

# Commercial Policy and Dynamic Adjustment Under Monopolistic Competition

by

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## Abstract

We assess some likely consequences of commercial policy in an intertemporal CGE model of an imperfectly competitive, small open economy. Specifically, we combine an overlapping generations model of aggregate savings with capital accumulation by forward looking investors and production under monopolistic competition and increasing returns to scale. The model replicates Austrian data. We find that unilateral tariff cuts have an expansionary effect resulting both in rationalization of industrial production and in new products supplied by new firms entering the market. Small export subsidies are self financing. The expansionary effects and the welfare increases get magnified under monopolistic competition as compared to a more competitive case. Although all generations are able to participate in the efficiency gains, we note uneven generational gains and a characteristic intergenerational welfare pattern. Finally, we report large overshooting in the net asset position which we attribute to a life-cycle type savings mechanism.

Wir bewerten einige Auswirkungen der Handelspolitik in einem intertemporalen rechenbaren Gleichgewichtsmodell einer unvollständig wettbewerblichen, kleinen offenen Volkswirtschaft. Wir verbinden Kapitalakkumulation mit monopolistischer Produktion und zunehmenden Skalenerträgen. Ersparnisse und Investitionen werden von intertemporal optimierenden, vorausschauenden Akteuren bestimmt. Das Modell wird auf österreichische Daten kalibriert. Wir berechnen expansive Effekte einer einseitigen Zollsenkung, und zwar sowohl in Form von Rationalisierung der industriellen Produktion als auch in Form eines erweiterten Produktspektrums in Folge von Firmenzutritt. Kleine Exportsubventionen sind selbstfinanzierend. Die expansiven Effekte und Wohlfahrtsgewinne fallen unter monopolistischer Konkurrenz wesentlich stärker aus als unter wettbewerblichen Bedingungen. Alle Generationen partizipieren an den Effizienzgewinnen, allerdings sehr ungleichmäßig. Wir stellen ein charakteristisches intergeneratives Wohlfahrtsmuster fest. Langfristig entwickelt sich die Auslandsschuld negativ, kurz- und mittelfristig stellen wir eine stark überschießende Reaktion fest, die wir auf einen vorübergehenden Ersparnisausfall zurückführen.

**JEL Codes:** D58, F12, F13, F43.

**Keywords:** trade liberalization, CGE modeling, monopolistic competition, intertemporal investment, overlapping generations, net foreign assets.



# 1 Introduction

Recent literature has emphasized separately the importance of imperfect competition and capital accumulation for the likely effects of trade liberalization and economic integration. Preceded by work of Harris (1984), Cox and Harris (1985), Wigle (1988), and Brown and Stern (1989) on North American integration, a series of papers in Winters and Venables (eds. 1991) and Winters (ed. 1992) have incorporated elements of imperfect competition into static CGE models of European integration. Goulder and Eichengreen (1989, 1992) and Jorgenson and Ho (1993) have built intertemporal CGE models with forward looking investment and savings behavior for analyzing dynamic effects of U.S. trade policy under perfect competition. In discussing the effects of European integration, Baldwin (1989,1993) addresses issues of capital formation and dynamic adjustment using an "aggregate GDP approach". In this paper, we combine these two modeling approaches and develop a computational general equilibrium (CGE) model featuring both monopolistic competition and capital accumulation in an intertemporal optimization framework. Specifically, we extend our earlier work on a competitive economy [see Keuschnigg and Kohler (1994a, 1994b)] to include product differentiation under increasing returns to scale and market power.<sup>1</sup> In this way we may computationally address several important additional effects of commercial policy that trade theorists have repeatedly emphasized in highly stylized analytical models. Trade liberalization may increase the number of varieties available to consumers, and production may become more efficient due to increased variety of intermediate inputs *and* by virtue of being carried out on a larger scale [see Helpman and Krugman (1989) and Flam and Helpman (1987) for an analysis of trade policy in static models of monopolistic competition]. We emphasize the importance of embedding these effects into a fully specified growth model featuring forward looking investment and savings behavior. To the extent that trade liberalization has an expansionary effect on capital stocks, this will no doubt be conducive to variety and scale effects. Conversely, an increased range of differentiated products raises the average productivity

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<sup>1</sup>Although for a different purpose, the real business cycle literature recently introduced intertemporal equilibrium models with capital accumulation and imperfect competition, see Hornstein (1993) and Rotemberg and Woodford (1993). The R&D based endogenous growth theory also integrates monopolistic market structure with an intertemporal general equilibrium framework [see Grossman and Helpman (1991)] but has not yet found its way into applied CGE modeling. This would be the natural next step. For an early attempt without capital accumulation, see Westerhout (1993).

of intermediate inputs and capital goods and thereby feeds back into higher investment and capital accumulation. Our model thus incorporates a dynamic version of the type of external scale economies emphasized in the pioneering work of Ethier (1982).

We merge an intertemporal model of monopolistic production and capital accumulation with an overlapping generations model with life-cycle type savings and consumption decisions of long-lived agents.<sup>2</sup> In applying this framework to a trade liberalization scenario for the Austrian economy, we address the following questions in a computational way. (1) Is trade liberalization expansionary even if the rest of the world does not follow up? (2) How do the results change with the degree of scale economies and market structure? If there is expansion, is it brought about by new firm entry with increased product differentiation or by a larger production scale of incumbent firms? (3) What is the likely order of magnitude for welfare effects if variety and scale effects as well as capital accumulation are duly taken into account? Is there a characteristic intergenerational incidence? (4) How does tariff liberalization affect the net foreign asset position and what is the dynamic adjustment pattern? We first present in section two our framework and then discuss these questions in the light of our simulation results in the subsequent section. The paper concludes with a summary.

## 2 A Dynamic Trade Model

Our computational model of Austria portrays a small open economy that takes the interest rate as well as prices of import goods as given on international markets. The model consists of a static part, determining industry equilibrium under monopolistic competition and capturing a fair amount of sectoral detail, and an intertemporal part determining aggregate investment and savings. The intertemporal part rests on an overlapping generations model with life-time uncertainty, as pioneered by Blanchard (1985), Buiters (1988) and Weil (1989) [see Frenkel and Razin (1987) for a discrete time variant], and on intertemporal investment theory along the lines of Abel and Blanchard (1983) and Hayashi (1982). We first turn to savings and investment dynamics.

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<sup>2</sup>Eaton (1989) employed an OLG model with monopolistic production by a fixed number of firms to analyze the implications of capitalized domestic monopoly wealth for the current account.

## 2.1 Consumption and Savings

Savings derive from intertemporal optimization under perfect foresight. In each period, individuals of different ages choose some action and face a constant risk  $\theta$  of dying thereafter. Thus, agents born at date  $t - a$  choose at date  $t$  consumption bundles for dates  $s$ , denoted by  $v_{t-a,s}$ , in order to maximize expected life-time utility

$$\max \sum_{s=t}^{\infty} [(1 - \theta)\beta]^{s-t} u(v_{t-a,s}) \quad (1)$$

subject to a dynamic constraint. Since  $v$  is detrended from productivity growth, the discount factor  $\beta$  includes a term due to trend growth of labor productivity at rate  $\nu$ , in addition to the subjective discount rate. Life-time uncertainty further increases the effective rate of individual discounting.

Given a path of future disposable wage incomes  $y_{t-a,s}$ , consisting of the value of time endowment plus lump-sum income components, agents may shift consumption across periods by borrowing or lending in a perfectly competitive international capital market at a given real interest rate  $i^*$ , expressed in import goods with constant prices. Financial wealth  $A$ , denominated in some foreign commodity, consists of government debt, equities, and foreign bonds, all of which are perfect substitutes. Expressed per efficiency unit,  $A$  evolves according to

$$A_{t-a,s} = \frac{1 + i^*}{1 - \theta} \frac{A_{t-a,s-1}}{1 + \nu} + y_{t-a,s} - p^v v_{t-a,s}, \quad (2)$$

where consumption  $v$  is available at a price index  $p^v$ . Life-time uncertainty increases the effective interest paid on assets which provides the key link between individual uncertainty and deterministic behavior in the aggregate.

Agents maximize expected life-time utility (1) subject to (2) and an appropriately specified solvency constraint. Optimal consumption reflects the amount of life-time resources as well as observed relative prices of present and future consumption. Assuming intertemporal separability and a constant elasticity specification of utility, we obtain an explicit solution for current consumption expenditures  $p_t^v v_{t-a,t} = \Omega_t \mathcal{W}_{t-a,t}$ , where  $\Omega$  is the marginal propensity to consume out of total wealth  $\mathcal{W}$ . Wealth consists of financial and human wealth which is the present value of disposable wage incomes  $y$ .

Assuming large age cohorts, we may identify the individual probability of dying with the fraction of any cohort which dies at each date. Given the gross birth rate  $n + \theta$ ,

total population grows deterministically over time with the net birth rate  $n$ . Aggregate quantities per efficiency unit are obtained by summing over cohort specific variables and dividing by the overall population size to detrend from population growth. We assume that disposable wage income is age independent,  $y_{t-a,t} = y_t$ , which requires that government transfers are age independent. Given that individuals have identical time horizons and face identical prices this implies equal human wealth and equal  $\Omega$  for all generations, giving rise to economy wide overall consumption expenditures  $p^v v = \Omega \mathcal{W}$  per efficiency unit.<sup>3</sup>

Consumption of commodities  $C$  and leisure  $1 - L$  yields temporal felicity  $u(v) = u[v(C, 1 - L)]$ . Time endowment is normalized to unity and  $L$  is labor supply. Assuming linear homogeneity of subutility, one may treat the intertemporal problem of finding optimal consumption profiles over time separately from intraperiod allocation across commodities and leisure. Given a price index  $P^C$  for commodity consumption  $C$  and a net wage rate  $w^n$ , a unit of the overall composite consumption good may be obtained at minimal expenditures

$$p^v = \min_{\{c,h\}} \{P^C c + w^n h \quad s.t. \quad v(c, h) \geq 1\}. \quad (3)$$

With linear-homogeneity, demand and expenditure functions are linear in subutility. The consumer price index  $p^v$  for the consumption-leisure bundle is identical to the unit expenditure function, and compensated unit demand functions for consumption and leisure may be written as  $c(P^C, w^n)$  and  $h(P^C, w^n)$ , respectively. Hence, per capita labor supply is  $L^s = 1 - h(P^C, w^n)v$  and consumption amounts to  $C = c(P^C, w^n)v$ . Total expenditures add up to  $p^v v = P^C C + w^n(1 - L^s)$ . To take account of additional commodity disaggregation, we add further nests to the felicity function. This somewhat restrictive (but common) procedure is for tractability and allows to perform household optimization in separate stages as indicated in figure 1 and detailed in the appendix to this paper. Along these lines, one obtains demand for sectoral composite goods. Within each sector,  $C^j$  is an Armington type composite good which combines home and foreign goods bundles,  $C_H^j$  and  $C_M^j$  respectively. Each of these bundles are formed in turn by a range of differentiated varieties,  $c_h^j$  and  $c_m^j$ . As we shall detail below, the number of home made varieties  $n_j$  endogenously results from domestic industry equilibrium, while the number of foreign brands  $n_j^*$  is exogenously given by virtue of the small country assumption. One may as-

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<sup>3</sup>A separate appendix which is available upon request, gives all the details on individual optimization and aggregation.



sume that utility is defined over an infinity of varieties but only  $n_j + n_j^*$  are produced in equilibrium. The bottom level of the utility tree captures the consumer's love for variety. To be specific, we assume a Dixit-Stiglitz type utility function which is defined over a variable range of differentiated products or varieties [see Dixit and Stiglitz (1977), and for a recent application Rotemberg and Woodford (1993)]. Different varieties enter utility symmetrically, with an elasticity of substitution  $\sigma$  which exceeds unity.<sup>4</sup> Eventually, one obtains the demand function for a home made variety of sector  $j$  products

$$c_h^j = (P_H^{C,j} / p_h^{c,j})^{\sigma_j} C_H^j. \quad (4)$$

As explained in the appendix,  $P_H^{C,j}$  is a price index for the composite home good of type  $j$  while  $p_h^{c,j}$  is the consumption price of an individual home made variety.  $C_H^j$  is the quantity consumed of the composite home good, as determined by upper level optimization. A number of indirect taxes drive a wedge between demand and supply prices. It is important to note that the own price elasticity of variety demand is equal to  $\sigma$ .

## 2.2 Capital Accumulation

On the production side, we sharply distinguish individual workshops from industries or sectors (indexed by  $j$ ). Within each industry  $j$ , producers differentiate their products and offer an array of different brands. Hence, domestic production in industry  $j$  occurs in  $n_j$  workshops. Producers compete on competitive factor markets for labor, capital and intermediates and pay competitive factor prices. Labor is assumed completely mobile across industries as well as across workshops within each industry. Capital, too, is assumed completely mobile *within* each sector and, thus, can be costlessly redeployed in different workshops in any given period. By way of contrast, capital is imperfectly mobile *across* sectors. In each period, the industry capital stock is predetermined from past investments. With capital accumulation being a sticky process, capital is sector specific in the short-run but may be gradually reallocated over time by means of diverging sectoral investment rates.

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<sup>4</sup>Note that the elasticity  $\sigma$  governs substitution *within* the two classes of home and import brands while substitution *between* the home and import composites is determined by a lower Armington elasticity. By way of contrast, much of the theoretical literature assumes a perfectly symmetrical substitution across *all* varieties which would imply too high substitution between home goods and imports in an empirical implementation of the model.

Accumulation of the industry wide capital stock is based on forward looking inter-temporal optimization on the part of investors. The investor owns the preexisting capital stock and rents it out to individual producers. Since capital is completely mobile within each industry, producers pay a competitive rental rate  $m$  equal to the marginal value product of capital in the production of varieties. Hence, the investor collects gross revenues equal to  $m \frac{K_{-1}}{1+\bar{g}}$ . Note that the model is presented in detrended form. Hence,  $\frac{K_{-1}}{1+\bar{g}}$  is the capital stock of the previous period, measured per efficiency units of the current period. Allowing for investment outlays, currently consumable income of the investor is<sup>5</sup>

$$\chi = (1 - t_y)m \frac{K_{-1}}{1+\bar{g}} - (1 - et_y)P^I \Phi \left( I, \frac{K_{-1}}{1+\bar{g}} \right). \quad (5)$$

Dividends  $\chi$  are subject to an income tax with a proportional rate  $t_y$  but a fraction  $e$  of investment expenditures is allowed as a deduction from the tax base. Gross investment  $\Phi$  may be thought of as demand for a composite capital good available at a price  $P^I$ . A linearly homogeneous capital goods “technology” which is analogous to the utility nesting described above, combines various commodities to build capital. Assuming the technology to be identical, each sector faces the same price index. Adding  $I$  units to the stock requires to purchase  $\Phi(I, \frac{K_{-1}}{1+\bar{g}})$  units of capital goods.<sup>6</sup> Due to adjustment costs, demand for capital goods increases more than proportionately with the investment rate. Hence, capital accumulation is a sticky process as rapid expansion becomes rather expensive. With capital depreciating at a geometric rate  $\delta$ , each industry accumulates stocks according to

$$K = I + (1 - \delta) \frac{K_{-1}}{1+\bar{g}}. \quad (6)$$

Domestic capital is owned by residents. In the absence of uncertainty and with perfect capital markets, all assets must yield identical rates of return equal to  $i^*$ , denominated in import goods. The return on equities accrues in the form of dividends as well as capital gains. Hence, every sector faces a no arbitrage condition

$$i^* = \left( \chi + V - \frac{V_{-1}}{1+\bar{g}} \right) / \frac{V_{-1}}{1+\bar{g}}. \quad (7)$$

Equity value  $V$  as well as dividends are per efficiency unit. In imposing a transversality condition, we identify the fundamental value of capital as the present value of future

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<sup>5</sup>In presenting the core model we abstain from using sector and commodity indices.

<sup>6</sup>The installation technology  $\Phi$  is assumed linearly homogeneous and satisfies  $\Phi_I > 0$ ,  $\Phi_{II} > 0$  and  $\Phi_K < 0$ .

dividend flows. Capital accumulation is optimal if it maximizes equity value,

$$\max \sum_{s=t}^{\infty} \chi_s \prod_{u=t+1}^s \frac{1 + \bar{g}}{1 + i_u^*}. \quad (8)$$

Necessary conditions for an intertemporal production optimum imply

$$\begin{aligned} (a) \quad q &= \Phi_I(\cdot) P^I (1 - et_y), \\ (b) \quad q_{-1} &= \{[(1 - t_y)m - (1 - et_y)P^I \Phi_K(\cdot)] + q(1 - \delta)\} / (1 + i^*). \end{aligned} \quad (9)$$

Solving (9b) forward in time reveals that the shadow value of capital  $q_t$  equals the present value of incremental future net income streams that would be created by an additional unit of capital, including the effect of an increased capital stock on future adjustment costs. Hence, (9a) determines investment by the simple rule that the present value of incremental future profits induced by a new project must cover at least the effective acquisition costs. Figure 1 shows how the economy wide demand for the composite capital good,  $\sum_j \Phi^j$ , translates into derived investment demands for individual commodities and varieties. In view of the homogeneity assumptions on technology, we may invoke Hayashi's (1982) theorem which equates firm value to the shadow value of new capital:  $V = qK$ .

### 2.3 Other Final Demand Components

In addition to consumption and investment demand, our model incorporates government procurement, intermediate input demand, and export demand. Government purchases derive from quasi-preferences which are analogous to those underlying consumption demand. The crucial difference is that demand for the top level composite good is based on some exogenously motivated policy scenarios rather than on intertemporal optimization. Demand for intermediates arises from production which requires, in addition to labor and capital, a composite intermediate input good. The intermediate input requirements of all sectors add up to total demand for the composite good which translates into derived commodity demands for use as intermediates [see figure 1].

Domestic producers supply differentiated brands and exert market power also on export markets. Consequently, the home economy is able to influence its terms of trade. We assume, however, that the home economy is too small to have any impact on foreign factor incomes  $Y^*$ . With details given in the appendix, one may therefore derive export

demands from maximization of foreign utility  $u(E) + N$  subject to an income constraint  $P^E E + N \leq Y^*$ . Utility is defined over all traded goods as captured by  $E$  and a composite non-traded good  $N$ . Foreigners demand a basket of commodities  $E[E^1(\cdot), \dots, E^J(\cdot)]$  with each type  $E^j(\cdot)$  representing an array of home produced and foreign varieties. Using an isoelastic utility specification, demand for the overall basket is

$$E = b(P^E)^{-\mu}. \quad (10)$$

The specification of the foreigner's utility implies that all income effects are absorbed by the non-traded goods aggregate  $N$ . Consequently, foreign demand for the traded goods aggregate depends on its price index exclusively which, in effect, reflects the home economy's terms of trade. The elasticity  $\mu$  controls the strength of the terms of trade effects. The overall demand level implies derived sectoral demands  $E^j$  which are allocated to home and foreign varieties, as familiar from (4) above (see appendix for more details).

All demands face an identical producer price of  $p_h^j$  for home produced and  $p_m^j$  for imported varieties. World prices of imports are normalized to unity by an appropriate unit convention, and are held constant in the counterfactual scenarios. Hence, an arbitrary import good serves as the numéraire. Three types of indirect taxes drive a wedge between supply and demand prices: a value added tax, a general excise tax, and import tariffs. Tax rates for these indirect taxes vary between different categories of demand, reflecting both different treatment by tax law as well as different compositions of aggregates by individual commodities.<sup>7</sup> Tax treatment of imports and exports follows an unrestricted **destination principle**. Incoming imports are subject to all domestic indirect taxes, whereas exports leave the country net of domestic indirect taxes (at a price  $p_h^j$ ) and are subject to the foreign countries' indirect tax system. Export demand faces a price of  $p_h^{e,j} = p_h^j(1 + t^{j,*})$  where  $t^{j,*}$  denotes the foreign tariff.

## 2.4 Monopolistic Production of Varieties

Following common modeling practice we assume that all domestic varieties are produced subject to the same technology. As opposed to much of the analytical literature, our

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<sup>7</sup>Due to the symmetry property of the model, all domestic varieties of each commodity fetch an identical price, and similarly for all imported varieties. Indirect taxes are assumed to discriminate across commodities but not across varieties.

technology requires inputs of both labor and capital, as well as an intermediate input. Both capital and the intermediate input are composite goods. While firms behave competitively on all factor markets, each of them specializes in a single variety. Each variety is, therefore, monopolistically supplied by a single firm. In maximizing profits, firms equate marginal costs with perceived marginal revenues. When demand is perceived to be less than infinitely elastic, firms set prices above marginal cost. Absent any barriers to entry, positive monopoly profits tend to attract production of new varieties which we assume to take place by new firms entering the market. We allow for overhead costs, recurring each period, which may be identified as fixed costs of setting up and maintaining a firm. This implies falling average costs and increasing returns to scale and allows us to endogenously determine the number of firms through a zero profit condition reflecting the assumption of free entry.

We assume labor to be completely mobile across and within industries. By way of contrast, capital is imperfectly mobile across industries, but perfectly mobile across workshops within an industry. This key assumption renders the production problem completely static at the workshop level while all intertemporal aspects are taken care of by the investor agent at an industry wide level. In addition to its other factor requirements, each workshop may flexibly hire any amount of capital at a given competitive rental rate. The overall operation exhibits increasing returns to scale due to fixed costs, while variable inputs are determined by a constant returns to scale technology  $x^j = x^j[x^j(k^j, l^j), q^j]$ , which is identical for all workshops and and weakly separable in value added  $f^j$  and intermediates  $q^j$ .<sup>8</sup> While lower case letters refer to individual producers, aggregate quantities are denoted by capital letters:  $X^j = n_j x^j$ . Given symmetry in demand and identical technologies for all differentiated products, we may omit the variety index and refer to representative varieties instead. Given linear homogeneity of factor use, the firm's cost minimizing factor combinations are fully characterized by unit demand functions and price indices that result from the following unit problems:

$$\begin{aligned}
 (a) \quad \tilde{p}(w, m) &= \min_{k, l} \{wl + mk \quad s.t. \quad F(k, l) \geq 1\}, \\
 (b) \quad u(\tilde{p}, p^Q) &= \min_{f, q} \{\tilde{p}f + p^Q q \quad s.t. \quad X(f, q) \geq 1\}.
 \end{aligned}
 \tag{11}$$

All input demands are linear in outputs. Per unit of output  $x$ , the firm requires a value added quantity  $f(\tilde{p}, p^Q)$  and an intermediate input quantity  $q(\tilde{p}, p^Q)$ . Furthermore, a unit

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<sup>8</sup>Specifically, we employ Cobb-Douglas for  $x^j[\cdot]$  and CES for  $f^j(\cdot)$ .

of value added demands primary factors  $k(w, m)$  and  $l(w, m)$ . In addition to the value added required for variable output  $x$ , each firm's overhead operations use a fixed amount  $\bar{f}$  of value added. Consequently, total input demands amount to  $k(\bar{f} + fx)$  for capital,  $l(\bar{f} + fx)$  for labor, and  $qx$  for the intermediate composite good. A unit of value added is priced at  $\tilde{p} = wl + mk$  which gives the primary unit factor cost. Hence, variable unit cost of a workshop is  $u(w, m, p^Q) = (wl + mk)f + p^Qq$ , which is independent of output  $x$ .

Having minimized unit costs, workshops engage in maximization of perceived profits. The true demand function for a home produced variety is obtained by adding the bottom level demands such as in (4) over all demand categories. Assuming that the elasticity of substitution  $\sigma$  is identical in all categories, total demand for a home variety is of the form<sup>9</sup>  $D_h = D_0 p_h^{-\sigma}$ . In writing this aggregate demand function, we assume identical producer prices across all types of demand and, thus, abstract from possible market segmentation. The demand shift parameter  $D_0$  is associated with the state of aggregate demand which the individual producer perceives as beyond her control. Since she is a monopolist for her brand, she supplies all of the market. By inverting her perceived demand function, she reckons to obtain a price  $p_h$  when supplying an output  $x$ , equal to

$$p_h(x) = (D_0/x)^{1/\sigma}. \quad (12)$$

In taking the state of aggregate demand  $D_0$  as given, the producer ignores any effect of her supply variations on the position of the true demand schedules. The error committed when calculating marginal revenue on the basis of a perceived demand function with elasticity  $-\sigma$  falls with an increasing total number of firms. Our approach thus in a way presumes, a priori, that the number of firms, which the supplier similarly takes as given, is large.<sup>10</sup>

The above assumption of  $\sigma > 1$  guarantees that revenue is increasing and concave in output. With individual producer behavior based on perceived demand functions, profit maximization entails

$$\Pi(w, m, p^Q) = \max_x \{p_h(x)x - ux - \tilde{p}\bar{f}\}. \quad (13)$$

Variable costs amount to  $ux$  but the operation of the production unit also involves fixed overhead costs  $\tilde{p}\bar{f}$ . Fixed costs are associated with capital and wage costs in exactly

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<sup>9</sup>Due to indirect taxes, the demand price for consumption is related to the producer price by  $p_h^{c,j} = (1 + \tau_h^{c,j})p_h^j$ , where  $\tau_h^{c,j}$  summarizes all indirect taxes mentioned above, and similarly for other demands. Therefore,  $D_0$  is a relatively complicated expression involving both top level quantities and tax rates.

<sup>10</sup>See Yang and Heijdra (1993) and Dixit and Stiglitz (1993) for an in depth discussion of this issue.

the same way as variable production. While fixed costs are thus importantly affected by factor prices, they do not themselves enter the supply decision of an existing firm. The first order condition for firm output is

$$p_h(x) = (1 - 1/\sigma)^{-1}u(w, m, p^Q). \quad (14)$$

This is the familiar markup pricing rule of a monopolistic supplier. Given our assumption of  $\sigma > 1$ , producers set a positive markup over unit costs for variable inputs of labor, capital and intermediates.

If the number of firms is fixed because of sufficiently high barriers to entry, fixed costs simply reduce monopoly profits. However, our model features free entry and exit of firms and thereby endogenizes the range of varieties available to the consumer as well as the producer. In this case, firm entry (or exit) continues until profits are competed away (or losses disappear), and the incentives of entering or exiting the industry are thus eliminated. Such an industry equilibrium then satisfies

$$\Pi = p_h(x)x - ux - \tilde{p}\bar{f} = 0. \quad (15)$$

Industry  $j$  faces an economy wide wage rate  $w$  and a price  $p^Q$  for the composite intermediate good which are determined by general equilibrium repercussions. Furthermore, the industry specific capital stock  $\frac{K_{-1}^j}{1+\beta}$  is given by past investments of an intertemporally optimizing investor. A temporary industry equilibrium in sector  $j$  is characterized by (11), (12), (14), (15) and

$$\begin{aligned} (a) \quad \frac{K_{-1}^j}{1+\beta} &= n^j k^j (\bar{f}^j + f^j x^j), \\ (b) \quad L^j &= n^j l^j (\bar{f}^j + f^j x^j). \end{aligned} \quad (16)$$

Given  $w$ ,  $p^Q$  and  $K_{-1}^j$ , these equations determine the industry specific variables  $p_h^j$ ,  $x^j$ ,  $n^j$ ,  $m^j$  and  $L^j$ .

## 2.5 Public Sector Balance and the Current Account

The government spends on commodities and on transfers to the household sector. It finances its budget by raising taxes and accumulating debt. The model incorporates direct taxes plus three types of sector specific commodity taxes, a value added tax, an excise tax,

and an import tariff. Although the government may temporarily run deficits or surpluses, it must keep its liabilities within sustainable levels. If not otherwise indicated we assume that the government follows a prespecified path of debt and public consumption, and lets transfers adjust endogenously to satisfy the budget constraint. The following laws of motion tie primary balances to the accumulation of associated stocks,

$$\begin{aligned}
(a) \quad D^G &= (1 + i^*)D_{-1}^G / (1 + \bar{g}) + S^G, \\
(b) \quad D^F &= (1 + i^*)D_{-1}^F / (1 + \bar{g}) + S^F, \\
(c) \quad A &= (1 + i^*)A_{-1} / (1 + \bar{g}) + S^H,
\end{aligned} \tag{17}$$

where the stock of government bonds,  $D^G$ , net foreign assets,  $D^F$ , and aggregate financial wealth  $A$  are denominated in foreign commodities. Note that (17c) is the aggregate version of (2). It omits the death probability which can be interpreted as an insurance premium that is cancelled in the process of aggregation. With  $y = w^n + t_y d + z$ , primary household sector savings out of disposable wage income in (17c) are equal to  $S^H = w^n L^s + t_y d + z - P^C C$ . Disposable income includes government transfers  $z$  and the tax savings from a lump-sum deduction  $d$  from the income tax base. Such a deduction makes the income tax indirectly progressive. The government runs a primary deficit equal to  $S^G = z + P^G G - T$ . Total tax revenues  $T$  include a general income tax, social security contributions, factor taxes, a value added tax, excise taxes as well as tariff revenues. The trade balance adds up to  $S^F = \sum_j [n_j p_h^j e_h^j - n_j^* p_m^j (c_m^j + g_m^j + \sum_i (i_m^{ji} + q_m^{ji}))]$  where lower case symbols indicate demand for individual varieties, and  $i_m^{ji}$  denotes the demand for an imported variety of commodity  $j$  for investment purposes of sector  $i$ , and similarly for intermediates  $q_m^{ji}$ . Solving these equations forward in time one obtains the intertemporal budget constraints which restrict the present value of future excess spending to the amount of existing wealth.

As is evident from (5), investors are assumed to finance investments with retained earnings  $R^j \equiv P^I \Phi^j$ , hence,  $R = P^I \Phi$  in the aggregate with  $R = \sum_j R^j$  etc. Given that the no arbitrage condition (7) is satisfied and the aggregate portfolio identity  $\sum_j V_j + D^G + D^F \equiv A$  holds for both the current and the previous period, we can substitute (17a,b) into (17c) and expand with  $R$  to obtain the familiar savings investment relationship of an open economy,

$$S + R = p^I \Phi + \nabla D^G + \nabla D^F, \tag{18}$$

where we denote changes in asset positions per efficiency unit by  $\nabla D = D - D_{-1} / (1 + \bar{g})$ .



Total household sector savings,  $S = S^H + \sum_j \chi^j + i^*(D_{-1}^G + D_{-1}^F)/(1 + \bar{g})$ , is primary savings out of disposable wage income augmented by capital income.

An intertemporal equilibrium with perfect foresight consists of sequences of prices and quantities such that all optimality conditions and budget constraints are satisfied and all markets clear at each date. Temporary equilibria are interconnected in two ways. All “backward looking” stock variables are predetermined from previous equilibria, and future equilibria determine current values of the “forward looking”, expected variables. While initial conditions for predetermined variables are given by the data, terminal values of expected variables are generated by an independent computation of the final steady state.<sup>11</sup>

The model is presented in detrended form. The original economy grows at a constant exogenous growth rate  $\bar{g}$  that reflects population and productivity trends at rates  $n$  and  $\nu$ :  $(1 + \bar{g}) = (1 + \nu)(1 + n)$ . To support balanced growth with constant relative prices, output of workshops must grow in line with aggregate demand [see (12)]. The zero profit condition then dictates that fixed value added requirements also grow at this rate.<sup>12</sup> Hence, in the initial balanced growth equilibrium, firm numbers remain constant while firm outputs grow in line with the economy wide trend without any rationalization effects present. Average costs remain constant. When the model is shocked by some policy experiment, the path of fixed value added requirements remains unaffected while numbers and outputs of firms deviate from their initial paths.

The empirical implementation of the model replicates a 1976 benchmark data set for the Austrian economy as a steady state equilibrium. A more recent benchmark period is, of course, highly desirable and will be implemented in due course as more recent data become available. Details on the empirical calibration are given in Keuschnigg and Kohler (1994a) including an extended separate appendix that is available on request. The appendix to this paper explains in full detail calibration of those parts of our model that relate to monopolistic competition.

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<sup>11</sup>The computation of perfect foresight solutions follows an iterative procedure that was introduced by Wilcoxon (1989) and is described in detail in Keuschnigg (1991).

<sup>12</sup>If  $\bar{f}$  were kept constant, the aggregate economy would not be linearly homogeneous and could not support balanced growth at an exogenous rate.

### 3 Trade Liberalization

How does commercial policy affect a growing economy in the presence of monopolistic competition? How do these reactions contrast with the case of perfect competition? We now discuss the questions raised in the introduction by considering a rather simple policy experiment which is a unilateral reduction of all benchmark tariff rates. Table 4 reports average initial tariff rates and, thus, on the size of the policy shock. In addition, we contrast the effects of tariff liberalization with the introduction of export subsidies at equal budgetary costs. In contrast with much of the theoretical literature, these changes are done in the presence of a number of other tax distortions relating to direct and indirect taxes. The government accommodates the budgetary impact by an appropriate adjustment of transfers to households so as to leave the path of government debt (in terms of imported goods) and real government consumption unaffected. Finally, we remind the reader that the long-run growth rate is exogenous in our model. Hence, the long-run consequences of trade liberalization refer to pure level effects in capital stocks and all derived variables.

#### 3.1 Is Trade Liberalization Expansionary?

Tariff cuts make imports cheaper. Given producer prices, agents feel an incentive to substitute home goods for imports resulting in depressed demand for home produced goods. A further impact effect derives from the government budget constraint. Given the wage rate, households receive lower disposable wage incomes  $y$  as the government reduces transfers to make up for lower tariff revenues. In the long-run, aggregate household sector expenditures for both commodities and leisure,  $p^v v$ , are just proportional to disposable wage income. With relative changes denoted by a hat, we have  $\hat{y} = \hat{p}^v + \hat{v}$ . Hence, a reduction in disposable wage income due to lower transfers depresses both demands for commodities and leisure.<sup>13</sup> The reduction in commodity demands would be alleviated somewhat since the purchasing power of the expenditures allocated to commodities increases due to a lower consumer price index,  $\hat{p}^C < 0$ . The net effect would possibly be

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<sup>13</sup>Since  $v(C, 1 - L)$  is specified Cobb-Douglas, the substitution and income effects of relative price changes between consumption and leisure cancel in our model. Constant expenditure shares imply  $\hat{C} = -\hat{p}^C + \hat{y}$  and  $\hat{H} = -\hat{w} + \hat{y}$ .

a further reduction in demand for home goods. With demand shifting away from home produced goods, can unilateral tariff liberalization still be expansionary?

Depending on the import content, a tariff cut reduces prices of the composite intermediate and capital goods,  $\hat{p}^Q < 0$  and  $\hat{p}^I < 0$ . Since all sectors use the same composite good, these prices are identical across sectors. The investor accumulates capital until the present value of marginal profits just equals the acquisition price of the capital good. According to the long-run version of (9), the relative decline in the rental rate of capital would be equal to the reduction in the capital goods price,<sup>14</sup>  $\hat{r} = \hat{p}^I < 0$ . Furthermore, since all sectors use the same capital good and since capital is freely accumulated, rental rates are completely equalized across sectors in the long-run. Given the wage rate, cheaper capital goods imply a lower rental rate of capital making a higher capital intensity optimal [see the technology given in (11)]. Lower costs for capital and intermediates translate into lower unit costs  $u(w, m, p^Q)$  which would induce producers to cut output prices according to their markup pricing rule given in (14). Lower prices at home generate an export boom as foreigners substitute towards home goods. Furthermore, lower prices increase the purchasing power of domestic agents and run counter to the initial substitution effects away from home goods. Hence, the cost reductions on the supply side initiate strong expansionary forces which have to be accommodated by increased availability of primary factors. With capital freely accumulated in the long-run and capital intensities increased, labor is the limiting factor and is paid a higher wage.

In fact, the wage rate is the main equilibrating price in the long-run. In a stationary equilibrium with freely accumulated capital, the rental rate is proportional to the capital goods price. Aside from policy induced changes in import prices, the prices for the composite capital and intermediate goods depend endogenously on domestic producer prices. Hence, the markup pricing rule (14) may be viewed as a complicated implicit function that positively relates domestic prices to the wage rate. Wage pressure would increase unit costs, raise output prices and thereby eliminate excess demand. In the base case scenario of table 1, tariff cuts reduce unit costs, allow for lower prices and create aggregate excess demand for domestically produced goods. The cost pressure resulting from higher wages raises domestic producer prices, chokes off export demand and shifts domestic demands towards imports. The effects on consumption demand are ambiguous

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<sup>14</sup>Note that the derivatives of the adjustment cost function and the other tax parameters are constants in the long-run.

because higher wages also mean increased disposable wage income which increases demand for all goods. Much of the price sensitivity of the aggregate long-run ‘excess demand’ function depends on the export elasticity  $\mu$ . Compare the base case of table 1 with the case of a low export elasticity. The cost reductions resulting from tariff cuts reduce producer prices. Export demand, however, would not soak up the shortfall in domestic demand since it is rather price insensitive. Further wage and price reductions are needed to make exports increase and to have domestic demand shift into home goods. This is clearly evident from table 1.

Tariff liberalization is expansionary. Despite of the initial substitution away from home goods, the result is robust with respect to the sensitivity analysis presented in table 1. The main reason is that the wage rate rises relative to the prices of capital goods and intermediates which additionally reflect lower import costs. Hence, the rental rate of capital falls relative to wages and, thus, implies higher capital intensity. Since the household sector supplies more labor, all inputs and production expand. In table 1, we recompute the effects in case of fixed labor supply. As emphasized by Sen and Turnovsky (1989), endogenous labor supply is important and makes tariff liberalization more expansionary. However, it is not essential for the expansionary effects of tariff cuts in our more general setup emphasizing the import content of the capital good.

Tables 3 and 4 report some disaggregate demand and supply effects. As is evident from column  $\tau_m^0$  in table 4, initial tariff protection is spread quite unevenly. Agriculture, food, textiles and clothing are the most heavily protected sectors while services, energy and construction industries essentially supply non-traded goods. Thus, complete elimination of tariff rates reduces demand prices of imports rather unevenly. The general equilibrium repercussions, however, transmit the effects to all sectors of the economy. Capital accumulation equates the rental rates of capital  $m$  across sectors in the long-run making all producers pay identical factor prices [see the changes in  $p^I$ ,  $p^Q$  and  $w$  noted in table 1]. Significant sectoral diversity remains, however, since different sectors employ different technologies. Figures 2 to 4 report the long-run percentage changes in firm numbers, output per firm, and domestic producer prices for both the base case and the more competitive (lower scale economies) scenario. Looking at the long-run demand reactions reported in table 4, the substitution effect towards imports is clearly visible and strongest for those products that were most heavily protected to start with. Despite of the substitution effect away from home goods, demand nevertheless expands due to the

dynamic forces at work in the long-run which increase capital stocks and real disposable wage income. Finally, table 4 reports an export boom due to the terms of trade effect associated with falling domestic producer prices. Foreigners demand more of their traded goods bundle [the top level effect of a lower price index  $P^E$ , see (10)] and shift the composition of this bundle towards home goods (Armington type substitution behavior).

Export subsidies are a widespread instrument of commercial policy and can take various forms such as direct subsidies, tax credits, duty exemptions, credit subsidies and others [see Rodrik (1994) for a recent study]. While our model obviously violates the precise conditions of the Lerner symmetry theorem, one might nonetheless expect that the effects of a tariff cut could be mimicked by an export subsidy of appropriate magnitude.<sup>15</sup>

In table 2, we contrast tariff cuts with export subsidies that have comparable budgetary impacts in present values. In particular, we halve the initial tariff rates and compute the present value of transfer payments to the household sector. Then we introduce export subsidies by a magnitude that produces an equally sized change in the present value of transfer payments [see the line  $PV(z)$ ]. These present value calculations require to compute the whole transition while table 2 reports only the long-run results. In order to avoid any diverging structural effects, we get sectoral export subsidies by scaling the vector of average initial tariff rates as indicated in table 2.

Export subsidies reduce the demand price,  $p_h^{e,j} = p_h^j(1 - \tau^{e,j})$ , that foreigners pay for home produced varieties. Consequently, foreigners create excess demand at home which is eliminated by wage pressure and rising domestic prices. Wages have to increase by more than the capital goods price which drives the economy to a higher capital intensity. Since transfers are an important income component initially, the relative increase in disposable wage income is more moderate than the increase in wage income alone. Hence, labor supply rises making export subsidies clearly an expansionary policy. Quite surprisingly, government revenues increase rather than decline since the expansion raises revenues from existing direct and indirect taxes to such an extent that the budgetary cost of export subsidies is more than compensated. Hence, the introduction of small export subsidies is self financing! However, this aspect is a local phenomenon only. For higher subsidies, a further increase will eventually reduce the present value of transfers. Introducing export

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<sup>15</sup>Razin and Svensson (1983) showed that Lerner's symmetry theorem also holds in an intertemporal two period model of a small open economy if trade taxes are permanent.

subsidies in a size approximately equal to the initial average tariff rates (scaling factor about unity) raises the present value of transfers by exactly the same percentage amount as tariff cuts reduce it. Export subsidies, however, have much more powerful expansionary effects than tariff cuts including a more beneficial effect on welfare. This gives room for revenue neutral commercial policy. The last column of table 2 combines a 50 % tariff cut with new export subsidies which are 1.2 times as large as initial average tariff rates. Overall, the net effect on the present value of transfers is zero but the allocational effects are further magnified.

### 3.2 Expanding Product Variety or Rationalization?

Expansionary effects of trade liberalization may be felt in expanding product variety. When new firms enter the market, they introduce new products and services and contribute to progressive division and specialization of industries. Increased product variety is directly beneficial to consumers who love variety. Quite analogously, the productivity of intermediate inputs or capital goods increases with the range of available differentiated varieties. This has been called increasing returns due to specialization [see Ethier (1982), Romer (1987) and Matsuyama (1993)]. Alternatively, an expansion may lead to incumbent firms producing at a larger scale. Such rationalization effects in industrial production have been discussed in the context of US-Canadian trade liberalization [see, for instance, Wigle (1988), Brown and Stern (1989), the comment by Staiger (1989) as well as the survey by Richardson (1989)]. Our model contains the potential for both sources of efficiency enhancing adjustment. Note, however, that we have fixed value added requirements growing at a basic exogenous growth rate. To be compatible with balanced growth, firm outputs must grow at the same rate without any scale economies realized while firm numbers must remain constant. Hence, both rationalization and increasing specialization are shut off in a steady state equilibrium. If the model is shocked, however, the level effects associated with the adjustment to a new long-run equilibrium may either reflect expanding product variety or rationalization effects in production.

What is the reason for expansion resulting in increased size of incumbent firms rather than new firms entering the market? Due to markup pricing as noted in (14), the relative change in output prices is tied to unit costs,  $\hat{p}_h = \hat{u}$ . To break even, firms must earn gross profits that just match fixed costs. By (14) and (15), the zero profit condition reads as

$\frac{u\bar{x}}{\sigma-1} = \tilde{p}\bar{f}$  and implies  $\hat{x} = \hat{\tilde{p}} - \hat{u}$ . Unit costs derive from value added and intermediate inputs. Depending on the factor share of value added,  $s_f$ , the technology noted in (11) gives  $\hat{u} = s_f\hat{\tilde{p}} + (1-s_f)\hat{p}^Q$ . Consequently, the change in individual factory output depends on the initial cost share of value added according to  $\hat{x} = (1-s_f)(\hat{\tilde{p}} - \hat{p}^Q)$ . Analytical models often do not involve any such scale effect because of a highly stylized representation of technology. For instance, if labor is the only factor of production, the resource use for fixed and variable outputs would be identical and scale effects could not materialize. In our model, the technologies behind fixed and variable costs differ by the use of intermediates. The lower the share of intermediates in variable costs,  $(1-s_f)$ , the more variable and fixed cost technologies resemble each other, and the smaller the reaction of firm outputs in response to shocks. Tables 1 and 3 and figures 2 to 4 report on the numerical results. In the base case, value added costs  $\tilde{p}$  increase in most sectors due to wage pressure while intermediates become cheaper reflecting lower import costs as well as declining domestic prices. Hence, part of the expansion results in increased firm outputs. The average cost reduction due to positive scale effects seems not to be a big stake, however, as it remains within the vicinity of one tenth of a percent (table 1). The expansionary effects are also felt in new firms entering the market and introducing new varieties. Increased product variety raises the average productivity of differentiated intermediates and capital goods which additionally operates like a cost reduction to the benefit of both consumers and producers. Hence, our tariff liberalization scenario captures the beneficial effects of both rationalization and increased specialization of industrial production.

Tables 1 and 3 and figures 2 to 4 contrast the base case with the long-run results obtaining in case of lower scale economies. In particular, we calibrate the model with an increased output elasticity of cost which, in turn, requires to raise the elasticity of variety substitution  $\sigma$  and to reduce the fixed cost requirements  $\bar{f}$  [see the appendix on calibration of an industry equilibrium]. Thus, the scenario with lower scale economies mimicks the case of perfect competition. Note that quantities and prices of the initial reference equilibrium always remain the same. The sensitivity check clearly establishes that trade liberalization tends to be more expansionary under monopolistic competition. This result is in the spirit of New Keynesian macroeconomics which established that policy intervention in imperfect competition models triggers multiplier like adjustment processes [see Matsuyama (1993) and Heijdra and v.d.Ploeg (1994), for example]. The reason lies with the fact that rationalization as well as firm entry introduce increasing returns on

the macro level. With new firms entering the market, the expanded product range raises the average productivity of differentiated intermediates as well as capital goods, and makes them effectively cheaper. In a sense, the activities of new and incumbent firms are complementary, reinforce each other and, thus, start a cumulative process. Cheaper capital goods operate like an investment incentive that reinforces the incentives for capital accumulation. Tables 1 and 3 repeat the base case calculations with lower scale economies and clearly establish that the expansionary effects of trade liberalization are magnified under monopolistic competition. The increase in welfare, too, is substantially higher in the base case. Since output is too low in a monopolistically competitive economy, any expansionary policy would have the beneficial side effect of reducing this market distortion.

### 3.3 Intergenerational Incidence of Commercial Policy

How do present and future generations participate in the potential gains from trade liberalization? Might trade policy entail conflicting generational interests? Before turning to a complete generational welfare accounting, we report in table 1 a welfare gain of a representative new agent born into the final steady state which is equivalent to approximately one percent of life-time wealth. This welfare gain results despite of the rather pessimistic policy scenario of a unilateral tariff cut that is not repeated abroad, and despite of the negative terms of trade effects associated with it. Furthermore, table 1 shows higher welfare gains in an imperfectly competitive environment (base case) as compared to the more competitive scenario with lower scale economies. Since output is too low in a monopolistically competitive economy, the expansionary effects of trade liberalization contribute to alleviate the consequence of this market distortion. Finally, if the price elasticity of exports is rather low, the negative terms of trade effects are magnified and the associated welfare losses start to dominate the efficiency gains resulting in an overall decline in welfare for future generations.<sup>16</sup>

Figure 6 traces the generational pattern of welfare changes. The horizontal axis gives birth dates of generations and the vertical axis measures the associated equivalent variation in life-time wealth. Since new generations or dynasties start life without any bequests, welfare of new born agents hinges entirely on their life-time disposable wage

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<sup>16</sup>Keuschnigg and Kohler (1994b) investigate in more detail the importance of terms of trade effects for welfare results.



income and its purchasing power as reflected in the price index  $p^v$  of the consumption leisure bundle. Sticky capital accumulation implies that disposable wage income rises only gradually. Figure 8 reports the change in wage income as denominated in import goods. To arrive at the welfare implications, we need to consider the reduction in the overall price index which implies an increase in real wages at least in the long-run. Reflecting the present value of wage incomes, human wealth will be rather low in the early adjustment phase and will increase in the full amount only about three decades after the policy implementation. Reflecting this pattern of wage incomes, future generations are more favorably affected than current young generations.

In addition to the effects on human wealth and commodity prices, old agents living at the date of the policy shock reap windfall gains on their previously accumulated equity wealth. Indeed, figure 5 shows that firm values increase in real terms although with quite significant sectoral variation. In the short-run, capital stocks are predetermined and any equity revaluation is due to initial jumps in the shadow value of capital stocks. In the spirit of Tobin's  $q$ -theory of investment, the market valuation of capital must increase in the short-run (or at least decline less than in the long-run) in order to initiate capital accumulation. The early adjustment phase is characterized by a shortage of capital and, thus, relatively high rental rates which are capitalized in a high initial market value of capital. The subsequent capital deepening gradually shifts the factor price frontier towards higher wages and lower dividend returns on capital. The ensuing decline in the market value eventually eliminates all incentives for further investment. During the transition, the excessive dividend return is just offset by the capital losses on market value to give a total return on equities equal to the economy wide rate of interest. Thus, the interests of capital owners in the policy change are affected exclusively by the initial jump in the market value which capitalizes the future stream of capital income. The older an agent is, the more will her total wealth portfolio be dominated by financial assets (equity, government debt and net foreign assets), and the more will her welfare be affected by a revaluation of these assets. Figure 6 reflects the intergenerational redistribution of wealth due to equity revaluation and changes in human wealth.<sup>17</sup>

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<sup>17</sup>See also Engel and Kletzer (1990) and Eaton (1989) for a related discussion in a more stylized model. Rather obviously, much of the intergenerationally redistributive effects will depend on the type of budgetary policy that is chosen to compensate the loss in tariff revenues. See Keuschnigg and Kohler (1994b) on this issue.

Apart from changing relative prices, many policy experiments also redistribute across generations in a more or less explicit form. In order to separate efficiency from purely redistributive effects, we introduce a lump-sum redistribution agency with the sole purpose of taking from some agents and giving to others in order to have all generations participate equally in any efficiency gains or losses. For the same reasons as noted in Calvo and Obstfeld (1988) we need as many instruments as generations. The basic idea of the lump-sum redistribution agency is spelled out in Auerbach and Kotlikoff (1987) and Bovenberg (1993) [see also Keuschnigg (1994a) for a somewhat different approach that isolates the substitution effects]. We define a specific policy as intergenerationally neutral when all generations share equally in the efficiency gains or losses. An intergenerationally neutral fiscal or commercial policy package thus isolates the efficiency effects and gives a Pareto improvement or deterioration.

The lump-sum redistribution agency (LSRA) uses generation specific lump-sum taxes and transfers to control the wealth position of all generations, the currently living old as well as future new born agents. In the first period, the agency deals with all existing generations by collecting taxes or handing out transfers. In subsequent periods, it needs to tax or transfer only the new born agents. The tax is imposed at the beginning of life of new agents, or at the beginning of the remaining life-time of old agents. Hence, the aggregate transactions of the agency amount to

$$\begin{aligned} l_1 &= \sum_{a=0}^{\infty} \omega_a l_{1-a,1} \quad \text{for } t = 1, \\ l_t &= \omega_0 l_{t,t} \quad \text{for } t > 1. \end{aligned} \tag{19}$$

Payments to individuals must be multiplied by the size  $\omega_a$  of the respective cohort to weigh correctly in the macroeconomic aggregates. To shift the benefits or burden across generations, the agency may accumulate a net asset position subject to the flow constraint

$$D_t^R = \frac{1 + i_t^*}{1 + \bar{g}} D_{t-1}^R + l_t. \tag{20}$$

Welfare changes may be measured separately for each generation by the equivalent variation in life-time wealth,<sup>18</sup>  $\phi(l)$ . It depends positively on  $l$  since the transfer directly increases life-time wealth. For intergenerational neutrality, those generations with an above average gain ( $\phi > \bar{\phi}$ ) would have to pay a tax and those with a below average gain ( $\phi < \bar{\phi}$ ) would receive a transfer. This redistribution will be continued until

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<sup>18</sup>A separate appendix gives all the details and is available upon request.

all generations participate equally:  $\phi_{t,t} = \phi_{1-a,1} = \bar{\phi}$  for all future generations indexed by  $t$  and all current generations indexed by  $1 - a$ . We have to guarantee that the net present value of these operations is zero in order to avoid injecting additional debt into the economy. Furthermore, we need to respect a fundamental simultaneity: the equilibrium paths for factor incomes requires a specific transfer scheme for intergenerational neutrality, and each transfer operation disturbs the equilibrium. In an intergenerationally neutral equilibrium, of course, all generations share equally in the efficiency gain and the required transfer scheme is compatible with an intertemporal equilibrium. The efficiency gain  $\bar{\phi}$  yields an equally sized welfare effect for all agents. The transfer scheme that establishes intergenerational neutrality, may be interpreted as a measure of intergenerational incidence.

The results of the intergenerationally neutral tariff cut are documented in the last column of table 1 and in figures 6 and 7. Table 1 compares the base case with the intergenerationally neutral case and shows that the long-run welfare gains of future generations by and large coincide with the efficiency effects [see also figure 6]. Almost all of the intergenerational redistribution goes on among the currently living old and young generations and the agents born in the early transition phase. Figure 7 portrays the specific debt transfer policy needed for intergenerational neutrality. The generational transfer pattern gives a precise incidence measure that shows who gains and loses relative to the average. Moderately old generations and new generations born early in the transition phase gain the least and need to be given net transfers to establish intergenerational neutrality. The overall group of old agents are taxed with the proceeds funding a stock of assets which are subsequently decumulated to compensate new generations born in the early transition phase.

### 3.4 Does Liberalization Increase Foreign Indebtedness?

Trade theorists have traditionally addressed commercial policy under the assumption of balanced trade. After all, trade policies are geared towards changes in *temporal* price structures. One might expect that *intertemporal* trade should not be vitally affected. This is in marked contrast with the high level of attention that presumed current account effects of commercial policy enjoy in the process of policy formation. However, a number of more recent analytical studies emphasize various channels through which trade policies

may affect intertemporal trade and the long-run net foreign asset position of an economy.<sup>19</sup> Current account and foreign debt dynamics may often be pinned down unambiguously in highly stylized analytical models that single out certain effects and disregard others, but they typically become ambiguous if several effects are simultaneously considered as we do in our computational model.

The effects of trade liberalization on the net foreign asset position are best evaluated by considering the aggregate portfolio identity:  $A = \sum_j V_j + D^G + D^F$ . The amount of aggregate financial wealth results from domestic savings behavior while firm values reflect domestic investment behavior and the market valuation of capital. Except in the intergenerationally neutral scenario, our policy experiments feature a constant path of government debt. Assuming that all home equities are owned by residents, net foreign assets are residually determined to fill the gap between domestic savings and investment behavior. We first turn to the long-run results reported in table 1. Given a constant, internationally determined interest rate and stationary commodity prices, the marginal propensity to consume is not affected across steady states. Consequently, aggregate financial wealth is exclusively related to disposable wage income<sup>20</sup>  $y$ . Reflecting the change in the wage rate and the loss in government tariff revenues, the long-run effect on disposable wage income and financial wealth is rather ambiguous. They increase weakly in the base case but are reduced in other scenarios of table 1. Long-run firm values  $V = qK$  reflect a large quantity effect on capital stocks due to the expansionary effects of tariff liberalization which dominates in most cases over a negative valuation effect due to the reduction in the capital goods price. Since the boost in domestic equity value exceeds the increase in financial wealth, the net foreign asset position is weakened. In case of a low export elasticity which magnifies the terms of trade effects, firm values decline less than financial wealth giving the same conclusion. That tariff liberalization increases net foreign indebtedness is robust with respect to the sensitivity analysis performed in table 1 and is in line with the perceived wisdom in the established literature.<sup>21</sup>

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<sup>19</sup>See Razin and Svensson (1983), Matsuyama (1988), O'Rourke (1989), Sen and Turnovsky (1989), Eaton (1989), and Gavin (1991).

<sup>20</sup>A separate appendix available upon request contains the analytical details.

<sup>21</sup>In most cases, the literature considers only tariffs on consumption imports. Keuschnigg (1994c) shows that an isolated reduction in investment tariffs may increase net foreign assets. Our result is thus dominated by consumption tariffs.

Figure 9 shows the transitional effects of trade liberalization on foreign indebtedness which reflect both intertemporal substitution behavior and life-cycle type savings response. Sticky capital accumulation and the savings dynamics of the OLG household sector results in gradual changes of domestic prices that induces agents to substitute intertemporally. Furthermore, disposable wage income increases during a transitional adjustment phase to approach gradually its long-run value [see figure 8]. Hence, generations living in the early adjustment phase see their income profiles tilted towards the future relative to their desired consumption profiles and perceive strong disincentives to save. This transitory shortfall in savings is felt in an overshooting of net foreign indebtedness in figure 9. The temporary savings disincentives vanish as soon as wage profiles become flat again. At that time, foreign indebtedness is too high already. As the permanent savings incentives are reinstalled and the population is continuously replaced by new agents, aggregate savings picks up again and part of the increase in foreign indebtedness is reversed, giving a more moderate increase of foreign indebtedness in the long-run. Such transitory savings effects are specific to OLG models with long lived agents and have largely been ignored in the literature.<sup>22</sup> Furthermore, figure 9 also shows that adjustment of the net asset position may require several decades. Aggregate household sector dynamics not only reflects intertemporal optimization behavior but also demographic change. The long-run steady state is approached only after the population is completely replaced by new agents. Given realistic values for death and birth rates, demographic change takes more time than adjustment of the production sector. Note, however, the rather rapid adjustment of the net asset position in case of lower scale economies. In this case, the difference in short and long-run disposable wage income is smaller [see figure 8]. Hence, the transitory savings shortfall is less dramatic and merely serves to speed up the decline in the net asset position with only minor overshooting [see figure 9].

## 4 Conclusions

Our numerical treatment of monopolistic competition and increasing returns to scale within a fully specified growth model based on intertemporal optimization has produced a number of interesting insights. First, trade liberalization is clearly expansionary. Even

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<sup>22</sup>See, however, Keuschnigg (1994b,c) and, in a different context, Matsuyama (1987).

in the rather pessimistic scenario of unilateral tariff cuts that are not repeated abroad, the home economy experiences an investment boom as well as rising employment and output. Small export subsidies may be even self financing in a present value sense. Second, with increasing returns to scale and monopolistic competition, the expansion results in both increased product variety and rationalization of industrial production. An expanded product range is directly beneficial to consumers but also raises the average productivity of differentiated intermediates and capital goods which further magnifies the effects of trade liberalization. Cheaper capital goods reinforce the incentives for capital accumulation. Thus, a dynamic model with imperfect competition gives more expansionary effects from trade liberalization than would obtain in a more competitive environment. Third, both the variety and the scale effects also magnify the welfare effects. In the benchmark equilibrium with monopolistic competition, output is too low. Hence, any expansionary policy has the beneficial side effect of alleviating this distortion. Admittedly, however, tariff cuts are not the most direct instrument to correct this market distortion. In comparing with an intergenerationally neutral scenario, we also found that intergenerational redistribution is from the old to the currently living young generations and to future generations born in the early transition phase. Generations born in the distant future by and large reap the efficiency gains. Finally, the dynamic adjustment of the economy to its long-run equilibrium position involves heavy initial worsenings of the trade balance and an increase in foreign indebtedness in terms of imported goods. We observe rather large overshooting in the net asset position which we associate with a transitory savings shortfall. Our results highlight a simple point which practitioners of commercial policy with the usual distaste for trade deficits may not always be fully aware of: foreign indebtedness in and of itself is devoid of any welfare significance. It may simply be the result of the dynamics of welfare improving expansion of the home economy.

## Appendix

This appendix elaborates some model details that are rather incompletely presented in the main text. Moreover, it demonstrates how we have calibrated industry equilibrium with monopolistic competition.

## A Domestic Demand and Imports

Intertemporal optimization of the consumer's life time utility over a flow  $u(v)$  yields current expenditures  $p^v v$ . To take account of commodity disaggregation in consumption,  $v$  is interpreted as a bundle of goods available at a price  $p^v$ . The optimal composition of the overall consumption bundle derives from a weakly separable function  $v[C[C^1(\cdot), \dots, C^J(\cdot)], 1 - L^s]$  with linearly homogeneous and strictly quasi-concave subutility functions. This somewhat restrictive (but common) assumption is for tractability and allows to perform household optimization in separate stages. Expenditure minimization at each stage generates unit demand functions, price indices, and least cost budgets according to

$$\begin{aligned}
 (a) \quad p^v v &= P^C C + w^n (1 - L^s), \\
 (b) \quad P^C C &= P^{C,1} C^1 + \dots + P^{C,J} C^J, \\
 (c) \quad P^{C,j} C^j &= P_H^{C,j} C_H^j + P_M^{C,j} C_M^j, \\
 (d) \quad P_H^{C,j} C_H^j &= \sum_{h=1}^{n_j} p_h^{c,j} c_h^j, \quad P_M^{C,j} C_M^j = \sum_{m=1}^{n_j^*} p_m^{c,j} c_m^j.
 \end{aligned} \tag{A.1}$$

To obtain a composite commodity bundle  $C$ , for example, consumers incur a least cost budget as given in (A.1b) which is further allocated to various types of commodity baskets. Within each sector,  $C^j(C_H^j, C_M^j)$  is composed of a home and a foreign composite good, each of which is formed by a range of  $n_j$  home and  $n_j^*$  import varieties. These are identified by subindices  $h, m$ . Having solved the intraperiod allocation problem, one may interpret overall expenditures  $p^v v$  as the least cost budget necessary to obtain  $v$  units of the aggregate consumption bundle.

It may be worthwhile to be more specific on consumer demand at the sectoral level, other demand categories may then be thought of in perfect analogy. We specify a CES function to capture the trade-off between domestic and imported bundles of varieties of commodity type  $j$ ,

$$C^j = [(1 - \xi^{C,j})^{1/(1-\varepsilon_j)} (C_H^j)^{\varepsilon_j} + (\xi^{C,j})^{1/(1-\varepsilon_j)} (C_M^j)^{\varepsilon_j}]^{1/\varepsilon_j}. \tag{A.2}$$

The bottom level aggregates are composed of different varieties according to

$$C_H^j = \left[ \sum_{h=1}^{n_j} (c_h^j)^{\eta_j} \right]^{1/\eta_j}, \quad C_M^j = \left[ \sum_{m=1}^{n_j^*} (c_m^j)^{\eta_j} \right]^{1/\eta_j}. \tag{A.3}$$

We thus depart from the usual assumption of complete symmetry between home and foreign varieties. The Armington aggregate conveniently allows us to accommodate varying import shares for different categories of demand, as featured by our benchmark data set. These specifications result in demand functions

$$\begin{aligned} (a) \quad C_H^j &= (1 - \xi^{C,j})(P^{C,j}/P_H^{C,j})^{\lambda_j} C^j, & C_M^j &= \xi^{C,j}(P^{C,j}/P_M^{C,j})^{\lambda_j} C^j, \\ (b) \quad c_h^j &= (P_H^{C,j}/p_h^{c,j})^{\sigma_j} C_H^j, & c_m^j &= (P_M^{C,j}/p_m^{c,j})^{\sigma_j} C_M^j. \end{aligned} \quad (\text{A.4})$$

We generally use lower case letters to indicate variables relating to varieties. Home and import bundles are substituted according to the Armington elasticity  $\lambda_j \equiv 1/(1 - \varepsilon_j)$  while the elasticity of substitution between different varieties is  $\sigma_j \equiv 1/(1 - \eta_j)$ . The price index dual to the Armington aggregate in (A.2) is  $P^{C,j}$  whereas  $P_M^{C,j}$  and  $P_H^{C,j}$  denote the unit expenditure functions associated with the bottom level aggregates over home produced and imported varieties:

$$\begin{aligned} (a) \quad P^{C,j} &= \left[ (1 - \xi^{C,j})(P_H^{C,j})^{1-\lambda_j} + \xi^{C,j}(P_M^{C,j})^{1-\lambda_j} \right]^{1/(1-\lambda_j)}, \\ (b) \quad P_H^{C,j} &= \left[ \sum_{h=1}^{n_j} (p_h^{c,j})^{1-\sigma_j} \right]^{1/(1-\sigma_j)}, & P_M^{C,j} &= \left[ \sum_{m=1}^{n_j^*} (p_m^{c,j})^{1-\sigma_j} \right]^{1/(1-\sigma_j)}. \end{aligned} \quad (\text{A.5})$$

Here, domestic consumer prices for individual home and imported brands amount to  $p_h^{c,j}$  and  $p_m^{c,j}$ , respectively. Given that the number of alternative varieties is large, the elasticity of variety demand with respect to its own price is approximately equal to  $\sigma^j$ , see (A.4b). Each domestic variety in sector  $j$  is produced by a monopolist, and  $\sigma^j$  is herperceived demand elasticity.

In other categories of demand, the top level aggregates are determined either from industry supply decisions (intermediate inputs), from intertemporal optimization (investment demand), or from exogeneous considerations (government demand). The allocation of these bundles across different commodities and brands follows the same pattern.

## B Export Demand

Except for the top level aggregate, we model export demand in perfect analogy to consumption demand. A representative foreign agent maximizes a utility function of the form  $V = u(E) + N$ , where  $E$  is a quasi-concave subutility over all traded goods, and  $N$  is a



composite non-traded good. The foreigner's utility  $V$  is maximized subject to an income constraint  $P^E E + N \leq Y^*$ . Note that we have specified  $V$  such that all income effects are absorbed by a non-traded goods aggregate  $N$ . This, in a way, replaces the conventional small country assumption. The overall export composite  $E$  is allocated to sectoral quantities using a quasi-concave aggregator  $E = E[E^1(\cdot), \dots, E^J(\cdot)]$ . The Armington aggregate  $E^j = E^j(E_H^j, E_M^j)$  for sector  $j$  goods combines a bundle  $E_H^j$  of home produced varieties  $e_h^j$  with a bundle  $E_M^j$  of comparable brands  $e_m^j$  available on world markets. To see how export demands for domestically produced varieties are formed, one may just substitute the index  $C$  by an index  $E$  in equations (A.1) to (A.5) of the previous subsection. The only exception is that we assign a value of unity to the weights  $\xi$  and  $(1 - \xi)$  in (A.2) and (A.4a) since we don't have information on the foreigners' import shares. Finally, specifying an isoelastic top level utility  $u(E) = b^{1/\mu} E^{1-1/\mu} / (1 - 1/\mu)$ , we obtain a demand function  $E = b / (P^E)^\mu$  for the export composite.

Note that export demand involves the same Armington type separability in domestic and foreign varieties as it was assumed for domestic agents. If this Armington separability were absent, any variation in  $\sigma$  would not only change the market structure but also the strength of terms of trade effects on export demand. Our formulation allows to test the model's sensitivity w.r.t. terms of trade changes (by varying the elasticity  $\mu$ ) separately from the sensitivity w.r.t. a variation in market structure (by varying the elasticity of variety substitution  $\sigma$ ).

## C Calibration

### C.1 Production and Industry Equilibrium

We calibrate the model such that it replicates a benchmark data set for the Austrian economy as a steady state equilibrium with zero profits. Calibration of the industry equilibrium is tied to calibration of demand since the monopolistic markup of price over marginal cost depends on the elasticity of substitution of differentiated varieties in demand,  $\sigma_j$ . To obtain this elasticity, we use extraneous information on the degree of scale economies and then relate it to the monopolistic markup  $1 - 1/\sigma_j$  in order to calibrate the elasticity.

We may measure scale economies by the elasticity  $\Lambda$  of cost w.r.t. output. Write the cost function as  $C(x) = ux + c^f$  where  $u$  denotes variable unit costs and  $c^f \equiv \bar{p}\bar{f}$  represents fixed value added costs [see (19) in the main text]. Define the output elasticity of cost as  $\Lambda = \frac{x}{C} \frac{\partial C}{\partial x} = \frac{ux}{ux + c^f}$ . Furthermore, the elasticity of average cost ( $AC = u + c^f/x$ ) w.r.t. output is  $\epsilon_{ac,x} = -\frac{x}{AC} \frac{\partial(AC)}{\partial x} = c^f/(ux + c^f) = 1 - \Lambda$ . We use two sources to measure the degree of scale economies. One is the engineering estimates of cost disadvantage ratios (CDRs) for European industries which are reported by Gasiorek, Smith and Venables (1991, 1992), henceforth GSV. These are defined as the percentage increase in average costs that would follow from a 50 percent reduction in firm output,  $CDR = 0.5\epsilon_{ac,x} = 0.5(1 - \Lambda)$ . We have for sector  $j$

$$\Lambda_{j,0} = -CDR_{j,0}/0.5 + 1. \quad (\text{A.6})$$

In addition to GSV data, we use cost disadvantage ratios reported for as many as 97 3-digit Austrian industries. These are defined as the ratio between value added per worker for all firms and value added per worker for the 4 biggest firms:  $cdr = \frac{(v/l)_n}{(v/l)_4}$ . Obviously, if this ratio is smaller than unity, the four biggest firms produce more value added per worker and have lower unit cost because they produce at a larger scale. Equivalently,  $cdr < 1$  measures the cost disadvantage of an average sized firm relative to the four biggest firms. The relative difference in average costs would be  $\widehat{AC} = \frac{(l/v)_4}{(l/v)_n} - 1 = cdr - 1$ . To translate this into an estimate for the elasticity  $\Lambda$  of cost with respect to output, we need to know the size difference of the four biggest relative to the average sized firms. We resort to concentration measures  $C4 = S_4/S_n$  which give the ratio between sales of the four biggest firms and total industry sales for the same 3-digit industries.<sup>23</sup> One measures relative size difference between the four largest and the average sized firms by  $\hat{x} = \frac{S_4/4}{S_n/n} - 1 = nC4/4 - 1$ . See below for how the number of firms  $n$  is chosen. Finally, we employ the above noted elasticity  $\epsilon_{ac,x}$  to obtain the elasticity of total cost w.r.t. output,  $\Lambda = 1 - \epsilon_{ac,x} = 1 + \widehat{AC}/\hat{x}$ . Substituting the measures for cost disadvantage ratios and relative size differences, our estimate is

$$\Lambda_{j,0} = 1 + \frac{cdr_{j,0} - 1}{(nC4_{j,0})/4 - 1}. \quad (\text{A.7})$$

Aggregation from the 3-digit level to 31 sectors was carried out by means of unweighted averages, and further aggregation up to 10 sectors was performed using sectoral outputs as weights.

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<sup>23</sup>We are very grateful to Karl Aiginger and Josef Richter for generous help on the data side.

Where Austrian data do not offer any information on cost disadvantages, we resorted to GSV data. However, since Austrian data generally indicate a much lower degree of scale economies than the European estimates reported by GSV, we halved the GSV CDRs before using them in lieu of more accurate Austrian data.<sup>24</sup> The case of lower economies of scale mentioned in the tables refers to Austrian data, amended by GSV information where necessary, whereas the so-called base case refers to GSV instead of Austrian data.

Zero profits require  $px = ux + c^f$ , see (24). Note that the monopolist sets an output price equal to a fixed markup over unit costs [see (23)],  $p = u/(1 - 1/\sigma)$ . Remember also the output elasticity of cost  $\Lambda = ux/(ux + c^f)$  which is equal to the ratio of marginal over average cost. Combining these conditions, the elasticity of variety substitution in sector  $j$  is

$$\sigma_j = 1/(1 - \Lambda_{j,0}). \quad (\text{A.8})$$

A further requirement for calibration is knowledge of firm numbers. As is usual in this kind of literature, we take the number of firms from the Herfindahl measure of industry concentration. The Herfindahl index is defined as  $[\sum_{h=1}^{n_j} s_h^2]^{-1}$  where  $s_h$  is the share of sales by firm  $h$ . We choose firm numbers such that they would give rise to the observed measure of concentration in case of symmetry ( $s_h = 1/n_j$ ).

To complete calibration of the industry equilibrium, we need to set the fixed cost parameter  $\bar{f}$ . We start by calibrating steady state capital stocks and value added parameters as described in Keuschnigg and Kohler (1994a). This gives us a value added price  $\tilde{p}_0^j$ . The output price is normalized to unity,  $p_0^j = 1$ . Hence, firm output  $x_0^j$  follows from benchmark production data and firm numbers which are obtained as described above. Given a unit output price, unit costs are determined by the markup equation,  $u_0^j = 1 - 1/\sigma_j$ . An appropriate scale parameter of the production function  $x(\cdot)$  ensures that the unit cost exactly attains this value. Now we impose the zero profit condition,  $px = ux + \tilde{p}\bar{f}$  and use  $p = 1$  to obtain the fixed cost parameter  $\bar{f}_j = x_0^j(1 - u_0^j)/\tilde{p}_0^j = x_0^j/(\sigma_j\tilde{p}_0^j)$ .

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<sup>24</sup>There are cases on the 3-digit level where Austrian data actually indicate decreasing scale economies. Where this was the case, we assigned a  $\Lambda$  value of 0.99 which practically indicates constant returns to scale (associated with a very low markup).

## C.2 Domestic Demand

From calibration of the industry equilibrium, we know the elasticity of variety substitution,  $\sigma_j$ . In addition, calibration of demand parameters requires knowledge of the Armington elasticity of substitution between aggregate home and foreign varieties,  $\lambda_j$ . We use extra-neous econometric information on trade elasticities to obtain reasonable values for  $\lambda_j$ , as described in our earlier paper [Keuschnigg and Kohler (1994a)].

Our modeling of the tax system allows for a value added tax rate  $t_v$ , an excise tax rate  $t_x$ , and a tariff rate  $t_m$ . Thus, the price gross of indirect taxes that final domestic demand of category  $n \in \{C, I, G, Q\}$  has to pay for a home produced and an imported variety of commodity  $j$ , respectively, is<sup>25</sup>

$$\begin{aligned} (a) \quad p_h^{n,j} &= p_h^j (1 + t_{v,h}^{n,j} + t_{x,h}^{n,j}), \\ (b) \quad p_m^{n,j} &= p_m^j (1 + t_{v,m}^{n,j} + t_{x,m}^{n,j} + t_m^{n,j}). \end{aligned} \tag{A.9}$$

The value added tax is levied at ad-valorem rates  $t_{v,h}^{n,j}$  for home goods in sector  $j$ , as relevant for demand category  $n$  while  $t_{x,h}^{n,j}$  denotes the corresponding excise tax rate, and so forth. With producer prices normalized to unity, the indirect tax rates of our benchmark data set determine demand prices which allow us to calculate benchmark price indices  $P_{M,0}^{C,j}$  and  $P_{H,0}^{C,j}$ , given firm numbers which we derive from Herfindahl indices as explained above. Exploiting symmetry, we have  $P_{H,0}^{C,j} = n_j^{1/(1-\sigma_j)} p_{h,0}^{c,j}$ , and analogously for imports, where  $p_{h,0}^{c,j}$  is the benchmark consumer price identical for all home produced varieties. Denoting total benchmark expenditure data for sector  $j$  home goods by  $H_0^{C,j}$ , and equating this with  $P_{H,0}^{C,j} C_{H,0}^j$ , we obtain  $C_{H,0}^j = H_0^{C,j} / P_{H,0}^{C,j}$ .  $C_{M,0}^j$  is obtained by analogy. Given  $P_{H,0}^{C,j}$ ,  $P_{M,0}^{C,j}$ ,  $C_{H,0}^j$  and  $C_{M,0}^j$ , we calibrate  $\xi^{C,j}$  by taking ratios of (A.4a). Upon rearrangement,

$$\xi^{C,j} = \left[ 1 + \frac{(P_{H,0}^{C,j})^{\lambda_j} C_{H,0}^j}{(P_{M,0}^{C,j})^{\lambda_j} C_{M,0}^j} \right]^{-1}. \tag{A.10}$$

We use this to calculate a benchmark value  $P_0^{C,j}$  which, together with benchmark values for expenditures  $P^{C,j} C^j$ , then allows calibration of  $C_0^j$ . Upper level parameters are now readily obtained by standard procedures.

As opposed to our earlier model [Keuschnigg and Kohler (1994a)], the present model incorporates an identical intermediate input for all sectors which is a composite of different

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<sup>25</sup>Varieties are denoted by a subindex  $i = h, m$  while a superindex identifies demand categories.

commodities like capital. In deriving intermediate demands, we first sum up intermediate input requirements for all sectors. Knowing total demand for the composite intermediate good, we proceed to get the derived demands at the commodity and variety level.

### C.3 Export Demand

Invoking symmetry, we assign the same values to  $\sigma_j$  and  $\lambda_j$  for export demand as we do for domestic agents. We also know at this stage the number of home and imported varieties  $n_j$  and  $n_j^*$ . Normalizing benchmark producer prices to unity, we immediately obtain benchmark prices of varieties  $p_h^{e,j}$  and  $p_m^{e,j} = 1$ . Foreigners pay a price  $p_h^{e,j}$  for a domestic variety of commodity group  $j$ , including any tariff rates imposed abroad [as obtained from Deardorff and Stern (1986)] and export taxes imposed at home. The prices of comparable foreign varieties are normalized to unity. From (A.5b), we obtain price indices for the variety bundles,  $P_H^{E,j}$  and  $P_M^{E,j}$ . Consequently, (A.5a) yields a benchmark price for the sectoral Armington composite,  $P^{E,j}$ . Benchmark export data give a value for the product  $P_H^{E,j} E_H^j = n_j p_h^{e,j} e_h^j$  from which we infer benchmark quantities  $e_h^j$  and  $E_H^j$ . The demand function for the Armington aggregate results from (A.4a),  $E_H^j = (P^{E,j}/P_H^{E,j})^{\lambda_j} E^j$ , from which we infer the quantity of  $E^j$ . Consequently, we know expenditures  $\sum_j P^{E,j} E^j = P^E E$ . Assuming a Cobb Douglas top level aggregator, we easily calibrate the expenditure shares  $\epsilon_j = P^{E,j} E^j / (\sum_j P^{E,j} E^j)$ . Given the share parameter of the CD nest, we calculate the price index  $P^E$  and get a benchmark value for the quantity  $E$ . Finally, we specify a value for the elasticity  $\mu$  and calibrate parameter  $b$  of the top level demand function,  $b = E(P^E)^\mu$ .

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## Tables and Figures:

Table 1: Long-Run Effects of Tariff Liberalization

Variables, changes in %	Base	Scal.E.	Exp.E.	Fix.L.	I.Neut.
$p^v$ full price index	-0.748	-0.914	-2.257	-1.275	-0.746
$p^C$ consumption p.i.	-1.373	-1.343	-2.482	-1.275	-1.371
$p^I$ investment p.i.	-0.980	-0.977	-2.161	-0.902	-0.978
$p^Q$ intermediate p.i.	-0.983	-0.907	-2.050	-0.874	-0.980
$\bar{p}$ terms of trade	-0.465	-0.580	-1.966	-0.455	-0.463
$w$ wage rate	0.876	0.196	-1.677	0.649	0.877
$z$ gov. transfers	-1.829	-2.817	-5.139	-3.333	-1.809
$y$ disp. wage income	0.188	-0.568	-2.548	-0.789	0.194
$C$ commodity cons.	1.582	0.786	-0.068	0.491	1.588
$L^s$ labor supply	0.455	0.508	0.590	0.000	0.451
$\sum_j K^j$ capital stock	2.044	1.489	0.917	1.247	2.039
$\sum_j Q^j$ intermediate input	2.560	1.841	1.215	1.645	2.552
$\bar{n}$ number of firms	1.206	1.015	0.858	0.574	1.201
$\bar{x}$ output of firms	0.642	0.334	0.108	0.520	0.641
$SE$ scale effect	-0.094	-0.021	-0.016	-0.076	-0.094
$EV$ welfare change	0.943	0.350	-0.297	0.491	0.949
$A$ financial wealth	0.188	-0.568	-2.548	-0.789	0.225
$V$ firm values	1.062	0.506	-1.286	0.339	1.059
$D^{g,r}$ government debt	0.000	0.000	0.000	0.000	-0.099
$D^f$ net foreign assets	-0.874	-1.074	-1.262	-1.129	-0.735

(Base) Base case. (Scal.E.) Lower scale economies, cost elasticity w.r.t. firm output scaled up by factor 1.1. (Exp.E.) Lower export elasticity:  $\mu$  reduced from 10 to 2. (Fix.L.) Fixed labor supply. (I.Neut.) Inter-generational Neutrality.  $\bar{p}$ : Terms of trade, average change in domestic producer prices ( $\bar{p}, \bar{n}, \bar{x}, SE$  are weighted with sectoral outputs).  $SE$ : Average cost reduction due to increased firm outputs. Lower part of table reports changes of variables in percent of initial financial wealth.

**Table 2: Long-Run Effects of Export Subsidies**

Variables, changes in %		T.Cut	E.Subs.	R.Neut.
$s$	scaling factor	0.500	1.076	1.214
$p^v$	full price index	-0.370	2.026	1.916
$p^C$	consumption p.i.	-0.681	1.364	0.852
$p^I$	investment p.i.	-0.487	1.440	1.135
$p^Q$	intermediate p.i.	-0.488	1.243	0.910
$\bar{p}$	terms of trade	-0.231	1.974	2.002
$w$	wage rate	0.433	3.745	4.705
$z$	gov. transfers	-0.879	1.326	0.488
$y$	disp. wage income	0.099	3.119	3.620
$C$	commodity cons.	0.785	1.731	2.745
$L^s$	labor supply	0.222	0.402	0.691
$\sum_j K^j$	capital stock	1.005	2.348	3.709
$\sum_j Q^j$	intermediate input	1.256	3.151	4.897
$\bar{n}$	number of firms	0.593	1.315	2.105
$\bar{x}$	output of firms	0.317	0.882	1.324
$SE$	scale effect	-0.046	-0.128	-0.193
$EV$	welfare change	0.471	1.072	1.672
$PV(z)$	present value transfers	-1.016	1.016	-0.000
$A$	financial wealth	0.099	3.119	3.620
$V$	firm values	0.522	3.888	4.970
$D^g$	government debt	0.000	0.000	0.000
$D^f$	net foreign assets	-0.423	-0.769	-1.350

(T.Cut) Tariff cut,  $\tau_m = .5\tau_m^0$ . (E.Subs.) Export subsidy,  $\tau_e = s\tau_m^0$ . (R.Neut.) Revenue neutral combination,  $\tau_e = s\tau_m^0$ .  $\tau_m^0$ : Average initial tariff rates.  $\bar{p}$ : Terms of trade, average change in domestic producer prices ( $\bar{p}, \bar{n}, \bar{x}, SE$  are weighted with sectoral outputs).  $SE$ : Average cost reduction due to increased firm outputs. Lower part of table reports changes of variables in percent of initial financial wealth.

**Table 3: Long-Run Industrial Effects of Tariff Cuts**

**Base Case:**

Sectors	$\Lambda_j$	$\sigma_j$	$p_h^j$	$\tilde{p}^j$	$V^i$	$K^i$	$L^j$	$x^j$	$n_j$
1 Agr/For	0.879	8.267	-0.835	-0.734	0.910	1.909	0.767	0.102	1.755
2 Min/Quar	0.829	5.849	-0.399	0.507	1.376	2.379	1.433	0.909	1.619
3 Food	0.889	9.012	-0.755	0.359	0.741	1.738	0.284	1.123	0.684
4 Tex/Clot	0.899	9.904	-0.547	0.563	1.415	2.419	0.566	1.116	0.873
5 Pap/Wood	0.842	6.343	-0.593	0.387	1.773	2.780	1.153	0.986	1.576
6 Pet/Chem	0.797	4.935	-0.889	0.241	1.620	2.626	1.202	1.141	1.683
7 Met/Mach	0.826	5.761	-0.558	0.337	1.813	2.820	1.450	0.900	1.843
8 Energy	0.829	5.849	-0.544	-0.218	0.675	1.672	0.994	0.328	1.392
9 Constr	0.899	9.904	-0.403	0.167	0.257	1.249	0.642	0.572	0.872
10 Services	0.879	8.267	-0.411	0.005	1.157	2.159	0.335	0.418	1.182

**Lower Scale Economies:**

Sectors	$\Lambda_j$	$\sigma_j$	$p_h^j$	$\tilde{p}^j$	$V^i$	$K^i$	$L^j$	$x^j$	$n_j$
1 Agr/For	0.967	30.244	-0.853	-0.821	0.278	1.268	0.547	0.032	1.172
2 Min/Quar	0.912	11.355	-0.517	-0.037	1.074	2.071	1.472	0.483	1.590
3 Food	0.979	46.517	-0.716	-0.130	0.166	1.155	0.235	0.591	0.489
4 Tex/Clot	0.930	14.305	-0.630	-0.001	0.811	1.806	0.633	0.633	0.828
5 Pap/Wood	0.742	3.878	-0.757	-0.112	1.321	2.321	1.290	0.650	1.559
6 Pet/Chem	0.980	49.204	-0.733	-0.204	1.115	2.113	1.211	0.533	1.517
7 Met/Mach	0.953	21.438	-0.592	-0.144	1.275	2.274	1.408	0.451	1.657
8 Energy	0.912	11.355	-0.655	-0.495	0.226	1.215	0.787	0.161	1.039
9 Constr	0.989	90.379	-0.547	-0.252	-0.013	0.973	0.589	0.297	0.735
10 Services	0.967	30.244	-0.565	-0.353	0.530	1.522	0.368	0.213	0.905

$\Lambda_j$ : elasticity of total cost with respect to output.  $\sigma_j$ : Elasticity of variety substitution as implied by  $\Lambda_j$  (see appendix).  $p_h^j$ : Producer price of domestic variety.  $\tilde{p}^j$ : Value added price.  $V^j$ : Firm value.  $K^j$ : Sectoral capital stock.  $L^j$ : Labor demand.  $x^j$ : Firm output.  $n_j$ : Number of firms.

**Table 4: Long-Run Demand Effects of Tariff Cuts**

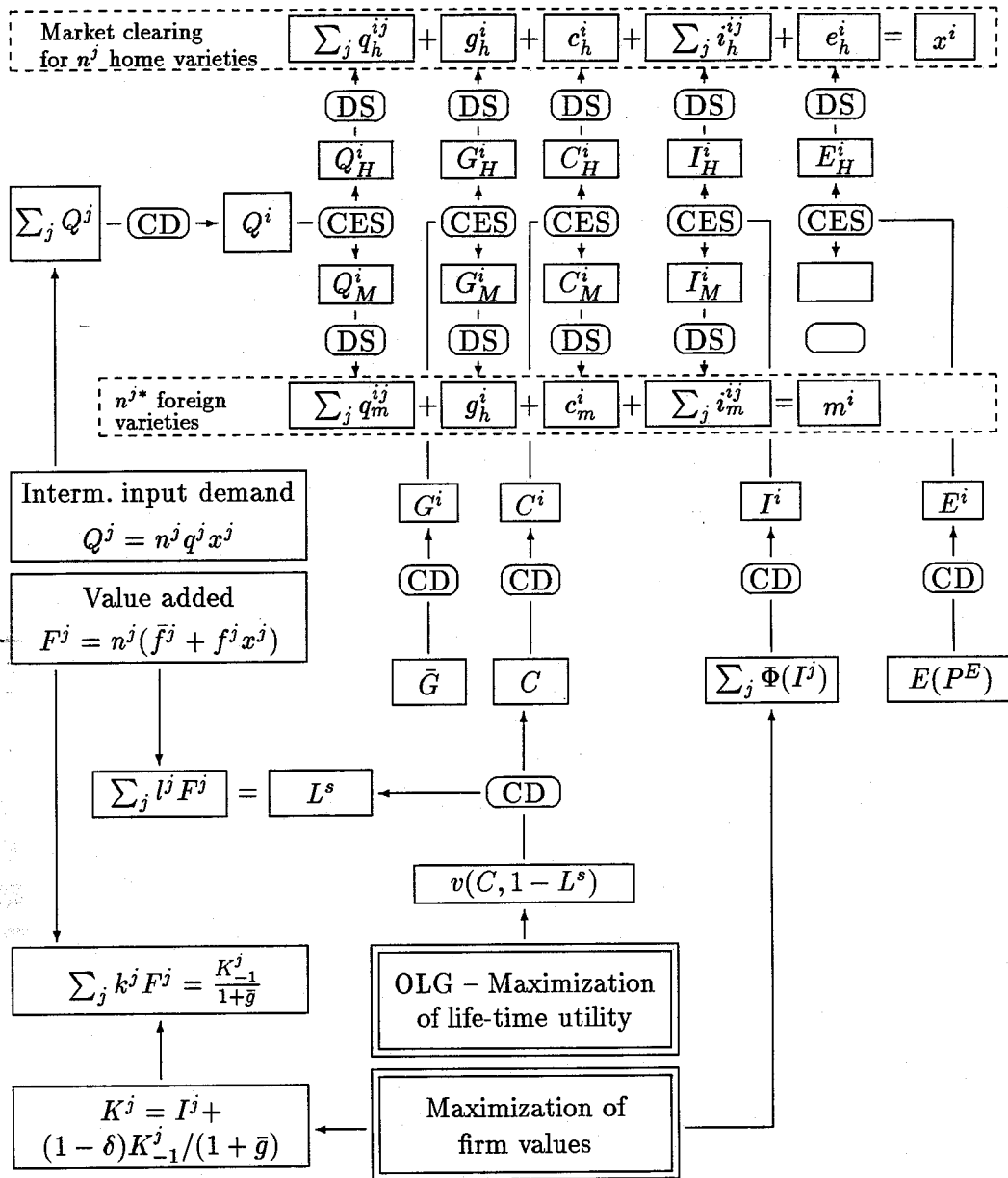
**Base Case:**

Sectors	$\tau_m^0$	$\lambda_j$	$C_H^j$	$C_M^j$	$\xi^{C,j}$	$I_H^j$	$I_M^j$	$\xi^{I,j}$	$E^j$
1 Agr/For	0.068	1.413	0.321	9.278	0.286	1.603	13.001	0.093	4.974
2 Min/Quar	0.013	0.551	2.245	5.778	0.666	1.448	0.000	0.000	4.109
3 Food	0.054	0.797	1.047	5.612	0.089	1.813	0.000	0.000	4.561
4 Tex/Clot	0.049	1.581	-0.458	7.696	0.412	1.452	10.471	0.046	4.633
5 Pap/Wood	0.030	1.500	0.444	3.176	0.411	1.610	5.825	0.028	4.720
6 Pet/Chem	0.021	1.058	1.016	5.612	0.311	1.945	7.629	0.022	4.830
7 Met/Mach	0.024	1.749	-0.036	3.456	0.572	1.016	4.010	0.516	4.835
8 Energy	0.000	0.440	0.727	0.646	0.021	1.596	0.000	0.000	4.193
9 Constr	0.000	1.100	0.593	0.000	0.000	1.453	0.000	0.000	4.305
10 Services	0.000	0.100	0.600	0.706	0.001	1.446	1.552	0.031	4.041

**Lower Scale Economies:**

Sectors	$\tau_m^0$	$\lambda_j$	$C_H^j$	$C_M^j$	$\xi^{C,j}$	$I_H^j$	$I_M^j$	$\xi^{I,j}$	$E^j$
1 Agr/For	0.068	1.413	-0.439	8.512	0.292	1.064	12.466	0.095	4.430
2 Min/Quar	0.013	0.551	1.612	4.971	0.658	1.020	0.000	0.000	3.728
3 Food	0.054	0.797	0.248	4.793	0.088	1.222	0.000	0.000	4.015
4 Tex/Clot	0.049	1.581	-1.115	6.867	0.415	0.988	9.844	0.047	4.215
5 Pap/Wood	0.030	1.500	-0.061	2.278	0.397	1.233	5.044	0.026	4.495
6 Pet/Chem	0.021	1.058	0.087	4.838	0.313	1.233	7.080	0.022	4.131
7 Met/Mach	0.024	1.749	-0.875	2.759	0.592	0.395	3.543	0.537	4.230
8 Energy	0.000	0.440	0.079	-0.154	0.020	1.159	0.000	0.000	3.809
9 Constr	0.000	1.100	-0.021	0.000	0.000	1.050	0.000	0.000	3.942
10 Services	0.000	0.100	-0.003	-0.032	0.001	1.053	1.024	0.029	3.668

$\tau_{m,j}^0$ : Average initial tariff rates.  $\lambda^j$ : Armington elasticity of substitution between home and import goods.  $\xi^{C,j}$ : Import weight for consumption.  $C_H^j$ : Consumption demand for home varieties.  $I_M^j$ : Investment demand for imported varieties.



**Figure 1: Overview of the model structure**

CD indicates Cobb Douglas aggregate, CES indicates constant elasticity of substitution aggregate (Armington), and DS indicates a Dixit Stiglitz variety aggregate with constant elasticity of substitution.

