeria, Libya, Mauritania.
\(^8\) Israel, Lebanon, Syria and the Gaza Strip.
population cannot migrate. Labor, however, can move freely between
domestic production activities.

The economy consists of \( N \) mono-product industries (activities), each
one producing a specific commodity indexed \( m = 1, 2, \ldots, M \). Since the
number of primary factors is lower than \( M \) (number of tradable
commodities), an “overspecialization” problem arises from the assumption
of constant returns to scale technologies (see Samuelson 1953). This is
solved through the adoption of the familiar Armington approach. Under this
assumption, domestic actors consider commodities with identical statistical
classification but different country of origin as imperfect substitutes.
Imported and domestically produced commodities are used to “produce” an
aggregate commodity, the Armington good, which is defined by a
conventional CES function, unambiguously identified by the scale
parameter, \( \phi^a \), the elasticity of substitution, \( \mu \) and the share parameter,
\( \phi^o \). Armington goods can be used either for consumption, which may be
public or private, or for investment or as intermediate for production. The
specifications of the CES function for each of the four types of Armington
aggregates (private and public consumption, intermediates and investment)
are to be found in the appendix (equations (A.11), (A.18), (A.25), (A.32)).
On the export side, an analogous approach is based on constant-elasticity of
transformation (CET) functions, as shown below.

Aggregate quantities (e.g. for consumption or investment) are also
obtained from CES aggregators defined by the scale parameter, \( \zeta \), the
elasticity of substitution, \( \kappa \) and the share parameter (for private
consumption, \( \varphi^{P,m} \), for investment and \( \varphi^{G,m} \) for government consumption).
The three CES aggregators (for private and public consumption as well as
for investment) are reported in the appendix (equations (A.21), (A.28),
(A.35)).

Perfect competition is assumed on all markets. Production factors are
fully homogeneous and mobile across sectors.

3.1 Production

Sectoral production \( Y^n \) employs physical capital \( K^n \), labor services
\( L^n = l^n \Omega \) (where \( l^n \) denotes the number of per-capita worked hours in
sector \( n \) during period \( t \) ) and land \( L^n_a \) and \( M \) intermediate inputs
according to the following Leontief fixed coefficients’ production function:

\[
Y^n = \min \left\{ F\left( K^n, L^n, L^n_a, x_1^n, x_2^n, \ldots, x_m^n, k^{M,n} \right) \right\}, \quad n = 1, 2, \ldots N,
\]

Under this assumption, the total number of produced commodities \( M \) equals the total
number of industries \( N \).
where \( x_{m,n}^{*} \) indicates the intermediate input \( m \) used for production of commodity \( n \) and \( a_{m,n}^{*} \) is the corresponding fixed input requirement. Each intermediate commodity \( m \) is an Armington aggregate of domestic origin \( x_{m,n}^{D,m,n} \) and imported origin \( x_{m,n}^{I,m,n} \) (see equation (A.11)). Value added of firm \( n \) is generated under constant returns to scale Cobb-Douglas technology specified as follows:

\[
F_i^n \left( K^n_i, L^n_i, L_{a}^{n} \right) = A^n_i \left[ \left( K^n_i \right)^{b_{K,n}^*} \cdot \left( L^n_i \right)^{b_{L,n}^*} \cdot \left( L_{a}^{n} \right)^{b_{La,n}^*} \right],
\]

(2)

where \( A^n_i \) is the total factor productivity in sector \( n \). The assumption of constant returns to scale requires:

\[
b_{K,n}^* + b_{L,n}^* + b_{La,n}^* = 1 \quad \text{and} \quad 0 \leq b_{j,n}^* < 1
\]

(3)

Since firms operate in a fully competitive environment, the production elasticities are equal to the respective factor income shares.

Firms operate under zero profits and value added equals

\[
P_i^{V,n} Y^n_i = \min \left\{ P_i \left( r_i + \delta \right) \cdot K^n_i + w_i \cdot L^n_i + P_i^{La} \cdot L_{a}^{n} \mid Y^n_i = F_i^n \left( K^n_i, L^n_i, L_{a}^{n} \right) \right\},
\]

(4)

where \( P_i \) is the price of capital (or investment good), \( r_i \) and \( \delta \) are, respectively, the rental rate and depreciation rate of capital. \( w_i \) and \( P_i^{La} \) are, respectively, the labor wage rate and rental rate of land. The solution of problem four equals:

\[
P_i^{V,n} Y^n_i = \frac{1}{A^n_i} \cdot \left( \frac{P_i \left( r_i + \delta \right)}{b_{K,n}^*} \right)^{b_{K,n}^*} \cdot \left( \frac{w_i}{b_{L,n}^*} \right)^{b_{L,n}^*} \cdot \left( \frac{P_i^{La}}{b_{La,n}^*} \right)^{b_{La,n}^*} Y^n_i,
\]

(5)

where \( P_i^{V,n} \) is the price of value added. The minimization of the value added costs gives the optimal demand of primary factors as well:

\[
K_i^n = \frac{b_{K,n}^*}{P_i \left( r_i + \delta \right)} P_i^{V,n} \cdot Y^n_i,
\]

(6)

\[
L_i^n = \frac{b_{L,n}^*}{w_i} P_i^{V,n} \cdot Y^n_i,
\]

(7)

\[
L_{a}^{n} = \frac{b_{La,n}^*}{P_i^{La}} P_i^{V,n} \cdot Y^n_i.
\]

(8)
Due to the mono-product nature of each activity $n$, activity output $Y^n_n$ equals the commodity supply $Q^n_n$ of each industry (see (A.13)). Domestic production $Q^n_n$ ($m = 1, 2, \ldots, M$) satisfies domestic demand, $D^n_n$ and foreign demand $E^n_n$. We denote with $P^{d,m}_n$ the price of the domestic commodity $m$ on the domestic markets and by $P^{c,m}_n$ the domestic (producer) price of exports\(^{10}\) of the same commodity $m$. For a given production $Q^n_n$, firms maximize the value of total sales (given by equation (A.14) in the appendix) under the CET restriction (equation (A.15)) as constraint. Solving this problem determines the optimal amount of domestically sold and exported goods (see the first order condition (A.16) in the appendix) as well as the producer price of the composite good (see equation (A.9)).

### 3.2 Capital accumulation

Capital dynamics follow the standard neoclassical capital accumulation equation:

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

where $I_t$ are aggregate investments (see Section 3.3) and $\delta$ is the capital depreciation rate. The investment good $I_t$ is a CES composite (see equation (A.28) in the appendix) of $m$ Armington aggregates (see equation (A.25) in the appendix). This CES composite has nominal investment price $P^I_t$. Investments are financed through households’ savings, $S^C_t$, and net foreign direct investment, $D_{t+1} - D_t$, which is subject to collateral requirements (see Section 3.5):

$$P^I_t I_t = S^C_t + (D_{t+1} - D_t),$$

where $S^C_t$ and $D_t$ are nominal variables.

### 3.3 Consumption and leisure

Generalizing Devarajan and Go (1998), infinitely-lived households can choose between consumption and leisure. In each period $t$ they are endowed with one unit of time, part of which is supplied on the labor market. The remaining time is devoted to leisure activities. The representative agent is represented by the following instantaneous utility function:

\(^{10}\) The producer price of exports may entail export subsidies.
\[ U_t(c_t, l_t) = \left[ (1-\eta)\left(\frac{c_t}{1-\alpha} - 1\right) + \eta \frac{(1-l_t)^{1-\beta} - 1}{1-\beta} \right] \cdot \Omega_t, \] (11)

where \( c_t \) is the per-capita composite 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 and \( \eta \) is the leisure share parameter.

At the beginning of her life \( t = 0 \), the representative agent maximizes her lifetime utility:

\[ U_0 = \sum_{t=0}^{\infty} \left( \frac{1}{1+\rho} \right)^t \cdot U_t, \] (12)

with being \( \rho \) the consumer’s positive and constant rate of time preference.

Households’ assets are ownership claims on two types of durables, productive capital \( K_t \) and land \( L_t \). In order to finance a share of private capital accumulation, they are allowed to borrow from abroad. Their liabilities have the form of net external debt \( D_t \), a nominal variable. As required by the so called collateral rule (as introduced in Barro, Mankiw, Sala-i-Martin (1995) and further developed in Penalver (2000)), households’ external borrowing is constrained to be a fraction of the existing physical capital so that \( D_t \leq \nu_{t-1} \cdot P_t^t K_t \) with \( 0 < \nu_{t-1} < 1 \). .

Households behave competitively, taking as given the real domestic interest rate \( r_t \), the price of capital goods \( P_t^t \) and the wage rate \( w_t \), paid per unit of labor services. The total income of the aggregate of households encompasses labor income, \( w_t^t L_t \) \( (L_t = l_t \Omega_t) \), and asset income. This is the sum of capital rents, \( P_t^t r_t K_t \), and land rents, \( P_t^t L_t^a \cdot L_t \) minus interest income paid on external debt (if \( D_t > 0 \)) or received on external wealth (if \( D_t < 0 \)). In addition, households receive a net lump transfer \( T_t^G \) from the government and foreign remittances \( T_t^W \). Total disposable income is given by:

\[ Y_t^{disp} := (1-\tau) \left[ (1-\tau^L) w_t L_t + (1-\tau^K) P_t^t r_t K_t + (1-\tau^{La}) P_t^t L_t^a \right] + T_t^G + T_t^W - \tau D_t, \] (13)

where \( \tau \) is a general income tax rate and \( \tau^L, \tau^K, \tau^{La} \) are factor income tax rates on labor, capital, land income respectively.

Net income is allocated to consumption and to savings. In each period \( t \), households choose among a variety of domestic and imported goods. Each consumption good \( c_t^{m} \) is an Armington aggregate of domestic goods \( c_t^{D,m} \).
and imports $c_t^{IM,m}$ (see equation (A.18)). The final composite good is the result of a CES-agggregation of each of the $M$ commodities (see equation (A.21)). Its market price is $P_t^C$. Savings $S_t^C$ are used to accumulate productive capital or may be rented out on the international capital market. The budget constraint of the household is given by:

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

(14)

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

The household optimization problem is to maximize the lifetime utility $U_0$ in equation (12), subject to the budget constraint in equation (14), the stock of initial assets (capital, $K_0$, land, $L_0$, and nominal debts, $D_0$) and the borrowing constraint. The solution of the optimization problem gives the optimal demand for leisure:

$$(1-l_t)\beta = \eta \frac{P_t^C (c_t)^\alpha}{1-\eta (1-\tau) (1-\tau^l) w_t},$$  

(15)

being the Euler condition given by:

$$\left( \frac{c_{t+1}}{c_t} \right)^\alpha \frac{P_t^C}{P_t} \frac{v_t P_{t+1}^L - P_t^L}{v_t P_{t+1}^L} = 1 + \tau \left( 1 - \tau^K \right) r_{t+1} - \delta,$$

(16)

### 3.4 Government behavior

Public revenues $R_t$ include general income taxes and single factor taxes on labor, capital and land income. Additionally the government raises import taxes on imported quantities and collects indirect taxes $\nu^n$.

$$R_t = \tau \left( \left[ \left( 1 - \tau^l \right) w_t \cdot L_t + \left( 1 - \tau^K \right) P_t^l r_t \cdot K_t + \left( 1 - \tau^{La} \right) P_t^{La} \cdot L_{a} \right] + \right.$$  

$$+ \tau^l \left( w_t \cdot L_t \right) + \tau^K \left( P_t^l r_t \cdot K_t \right) + \tau^{La} \left( P_t^{La} \cdot L_{a} \right) +$$  

$$+ \sum_{n=1}^N \nu^n P_t^{V,n} Y^n + \sum_{m=1}^M \left[ -\omega^m \left( 1 + \theta^m \right) + \theta^m \right] P_t^{IM,m} IM_t^m,$$

(17)

with $IM_t^m := x_t^{IM,m} + \Omega_t c_t^{IM,m} + I_t^{IM,m} + G_t^{IM,m}$,

where $x_t^{IM,m}$ denotes the import world price of commodity $m$. $\theta^m$ and $\omega^m$ are, respectively, the import tariff rate and import tax rate on commodity $m$. Government outlays $O_t$ consist of purchases of consumption goods and
services in the fixed aggregate quantity $G_t$, and (exogenous) payments abroad, $B^G_t$. Direct lump transfers $T^G_t$, in the amount of revenues exceeding expenditures($P^G_t G_t + B^G_t$), are paid to consumers.

\[ O_t = P^G_t G_t + B^G_t + T^G_t. \]  

(18)

Aggregate government consumption, $G_t$, is a CES-composite of each of the $M$ Armington aggregates $G^m_t$ (see equation (A.35)), which are each a composite of domestic good $G^{D,m}_t$ and imported commodity $G^{IM,m}_t$ (see equation (A.32)). $P^G_t$ is the composite price of $G_t$.

Obviously, a balanced budget requires:

\[ O_t = R_t. \]  

(19)

### 3.5 Foreign trade and international borrowing

International linkages of the domestic economy encompass trade as well as financial flows. Due to data limitations, the model currently allows for just a single trading partner which is also the only foreign direct investor. Trade relations are modeled taking into account import tariffs and indirect taxes raised on imported goods. These accrue to the government. Export activity is neither subsidized nor subject to tariffs or taxes (see (A.6)). Quotas are excluded. Non-tariff barriers are not considered due to lack of reliable data.

As mentioned in Section 3.3, households are allowed to borrow from abroad while financing a share of private capital accumulation. According to the collateral rule (Barro, Mankiw, Sala-i-Martin (1995) and Penalver (2000)) productive capital serves as (imperfect) collateral for debt. Thus, the value of external debt must not exceed a fraction $\nu_t$ of the value of the domestic capital stock:

\[ D_t \leq \nu_{t-1} \cdot P^l_t K_t, \text{ with } 0 < \nu_{t-1} < 1. \]  

(20)

### 3.6 Market clearing

Factor market clearing requires:

\[ K_t = \sum_{n=1}^{N} K^n_t, \]  

(21)

\[ L_t = \sum_{n=1}^{N} L^n_t, \]  

(22)
\[ L a_i = \sum_{n=1}^{N} L a_i^n. \]  

(23)

On the domestic goods markets, equilibrium is given by:

\[ D_t^m = x_t^{D,m} + \Omega_t^{D,m} + I_t^{D,m} + G_t^{D,m} \]  

(24)

with \( x_t^{D,m} := \sum_{n=1}^{N} x_t^{D,m,n} \).

The equilibrium condition for the balance of payments requires that 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, foreign debt reimbursement and interest payments on debt. This equation is implied by Walras’ Law:

\[ \sum_{m=1}^{M} P_t^{E,W,m} \cdot E_t^{m} + T_t^{W} + D_{t+1} = \sum_{m=1}^{M} P_t^{M,W,m} \cdot I M_t^{m} + B_t^{C} + (1 + \bar{r}) D_t. \]  

(25)

4 Model calibration and solution technique

The model is calibrated so that its steady-state solution reproduces the data assembled in a social accounting matrix (SAM) for the base year 1997. The underlying idea is that this matrix measures Lebanon’s economic performance in 1997, i.e. basically prior to its recent efforts of integrating into the world economy, cf. Section 2. Unless otherwise specified, data are taken from the National Accounts’ (MOET, 2003) – actually 1997 data are the most recent National Accounts data currently available. The social accounting matrix (SAM) is based on these data and is the result of the authors’ own calculations\(^\text{11}\). The SAM distinguishes 8 production sectors and 3 production factors.

Calibration of model parameters is based on the SAM and some additional assumptions. In particular, the population growth rate is assumed to equal to 1.4% per annum according to World Bank (2004) and the world real interest rate \( \bar{r} \) is exogenously set at 4%. Substitution elasticities are obtained from the existing literature wherever possible.

On the demand side, the elasticity of substitution between different commodities is set at 0.9, while the Armington elasticity of substitution between domestic and imported good is set at 0.5 (see Devarajan, Go, Li, 1999). On the supply side the elasticity of substitution between domestic and exports is 2.3. In the utility function, the inverse of the consumer’s elasticity of intertemporal substitution and the elasticity of leisure are set equal to 1.

\(^{11}\) We thank Salam Said for very helpful research assistance.
Once elasticity values have been fixed, model share and scale parameters are calibrated from the SAM. To save space, only few aspects of the calibration shall be discussed. In particular, the parameter $\nu_i$, denoting the fraction of foreign debt to domestic capital, is not a free parameter but directly calibrated from data assembled in the SAM. Subtracting consumption and investment expenditures from households’ net factor income (including transfers from the government as well as from abroad) and relating this figure to gross capital income we obtain $\nu_i = 0.393$.

The model is programmed in Gauss and solved with the method of backward integration, 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 unstable 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 saddle path.

5 Simulation scenarios and results

As illustrated in Section 2, Lebanon implements trade liberalization mainly through bilateral and regional agreements. However, since previous studies demonstrated that the preferential (see Martin, (1996, 2000)) as well as the non-discriminatory (see Dessus and Ghaleb (2004)) trade liberalization have only minor static effects, we want to assess the maximum possible gain by allowing for dynamic adjustments and (counterfactually) the most generous form of tariff reduction (MFN). Even in this setting, however, it turns out that the economic impact of advances in political stability are larger than any kind of trade liberalization.

Our analysis begins at the time when the Interim Agreement was signed, so that time $t = 0$ corresponds approximately to 2003 in real time, and there is a 5-year transition period granted to Lebanon by the Interim Agreement for further structural reforms. We simulate a gradual reduction of tariff rates as specified in the Agreement, but counterfactually assume that this reduction applies to all trading partners rather than to just the EU countries. In order to compare the effects of tariff liberalization with economic benefits of political stability, we assume that the improvement in the political environment is managed progressively over a period of comparable length as in the trade liberalization scenario.

5.1 Gradual non-discriminatory tariff reductions

Title II of the Interim Agreement (see Table 1) is devoted to the free movement of goods and states that the free trade area will be established “over a transitional period not exceeding 12 years […]”. Goods are divided
into two categories, industrial products (chapter 1), and agricultural, fisheries and processed agricultural products (chapter 2). The second category is further divided into two classes, one including agricultural products and the other the processed agricultural products\(^{12}\). Exceptions to the provisions of chapter 1 are allowed for products listed in Annex 1 of the Agreement. These are agricultural and processed agricultural products as oil derivates or silk, cotton and wool.

Table 1 - Title II of the Interim Agreement (schematic structure)

<table>
<thead>
<tr>
<th>Chapter 1 Industrial products</th>
<th>Chapter 2 Agricultural + Processed agricultural products.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\downarrow)</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>Annex 1 (some exceptions to Chapter 2)</td>
<td>Protocol 1 Agricultural EX</td>
</tr>
<tr>
<td>Protocol 3 Processed agricultural products</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>Annex 1 EX</td>
<td>Annex2 IMP</td>
</tr>
</tbody>
</table>

Customs’ duties and charges with equivalent effect on imports of industrial products into Lebanon are to be abolished according to the schedule presented in table 2. A five-year transition period is allowed for appropriate structural reforms aimed at improving the competitiveness of the economy. By the fifth year the progressive reduction of tariffs’ will start according to the schedule indicated in the right column of Table 2 (Interim Agreement, Art. 5).

Table 2 - Tariffs abolishment schedule according to the Interim Agreement

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Rate (with reference to the basic rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5(^{th}) year</td>
<td>88%</td>
</tr>
<tr>
<td>6(^{th}) year</td>
<td>76%</td>
</tr>
<tr>
<td>7(^{th}) year</td>
<td>64%</td>
</tr>
<tr>
<td>8(^{th}) year</td>
<td>52%</td>
</tr>
<tr>
<td>9(^{th}) year</td>
<td>40%</td>
</tr>
<tr>
<td>10(^{th}) year</td>
<td>28%</td>
</tr>
<tr>
<td>11(^{th}) year</td>
<td>16%</td>
</tr>
<tr>
<td>12(^{th}) year</td>
<td>0%</td>
</tr>
</tbody>
</table>

Mapped onto the multi-sectoral structure of the model, this tariff reduction schedule will affect sector 2 (Energy & Water) and sector 3 (Manufacturing), which are the non-agricultural sectors of the economy.

Agricultural and fisheries’ imports (category 2, class 1) are addressed in Protocol 2. Tariff reduction for these products will occur in a single shot in the fifth year of the Agreement. Since the reduction will not affect all goods’ categories equally, we adopt an aggregate tariff rate, as calculated on

\(^{12}\) The classification at hand is based on the Combined Nomenclature 2002 (CN 2002) and of the Lebanese Custom Code (LCC).
the base of Protocol 2. The depicted tariffs’ abatement framework will be applied to sector 1 (Agriculture). Processed agricultural products (category 2, class 2), including those listed in Annex 1, will be granted a less binding treatment according to the general statement of Art. 9, to be interpreted alongside Protocol 3. These product categories are however aggregated to the manufacturing sector (sector 3) in our model and are therefore treated according to the provisions of chapter 1.

The provisions of the Interim Agreement are implemented in the model through an unexpected exogenous variation of the import tariff rate \( \theta^n \). Table 3 illustrates the (calibrated) benchmark value of \( \theta^n \) and its subsequent variations for each import sector.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>0.076</td>
<td>0.046</td>
<td>0.036</td>
</tr>
<tr>
<td>5(^{th}) year</td>
<td>0.053</td>
<td>0.041</td>
<td>0.031</td>
</tr>
<tr>
<td>6(^{th}) year</td>
<td>0.053</td>
<td>0.035</td>
<td>0.027</td>
</tr>
<tr>
<td>7(^{th}) year</td>
<td>0.053</td>
<td>0.030</td>
<td>0.023</td>
</tr>
<tr>
<td>8(^{th}) year</td>
<td>0.053</td>
<td>0.024</td>
<td>0.018</td>
</tr>
<tr>
<td>9(^{th}) year</td>
<td>0.053</td>
<td>0.019</td>
<td>0.014</td>
</tr>
<tr>
<td>10(^{th}) year</td>
<td>0.053</td>
<td>0.013</td>
<td>0.010</td>
</tr>
<tr>
<td>11(^{th}) year</td>
<td>0.053</td>
<td>0.007</td>
<td>0.006</td>
</tr>
<tr>
<td>12(^{th}) year</td>
<td>0.053</td>
<td>0.002</td>
<td>0.001</td>
</tr>
<tr>
<td>13(^{th}) year</td>
<td>0.053</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

### 5.2 Economic benefits of political stability

In order to quantify the economic benefits of political stability, we take Moody’s rating system as indicator. This is appropriate since Moody’s ratings do not only reflect changes in economic conditions, but also political concerns. For instance, the assassination of former Prime Minister Rafiq al Hariri prompted Moody’s to downgrade Lebanon by one notch (from B2 to B3).\(^{13}\) We identify the observed value of \( \nu_t = 0.393 \) with Moody’s rating of Lebanese government bonds and associate Moody’s prime rating (Aaa) with \( \nu_t = 1 \) (perfect capital mobility). All other Moody’s ratings are then linearly allocated, i.e. with equally spaced distances. Thus, an increase (decrease) in Moody’s rating by one notch is set to be roughly equal to +0.047 (−0.047). Thus, the Hariri assassination amounts to a decrease in \( \nu_t \) by 12%.

We first simulate an improvement in political stability, assuming an upgrade in Moody’s rating by 3 notches over a 20-year-period (see table 4). This corresponds to assuming that Lebanon manages to improve its creditworthiness to levels still below the rating currently held by Egypt and is hence a moderate aim for a twenty-year period. Secondly, we calculate the economic effects of a sudden deterioration in political environment as

\(^{13}\) A statement by Moody’s issued March 24, 2005, made clear that the assassination was the only motive for downgrading Lebanon. See Moody’s Rating Action of March 24, 2005.
exemplified by the assassination of Mr Hariri. The related fall in creditworthiness is reflected by a minor but instantaneous downgrade (by one notch).

**Table 4 - Gradual improvement in political stability**

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Moody’s rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1\textsuperscript{st} - 6\textsuperscript{th} year</td>
<td>B1 = Lebanon (1997)</td>
</tr>
<tr>
<td>7\textsuperscript{th} - 13\textsuperscript{th} year</td>
<td>Ba3</td>
</tr>
<tr>
<td>14\textsuperscript{th} - 19\textsuperscript{th} year</td>
<td>Ba2</td>
</tr>
<tr>
<td>20\textsuperscript{th} year</td>
<td>Ba1 = Egypt (2005)</td>
</tr>
</tbody>
</table>

The variations in Moody’s rating are depicted through an exogenous change in the fraction $\nu$, of foreign debt to productive capital. The change is set to be equal to $+36\%$ in the first and $-12\%$ in the second (Hariri) case. Since the initial fraction of debt to capital was calibrated as slightly less than 40\%, this means a final $\nu$ value of around 53\% or 35\%, respectively.

5.3 **Simulation results**

The first scenario implies a reduction of import tariff rates by the fifth year of the agreement. This induces an immediate decrease in the domestic price of each imported commodity $m$:

$$P_{t}^{IM,m} = (1 + \omega^{m}) \left( 1 + \theta^{m} \right) P_{t}^{IM,W,m}$$

which instantaneously affects the demand price $P_{t}^{A,m}$ of the Armington aggregates ($x_{t}^{m,n}$, $c_{t}^{m}$, $I_{t}^{m}$ and $G_{t}^{m}$). These price variations affect the overall price levels $P_{t}^{C}$, $P_{t}^{I}$ and $P_{t}^{G}$ of the three composite commodities.

The immediate effect of lower domestic price of imports is an increase in the demand for foreign goods by 1.6\%. The general price reduction following from the abolishment of tariffs stimulates long-run demand for private consumption (which increases by 1.2\%) and investment (which increases by 3\%). Government consumption remains constant, being exogenously given. Figure 1 shows the dynamics of aggregate private consumption and aggregate investment.
The overall benefits of trade liberalization give rise to an increase in GDP by 2.7%. These results are in line with the findings of other studies (see for instance Martin (1996, 2000)). As demonstrated by Dessus and Ghaleb (2004), public revenues suffer a relevant fall, which in our case is around 9.3%.

A progressive increase in external borrowing possibilities, as induced by increased political stability, enlarges households’ savings. The first consequence is an increase in the demand for investments, which grows in the long run by 7.6%, according to the non-monotonic transition path showed in Figure 2. After a strong increase during the first periods, the demand for investment reaches its highest value at around the last period of exogenous increase in $\nu_i$ and then descends to its steady-state value. The initial short term boost in investment demand influences private consumption demand, which shows an opposite non-monotonic transition path (see Figure 3) which ends up with an increase of 0.9%. A further
increase on the demand side is represented by exports, which grow steadily from the first transition period as far as achieving a 20.9% increase in the new steady state. On the supply side, consequences of the improvement in the political environment include a growth of the productive capital by 7.6%, which is supported by an FDI boost (in value) of 41.4% relative to the old steady-state. The overall demand increase brings about a long run GDP growth of 3.4%.

By contrast, a rapid (though limited) deterioration in the political environment due to a destabilizing incident like the assassination of the former Prime Minister has - not unexpectedly - generally negative effects. The underlying economic reasons are conceptually the same as before. Due to the fall in creditworthiness on global markets, the economy’s foreign borrowing constraint becomes stricter, thus limiting productive investment possibilities. Figure 4 shows the transition path of domestic consumption and investment. The second falls rapidly since the negative shock, leaving productive capital exceeding demand requirements. On the other hand, due to stronger constraints on international borrowing, households modify their consumption and savings’ path and more income is allocated to consumption than to investment. These two effects together bring about a
short term rise in consumption. Moreover, the fall in creditworthiness also implies deteriorating exports: In the new steady-state exports shrink by 6.1% relative to the benchmark. The overall negative effect is quantified by a GDP fall by 1% in the long term.

A comparison of the three scenarios shows the quantitative relevance of political stability in comparison to trade liberalization. Figure 5 depicts the long term GDP effects in the three scenarios. Leaving the positive effect of an increase in creditworthiness aside, evidence suggests how single destabilizing incidents as the one quantified here may undermine the positive effects of trade liberalization.

![Figure 5 - Effects on GDP in the three simulation scenarios](image)

### 5.4 Implications for policy

Lebanon’s economic performance has been very positive in recent years. While the country seemed close to bankruptcy prior to the 2002 Paris II accord, the restructuring of external debt lifted some of the pressures - in particular with respect to interest obligations. In 2004, Lebanon recorded a 5% growth rate of real GDP, strong exports of goods and services (up by 30%), and large inflows of FDI. The current account deficit decreased to 12 percent of GDP, tax revenues grew strongly and the primary budget surplus increased by 1%.

Debt, however, continues to be on record levels: As of 2004, Lebanon’s external debt (public and private debt denominated in foreign currency) is estimated at 15.8 billion US $. This is more than 84% of annual GDP, the 10th highest ratio in the world. Lebanon’s public debt (government borrowing denominated in domestic currency) in 2004 is estimated at 33.5 billion US $ or 177.9% of GDP, the second highest such ratio in the world.

Thus the path to prosperity remains knife-edged. While Lebanon may cite the exceptional capital requirements in its reconstruction phase after the civil war as at least partial explanation for its indebtedness, there is no doubt that Lebanon’s debt is suspiciously monitored by international financial
markets. Lebanon’s economic policy is bound to be successful – any sign of failure may lead to a withdrawal of foreign funds that leads into a crisis.

The results of our simulations are in line with this view. Credit constraints are the most important issue for Lebanese economic policy. Two ways suggest themselves to ease these constraints: Either strong growth performance (in our model expressed through capital stock growth and hence increases in available collateral) or stabilizing developments which foster international creditors’ trust and confidence. In this respect, it is certainly counterproductive that promises made to donor countries during Paris II (most notably the privatization of state-owned enterprises) are still blocked by rivaling parties in the political system.

Nevertheless, many signals from Lebanon are positive. Some problems notwithstanding (most notably deficits of public enterprises and imbalances in the social security system), the government has successfully communicated its commitment to market orientation and institutional reform to the private sector at home and abroad. The push for integration in the world trading system by bilateral and multilateral trade liberalization underlines a progressively western orientation both economically and in the foreign policy domain. The withdrawal of Syrian troops after the assassination of former Prime Minister Hariri, the arrest of suspects identified in the Mehlis report to the UN, and the largely peaceful and democratic parliamentary elections also contribute to a climate of political stabilization which, if sustained, should improve Lebanon’s access to the world capital market and hence open the most important door on its way to economic prosperity.

6 Conclusions

The main aim of this paper is to study the effects of Lebanon’s integration into the world economy with a dynamic CGE model. Unlike previous studies, the intertemporal structure of the model allows a dynamic quantification of the effects, including also the very long-run effects. Additionally, the analysis takes into consideration the role of FDI and its immediate dependence on Lebanon’s creditworthiness on the world capital market.

We show that even a non-discriminatory trade liberalization brings about not more than moderate effects with respect to GDP and in any case heavily affects public revenues. Political stabilization, by contrast, can easily produce larger gains than broad trade liberalization by attracting FDI into the economy. We hasten to add that trade liberalization and political stabilization are, of course, by no means exclusive, but that rather the two might complement each other.
References


Appendixes

Appendix A. Glossary

\( a_{m,n} \) fixed input (commodity \( m \)) requirement for production (activity \( n \))
\( A_n^{f} \) total factor productivity (activity \( n \))
\( B_t^G \) government payments abroad
\( b^{K,n} \) production elasticity of capital (activity \( n \))
\( b^{L,n} \) production elasticity of labor (activity \( n \))
\( b^{La,n} \) production elasticity of land (activity \( n \))
\( c_t \) per-capita composite consumption demand
\( c_t^{D,m} \) per-capita consumption demand of domestic commodity \( m \)
\( c_t^{IM,m} \) per-capita consumption demand of imports (commodity \( m \))
\( c_t^m \) per-capita consumption demand of Armington aggregate \( m \)
\( C_t^{V,n} \) value added cost
\( D_t \) stock of foreign debt
\( D_t^m \) domestic demand of domestic commodity \( m \)
\( E_t^m \) export demand of commodity \( m \)
\( G_t \) aggregate government composite demand
\( G_t^{D,m} \) aggregate government consumption of domestic commodity \( m \)
\( G_t^{IM,m} \) aggregate government consumption of imports (commodity \( m \))
\( G_t^m \) aggregate government consumption of Armington aggregate \( m \)
\( I_t \) aggregate composite investment demand
\( I_t^{D,m} \) aggregate investment demand of domestic commodity \( m \)
\( I_t^{IM,m} \) aggregate investment demand of imports (commodity \( m \))
\( I_t^m \) aggregate investment demand of Armington aggregate \( m \)
\( K_t \) physical capital (total stock)
\( K_t^n \) physical capital (activity \( n \))
\( l_t (L_t) \) per-capita (aggregate) total amount of working time
\( l_t^n (L_t^n) \) per-capita (aggregate) amount of working time (activity \( n \))
\( La_t \) land assets (total amount)
\( La_t^n \) land assets (activity \( n \))
\( m \) generic commodity
\( M \) total number of commodities
\( M_t^m \) domestic demand of imports (commodity \( m \))
\( n \)   generic mono-product industry (activity)
\( N \)   total number of mono-product industries (activities)
\( O_t \)  government outlays
\( P_t^A,m \) demand price of Armington aggregate \( m \)
\( P_t^C \)  optimal price of consumption (aggregate)
\( P_t^D,m \) price of the domestic commodity \( m \)
\( P_t^{E,m} \) domestic (producer) price of exports (commodity \( m \))
\( P_t^{E,W,m} \) world price of exports (commodity \( m \))
\( P_t^G \)  optimal price of government consumption (aggregate)
\( P_t^I \)  optimal price of investment (aggregate) commodity
\( P_t^{La} \) price of land
\( P_t^{IM,m} \) domestic price of imports (commodity \( m \))
\( P_t^{IM,W,m} \) world price of imports (commodity \( m \))
\( P_t^{Q,m} \) price index of commodity \( m \)
\( P_t^{V,n} \) market price of activity \( n \)
\( P_t^{V,a} \) minimal price of value added
\( Q_t^m \) domestic production (commodity \( m \))
\( r_t \)   real domestic interest rate
\( \bar{r} \)   real world interest rate
\( R_t \)  government revenues
\( S_t^C \)  households’ savings
\( T_t^G \) net lump transfer from the government
\( T_t^W \) foreign remittances
\( U_t^0 \) lifetime utility
\( U_t \)  instantaneous utility
\( V_t^n \) value added (activity \( n \))
\( w_t \)  wage rate
\( x_t^{D,m} \) intermediates’ demand of domestic commodity \( m \)
\( x_t^{D,m,n} \) intermediates’ demand of domestic commodity \( m \) (activity \( n \))
\( x_t^{IM,m} \) intermediates’ demand of imports (commodity \( m \))
\( x_t^{IM,m,n} \) intermediates’ demand of imports (commodity \( m \)) by activity \( n \)
\( x_t^{n,m} \) intermediates’ demand of Armington aggregate \( m \) (activity \( n \))
\( Y_t^n \) domestic production (activity \( n \))
\( Y_t^{disp} \) disposable income

\( \alpha \) absolute value of the inverse of the constant elasticity of substitution in the instantaneous utility function (consumption)
\( \beta \) absolute value of inverse of the constant elasticity of substitution in the instantaneous utility function (leisure)
\( \chi_m \) scale parameter in the CET function (commodity \( m \))
\( \delta \) capital depreciation rate
\( \varepsilon \) elasticity of transformation in the CET function
\( \phi_m \) domestic sales’ share parameter in the CET function (commodity \( m \))
\( \varphi^o \) share parameter in the CES function (Armington composite \( m \))
\( \gamma^n \) population growth rate
\( \eta \) leisure share parameter
\( \kappa \) elasticity of substitution in the CES function (final commodity aggregate)
\( \mu \) elasticity of substitution in the CES function (Armington composite)
\( \nu \) fraction of foreign debt to domestic capital
\( \Pi_{t,n} \) value added profit (activity \( n \))
\( \theta^m \) import tariff rate on commodity \( m \)
\( \vartheta^o \) scale parameter in the CES function (Armington composite \( m \))
\( \rho \) consumer’s rate of time preference.
\( \sigma^c \) substitution parameter in the CET function
\( \sigma^s \) substitution parameter in the CES function (final commodity aggregate)
\( \sigma^i \) substitution parameter in the CES function (Armington composite)
\( \tau \) general income tax rate
\( \tau^L \) labor income tax rate
\( \tau^K \) capital income tax rate
\( \tau^L_a \) land income tax rate
\( \upsilon^n \) indirect tax on domestic production (activity \( n \))
\( \omega^m \) import tax on imported commodity \( m \)
\( \Omega_t \) population at time \( t \)
\( \psi^{C,m} \) commodity \( m \)’s share parameter in the CES function (final consumption aggregate)
\( \psi^{I,m} \) commodity \( m \)’s share parameter in the CES function (final investment aggregate)
\( \psi^{G,m} \) commodity \( m \)’s share parameter in the CES function (final government consumption aggregate)
\( \zeta \) scale parameter in the CES function (final commodity aggregate)

**Appendix B. List of equations**

The model consists of equations (1) - (25) and of the equations listed in this appendix.

**B.1 Parameter relations**

\[
\varepsilon = \frac{1}{\sigma^\varepsilon - 1} \quad \sigma^\varepsilon > 1
\]  
(A.1)
\[
\mu \equiv -\frac{1}{1-\sigma^\mu} \quad \sigma^\mu < 1 \quad \text{(A.2)}
\]
\[
\kappa \equiv -\frac{1}{1-\sigma^\kappa} \quad \sigma^\kappa < 1 \quad \text{(A.3)}
\]

**B.2 Prices' relations**

\[
P_{t,\cdot} = \frac{\sum_{m=1}^{M} q_{m,n} + P_{t,\cdot}}{1-\nu^n} \quad \text{(A.4)}
\]

\[
P_{t,\cdot} = P_{t,\cdot}^{Q,m} \quad \text{(A.5)}
\]

\[
P_{t,\cdot}^{E,m} = P_{t,\cdot}^{E,W,m} \quad \text{(A.6)}
\]

\[
P_{t,\cdot}^{M,C,m} = (1 + \omega^m)\left(1 + \Theta^m\right)P_{t,\cdot}^{M,W,m} \quad \text{(A.7)}
\]

\[
P_{t,\cdot}^{A,m} = \frac{1}{\varphi^m} \left[ \left(\frac{P_{t,\cdot}^{D,m}}{\varphi^m}\right)^{1+\mu} \left(\frac{P_{t,\cdot}^{M,m}}{1-\varphi^m}\right)^{1+\mu} \right] \quad \text{(A.8)}
\]

\[
P_{t,\cdot}^{Q,m} = \frac{1}{\chi^m} \left[ \left(\frac{P_{t,\cdot}^{D,m}}{\chi^m}\right)^{1+\varepsilon} \left(\frac{P_{t,\cdot}^{E,m}}{1-\chi^m}\right)^{1+\varepsilon} \right] \quad \text{(A.9)}
\]

**B.3 Production**

**B.3.1 Armington composite**

\[
P_{t,\cdot}^{A,m} \cdot x_{t,\cdot}^{m,n} = P_{t,\cdot}^{D,m} \cdot x_{t,\cdot}^{D,m,n} + P_{t,\cdot}^{M,m} \cdot x_{t,\cdot}^{M,W,m,n} \quad \text{(A.10)}
\]

\[
x_{t,\cdot}^{m,n} = \varphi^m \left(\left(1 - \varphi^m\right)^m \frac{1}{\sigma^\mu} \right) \quad \text{(A.11)}
\]

\[
x_{t,\cdot}^{D,m,n} = \varphi^m \left(1 - \varphi^m\right)^m \left(\frac{1}{\varphi^m} \frac{P_{t,\cdot}^{D,m}}{P_{t,\cdot}^{M,m}}\right)^\mu \quad \text{(A.12)}
\]

**B.3.2 Commodity supply**

\[
Y_{t} = Q_{m}^n \quad \text{(A.13)}
\]

**B.3.3 CET composite**
\( P_t^{D,m} \cdot Q_t^m = \max_{P_{i,t}^{D,m} \cdot D_i^m} \left( P_t^{D,m} \cdot D_t^m + P_t^{E,m} \cdot E_t^m \right) \)  
(A.14)

\( Q_t^m = \chi^m \left[ \phi^m \left( D_t^m \right)^{\sigma^m} + \left( 1 - \phi^m \right) \left( E_t^m \right)^{\sigma^m} \right]^{\frac{1}{\sigma^m}} \)  
(A.15)

\( \frac{D_t^m}{E_t^m} = \left( \frac{1 - \phi^m}{\phi^m} \frac{P_t^{D,m}}{P_t^{E,m}} \right) \)  
(A.16)

**B.4 Consumption and leisure**

**B.4.1 Armington (consumption) composite**

\[ P_{i,t}^{A,m} \cdot c_t^m = P_t^{D,m} \cdot c_t^{D,m} + P_t^{M,m} \cdot c_t^{I,m} \]  
(A.17)

\[ c_t^m = \varphi^m \left[ \phi^m \left( c_t^{D,m} \right)^{\sigma^m} + \left( 1 - \phi^m \right) \left( c_t^{I,m} \right)^{\sigma^m} \right]^{\frac{1}{\sigma^m}} \]  
(A.18)

\[ \frac{c_t^{D,m}}{c_t^{I,m}} = \left( \frac{1 - \phi^m}{\phi^m} \frac{P_t^{D,m}}{P_t^{I,m}} \right)^{\beta} \]  
(A.19)

**B.4.2 Final aggregate consumption good**

\[ P_t^C \cdot c_t = \sum_{i=1}^{M} P_{i,t}^{A,m} c_t^m \]  
(A.20)

\[ c_t = \zeta \cdot \left[ \sum_{i=1}^{M} \varphi^m \cdot \left( c_t^m \right)^{\sigma^m} \right]^{\frac{1}{\sigma^m}} \]  
(A.21)

\[ c_t^m = \frac{1}{\xi^{\eta + \kappa}} \left( \frac{P_{i,t}^{A,m}}{\varphi^m \cdot P_t^C} \right)^{\kappa} c_t \]  
(A.22)

\[ P_t^C = \frac{1}{\xi^{\eta + \kappa}} \left[ \sum_{i=1}^{M} \left( \frac{P_{i,t}^{A,m}}{\varphi^m} \right)^{\eta + \kappa} \right]^{\frac{1}{\eta + \kappa}} \]  
(A.23)

**B.4.3 Armington (investment) composite**

\[ P_{i,t}^{A,m} \cdot I_t^m = P_t^{D,m} \cdot I_t^{D,m} + P_t^{M,m} \cdot I_t^{I,m} \]  
(A.24)
\[ I_t^m = \mathcal{G}^m \left[ \varphi^m \left( I_t^{D,m} \right)^{\sigma^m} + \left( 1 - \varphi^m \right) \left( I_t^{IM,m} \right)^{\sigma^m} \right]^{\frac{1}{\sigma^m}} \]  \hspace{1cm} (A.25)

\[ \frac{I_t^{D,m}}{I_t^{IM,m}} = \left( \frac{1 - \varphi^m}{\varphi^m} \frac{P_t^{D,m}}{P_t^{IM,m}} \right)^{\mu} \]  \hspace{1cm} (A.26)

\textbf{B.4.4 Final aggregate investment good}

\[ P_t^I \cdot I_t = \sum_{m=1}^{M} P_t^{I,m} I_t^m \]  \hspace{1cm} (A.27)

\[ I_t = \zeta \cdot \left[ \sum_{m=1}^{M} \varphi^{I,m} \cdot \left( I_t^m \right)^{\sigma^m+1} \right]^{\frac{1}{\sigma^m}} \]  \hspace{1cm} (A.28)

\[ I_t^m = \frac{1}{\zeta^{1+\kappa}} \left( \frac{P_t}{\psi^{I,m} \cdot P_t^I} \right)^{\kappa} I_t \]  \hspace{1cm} (A.29)

\[ P_t^I = \frac{1}{\zeta} \left[ \sum_{m=1}^{M} \left( \frac{P_t^{I,m}}{\psi^{I,m} \cdot P_t^I} \right)^{1+\kappa} \right]^{\frac{1}{1+\kappa}} \]  \hspace{1cm} (A.30)

\textbf{B.5 Government behavior}

\textbf{B.5.1 Armington composite}

\[ P_t^{A,m} \cdot G_t^m = P_t^{D,m} \cdot G_t^{D,m} + P_t^{IM,m} \cdot G_t^{IM,m} \]  \hspace{1cm} (A.31)

\[ G_t^m = \mathcal{G}^m \left[ \varphi^m \left( G_t^{D,m} \right)^{\sigma^m} + \left( 1 - \varphi^m \right) \left( G_t^{IM,m} \right)^{\sigma^m} \right]^{\frac{1}{\sigma^m}} \]  \hspace{1cm} (A.32)

\[ \frac{G_t^{D,m}}{G_t^{IM,m}} = \left( \frac{1 - \varphi^m}{\varphi^m} \frac{P_t^{D,m}}{P_t^{IM,m}} \right)^{\mu} \]  \hspace{1cm} (A.33)

\textbf{B.5.2 Final aggregate government consumption good}

\[ P_t^G \cdot G_t = \sum_{m=1}^{M} P_t^{A,m} G_t^m \]  \hspace{1cm} (A.34)

\[ G_t = \zeta \cdot \left[ \sum_{m=1}^{M} \varphi^{G,m} \cdot \left( G_t^m \right)^{\sigma^m+1} \right]^{\frac{1}{\sigma^m}} \]  \hspace{1cm} (A.35)
\[ G_i^m = \frac{1}{\zeta^{1+\kappa}} \left( \frac{P_{i,m}^{A_i,m}}{\psi^{G_i,m} \cdot P^G} \right)^{1/N} G_i \] (A.36)

\[ P^G_i = \frac{1}{\zeta} \left[ \sum_{m=1}^{M} \left( \frac{P_{i,m}^{A_i,m}}{\psi^{G_i,m}} \right)^{1+\kappa} \right]^{\frac{1}{1+\kappa}} \] (A.37)