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for small developing  
countries

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# On the static and dynamic costs of trade restrictions for small developing countries<sup>☆</sup>

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## Abstract

We analyze the costs of trade restrictions for a small developing economy (LDC). Intermediate goods invented elsewhere are only introduced on the LDC market if it is profitable to do so. The LDC economy evolves to a balanced growth path in which income, welfare, and the share of available goods increase if trade restrictions fall. The adjustment path is asymmetric: an increase in trade restrictions leads to a slow-down of economic growth, while a decrease may lead to a rapid catch-up process. The dynamic costs of trade restrictions are in general substantially larger than the static costs.

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## 1. Introduction

Developing countries are largely dependent on R&D efforts undertaken in the high income countries for access to newly developed goods and services and the availability of quality improvements for existing goods and services, see e.g. Coe et al. (1997). A few years earlier, Romer (1994) already incorporated this fact in a static model, where he argued that the costs of unexpected increases in trade restrictions are smaller than the costs of expected increases in trade

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restrictions, because the latter affect the range of goods available in the economy. In essence, if some new goods or quality improvements are *not* imported because of the high trade restrictions, this deprives consumers from the market surplus created by new goods and producers from the efficiency gains associated with new intermediate goods or better ways to organize the production process, leading to large welfare losses. Romer (1994) discusses these welfare losses, which he refers to as “Dupuit triangles” (named after a 19th century French engineer) to distinguish them from the Harberger triangles normally used to estimate welfare costs of trade restrictions.

We provide a dynamic extension of Romer (1994) in an endogenous growth setting, see Romer (1986, 1990), Grossman and Helpman (1991), and Aghion and Howitt (1992).<sup>1</sup> Using the variety approach, we analyze a small developing economy (LDC) which does not affect the equilibrium in the Rest of the World (RoW). All R&D is undertaken in RoW, which leads to the steady invention and introduction of new varieties of intermediate goods in RoW (with positive production externalities). As in Romer (1990), the providers of intermediate goods have market power and are able to charge a mark-up over marginal costs. As in Romer (1994), there is a fixed (set-up) cost that must be incurred before a newly invented variety can be introduced on the LDC market. Since these set-up costs differ between the varieties, inventors of new varieties will only incur these extra costs if they think it is worthwhile to do so, that is if the (expected) discounted operating profits for the LDC market are larger than the set-up costs for their particular variety. At any point in time, therefore, not all varieties available in RoW will also be available on the LDC market. Deriving balanced growth paths and explicit transition dynamics, the key questions we address are: (i) what determines which intermediate goods are actually introduced on the LDC market and (ii) what are the static and dynamic welfare consequences of trade restrictions.

Two implications of our model are worth emphasizing from the start. First, the estimated static costs of trade restrictions for the LDC are smaller than the dynamic costs of trade restrictions if, and only if, the increase in trade restrictions reduces the *share* of invented intermediate goods introduced on the market. In this dynamic setting it is therefore not the fact that we ignore the Dupuit triangles of newly invented goods in estimating the effects of an increase in trade restrictions, but the fact that an increase in trade restrictions affects the share of goods introduced on the LDC market. Second, as a result of the sunk-cost nature of the set-up costs, there is an asymmetric adjustment path of the LDC economy after a change in trade restrictions. An increase in the level of trade restrictions will slow-down economic growth and put the economy on a transition path to a new balanced growth rate. If the new level of trade restrictions exceeds a critical value, the new growth rate will be zero and stagnation occurs. If trade restrictions fall, on the other hand, the LDC economy may embark on a rapid catch-up process of economic growth by benefiting from the backlog of previously-invented-but-not-yet-introduced intermediate goods which may now, as a result of increased profitability, be introduced on the LDC market. Section 6 discusses some empirical evidence supporting this asymmetric adjustment path.

After providing the structure of our model (Section 2), we analyze the fraction of intermediate goods introduced on the LDC market (Section 3) and balanced growth paths (Section 4). We then analyze policy changes and (asymmetric) adjustment dynamics (Section 5), followed by a general discussion (Section 6) and some conclusions (Section 7).

## 2. The model

Our analysis focuses on a small developing economy (LDC) which at time  $t$  uses labor  $L(t)$  and a range (indexed by  $i$ ) of different types of intermediate goods  $x(i,t)$  to produce a final good  $Y(t)$ ,

<sup>1</sup> van Marrewijk (1999) provides an overview of endogenous growth.

see Eq. (1). The set of available intermediate goods at time  $t$  is denoted by  $A(t)$ . We use the term intermediate goods in a broad sense to refer to capital goods and services used in the production of final goods, see Ethier (1982) and Dixit and Stiglitz (1977). It is well-known that an increase in the number of varieties available in the economy leads to higher productivity through a positive externality effect. Since we focus on the introduction of new intermediate goods, we keep the level of employment constant.<sup>2</sup>

$$Y(t|\cdot) = L^{1-\alpha} \int_{i \in A(t)} x(i, t)^\alpha di; \quad \alpha \in (0, 1) \quad (1)$$

Our objective is to explain the level of economic development in a dynamic setting and illustrate various types of welfare costs of imposing trade restrictions or other impediments to economic interaction with the rest of the world (RoW). To do this, we have in mind a Romer (1990) or a Grossman and Helpman (1991) type endogenous growth model giving rise to an ever expanding variety of intermediate goods in RoW. Since the LDC economy is small, we make two simplifying assumptions, namely (i) the LDC economy cannot influence the economic growth rate in RoW (cf. Rutherford and Tarr, 2002) and (ii) the LDC economy does not engage in any R&D activity to develop new types of intermediate goods.

Assumption (ii) implies that the LDC depends on R&D activity in RoW for introducing new types of intermediate goods, which is in accordance with the empirical results of Coe et al. (1997) and Connolly (2003). Assumption (i), in combination with the assumption that RoW is on a positive balanced growth path, implies that the RoW growth rate of knowledge (measured by the range of invented intermediate goods  $N(t)$ ) is equal to a constant  $g > 0$ , see Eq. (2). In general, the range of intermediate goods available on the LDC market is a *subset* of the total range of invented goods (assumed to be a measurable set), see Eq. (3). Our objective is to determine the size of this subset as a function of trade restrictions and the costs of introducing the intermediate good on the LDC market.

$$N(t) = N(0)e^{gt} \equiv N_0 e^{gt}; \quad \dot{N}(t)/N(t) = g > 0; \quad \text{where } \dot{x} \equiv dx/dt \quad (2)$$

$$A(t) \subseteq [0, N(t)] \quad (3)$$

Given the range of available intermediate goods  $A(t)$ , the production function exhibits constant returns to scale in  $L$  and  $x(i, t)$ . This allows for perfect competition of final goods in the LDC economy, where the producers take the wage rate  $w(t)$  and prices  $p(i, t)$  for intermediate goods  $x(i, t)$  as given. In equilibrium, profits by the final goods producers are zero, labor's share of income will be equal to  $1 - \alpha$ , and the share of income paid for the use of intermediate goods will be equal to  $\alpha$ , see Eq. (4). Moreover, the price elasticity of demand for individual intermediate goods by final goods producers is equal to a constant  $\varepsilon > 1$ , see Eq. (5).

$$w(t)L = (1-\alpha)Y(t); \quad \int_{i \in A(t)} p(i, t)x(i, t)di = \alpha Y(t) \quad (4)$$

$$x(i, t) = \alpha^\varepsilon L p(i, t)^{-\varepsilon}; \quad \varepsilon \equiv 1/(1-\alpha) > 1 \quad (5)$$

<sup>2</sup> The notation  $t|$  signals that the income level may depend on historical developments, see below. Some restrictions of our production function are discussed in Section 6. Other things equal, the size of the economy as measured by  $L(t)$  affects discounted profits and therefore the attractiveness of introducing goods on the market. As pointed out by an anonymous referee, in our setting it is in general not the growth rate that is affected, but the share of invented goods that is introduced.

To determine the range of intermediate goods actually introduced on the LDC market, we confront the costs and benefits of introduction for the inventor of a particular intermediate good. Starting with the latter, we will assume that the monopolistic producer of an intermediate good (who has the sole property rights to selling this good) can produce one unit of the intermediate good at a constant marginal cost of 1. To enable us to investigate the dynamic effects of trade restrictions, we will assume that the LDC government requires a payment of tariff  $T$  for the import of foreign goods.<sup>3</sup> The foreign producers of intermediate goods take this tariff rate as given and assume that it will be applied indefinitely. As a result of the additively separable structure of the production function, the demand for a particular intermediate good  $i$  if it is introduced on the LDC market is stable over time, see Eq. (5). Since the price elasticity of demand is constant, the price of intermediate goods is a constant mark-up over marginal costs and does not change over time, see Eq. (6). Obviously, an increase in the tariff rate leads to a higher price charged for the use of intermediate goods and thus a lower quantity demanded, see Eq. (7). As a result of the above, instantaneous operating profits  $\pi$  for the providers of intermediate goods on the LDC market are constant over time, see Eq. (8). This means that the present value of operating profits of an intermediate good introduced on the LDC market at time  $t$  and discounted at the interest rate  $\rho > 0$  is equal to the instantaneous operating profits divided by the interest rate, see Eq. (9).<sup>4</sup>

$$p(i, t) = (1 + T)/\alpha \equiv p(T); \quad p'(T) = 1/\alpha > 0 \quad (6)$$

$$x(i, t) = \alpha^{2\varepsilon} L(1 + T)^{-\varepsilon} \equiv x(T); \quad x'(T) = -\varepsilon x(T)/(1 + T) < 0 \quad (7)$$

$$\begin{aligned} \pi(T) &\equiv p(T)x(T) - (1 + T)x(T) = (1 - \alpha)\alpha^{2\varepsilon-1}L(1 + T)^{1-\varepsilon} \\ \pi'(T) &= -(\varepsilon - 1)\pi(T)/(1 + T) < 0 \end{aligned} \quad (8)$$

$$\int_t^\infty e^{-\rho(\tau-t)} \pi(T) d\tau = \pi(T)/\rho \quad (9)$$

Before the owner of intermediate good  $i$  invented at time  $t$  can reap the benefits of discounted operating profits from the LDC market she has to incur fixed set-up costs  $c(i, t)$ . This can be the cost of setting up a service and parts supply network or the costs of setting up a local branch consulting office, etc. We assume these set-up costs may vary for the individual producers of intermediate goods from a minimum of  $a$  to a maximum of  $b$ . More specifically, we will assume that these costs are drawn independently from a cumulative distribution function  $F$ , without mass points and with support  $[a, b]$  (where  $0 < a < b$ ), see Eq. (10). The decision on whether or not to introduce a newly invented intermediate good on the LDC market is now simple. The answer is yes if the discounted value of operating profits is larger than the set-up costs. Otherwise, the

<sup>3</sup> Equivalently, the domestic government could impose a tax on goods produced by foreign companies.

<sup>4</sup> Note that we assume that the interest rate is equal to the discount rate, which holds as an equilibrium condition with logarithmic preferences in RoW if households can borrow and lend on a frictionless credit market, see Grossman and Helpman (1991, pp 27–29, 1995, p. 1311).

answer is no, see the indicator function  $I(i,t)$  in Eqs. (11) and (3'). Note that the net profits derived from introducing a variety on the LDC market depend only on the tariff and the set-up cost for that particular variety.

$$c(i,t) \text{ iid with cdf } F(x); x \in X = [a, b], F(a) = 0, F(b) = 1, \tag{10}$$

$$I(i,t) = \begin{cases} 1, & \text{if } \pi(T)/\rho > c(i,t) \\ 0, & \text{otherwise} \end{cases} \tag{11}$$

$$A(t) = \{i \in [0, N(t)] | I(i, \cdot) = 1\} \tag{3'}$$

### 3. The range of introduced intermediate goods

We are now able to determine the range of intermediate goods introduced on the LDC market relative to the range of goods in RoW as a function of the trade restrictions  $T$ . At each point in time, the growth rate of intermediate goods in RoW is  $g$ , implying that  $gN(t)$  new goods become available for introduction on the LDC market. If the discounted value of operating profits  $\pi(T)/\rho$  is smaller than the minimum set-up cost  $a$ , it is clear that no new intermediate goods will be introduced on the LDC market. Similarly, if the discounted value of operating profits is higher than the maximum set-up cost  $b$ , all new intermediate goods will be introduced on the LDC market. The more interesting case occurs, therefore, if the discounted value of operating profits is in between these two extremes, that is  $[\pi(T)/\rho] \in (a,b)$ . Since the set-up costs are drawn independently from the same distribution function, the law of large numbers ensures that a stable fraction ( $\beta$ , say) of the newly invented intermediate goods will be introduced on the LDC market, such that  $\beta gN(t)$  new intermediate goods will be available in the LDC economy.

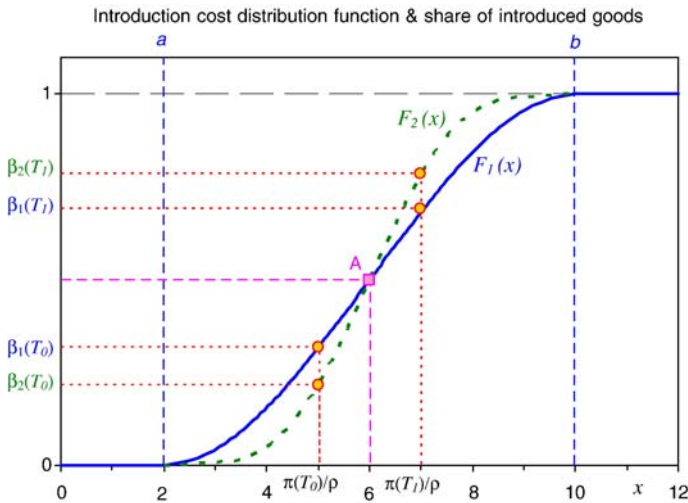


Fig. 1. Distribution function  $F$  and share of introduced goods  $\beta$ . The illustrated cdf is a beta distribution with support  $[2,10]$  and parameters equal to 2 (curve labelled 'F1') and equal to 5 (curve labelled 'F2'), a mean preserving reduction in the variation of the set-up costs.

Fig. 1 illustrates how the fraction  $\beta$  of intermediate goods on the LDC market depends on the trade restrictions  $T$  as a function of the operating profits  $\pi$  and the discount rate  $\rho$  for two distribution functions with common support, where  $F_2$  represents a mean preserving reduction in the variation of the set-up costs relative to  $F_1$ . Suppose the tariff is  $T_0$ , leading to discounted operating profits  $\pi(T_0)/\rho$ . Given enough observations, a fraction  $F_1(\pi(T_0)/\rho)$  of the randomly drawn set-up costs will be below the discounted operating profit threshold  $\pi(T_0)/\rho$ . All these intermediate goods will be introduced on the market. Similarly, a fraction  $1 - F_1(\pi(T_0)/\rho)$  will be above the discounted operating profit threshold  $\pi(T_0)/\rho$ . All these intermediate goods will not be introduced on the market. If the trade restriction falls, say to  $T_1 < T_0$ , the discounted operating profit threshold will rise to  $\pi(T_1)/\rho$  and a larger share of newly invented intermediate goods  $F_1(\pi(T_1)/\rho)$  will be available on the LDC market, see Fig. 1. The figure also illustrates how a reduction in the variation of set-up costs leads to a more rapid increase in the share of goods on the LDC market for a given reduction in  $T$  (since  $\beta_2(T_1) - \beta_2(T_0) > \beta_1(T_1) - \beta_1(T_0)$ ). Note, however, that the share itself may be either higher or lower (since  $\beta_2(T_1) > \beta_1(T_1)$  and  $\beta_2(T_0) < \beta_1(T_0)$ , see Section 5). For a given distribution function  $F$ , the share of intermediate goods introduced on the LDC market is equal to:

$$\beta(T) \equiv \begin{cases} 0, & \text{if } 0 < \pi(T)/\rho < a; & \beta' = 0 \\ F(\pi(T)/\rho), & \text{if } a \leq \pi(T)/\rho \leq b; & \beta' = F' \pi' / \rho < 0 \\ 1, & \text{if } b < \pi(T)/\rho < \infty; & \beta' = 0 \end{cases} \quad (12)$$

The crucial point is, of course, that the range of intermediate goods available on the LDC market depends negatively on the trade restrictions  $T$ , which allows us to investigate both dynamic and static welfare costs in the analysis below. An increase in the level of trade restrictions implies (i) a higher price charged for the use of intermediate goods, (ii) a lower quantity of intermediate goods used, and (iii) lower operating profits for the producers of intermediate goods. For trade restrictions in between two critical values determined by the minimum and maximum set-up costs (the support limits  $a$  and  $b$  of the distribution function), the lower operating profits will lead to a strict fall in the share of goods introduced on the LDC market. For ease of reference we will call these critical values  $T_{\text{upper}}$  and  $T_{\text{lower}}$ , defined as:

- $T_{\text{upper}} \equiv \pi^{-1}(\rho a)$ ;  $T \geq T_{\text{upper}} \Rightarrow \beta(T) = 0$
- $T_{\text{lower}} = \begin{cases} 0, & \text{if } \pi(0)/\rho < 1 \\ \pi^{-1}(\rho b), & \text{otherwise} \end{cases}$ ;  $0 \leq T \leq T_{\text{lower}} \Rightarrow \beta(T) = 1$

#### 4. Balanced growth and welfare

This section focuses on LDC welfare under the assumption that the same trade policy has been operative indefinitely. We therefore assume that the same fraction of intermediate goods as dictated by the function  $\beta(T)$  of Eq. (12) has also been introduced at time 0. The next section analyzes transitory dynamics if government policy is changed. Under the simplifying assumption above, the share of intermediate goods on the LDC market is constant over time; i.e. if  $M(\cdot)$  is the measure of firms, it follows that:

$$M(A(t)) = \beta(T)N(t); \beta(T) > 0 \Rightarrow \dot{M}(A(t))/M(A(t)) = \dot{N}(t)/N(t) = g \quad (13)$$

The growth rate of available intermediate goods in the LDC economy is therefore equal to the growth rate  $g$  in RoW for all time periods. This allows us to determine the level of output and government revenue as a function of the level of trade restrictions, see Appendix A. Since the use

of intermediate goods  $x$  is a declining function of  $T$  and the share of intermediate goods available on the LDC market is a non-increasing function of  $T$ , the output level is a decreasing function of the level of trade restrictions.<sup>5</sup> Instantaneous welfare  $W$  for the LDC is the sum of government revenue and labor income. As explained in Appendix A and summarized in Proposition I, it is a strictly declining function of the level of trade restrictions:  $W'(T) < 0$ . Since total welfare is just the discounted value of instantaneous welfare, the optimal LDC policy is to impose no trade restrictions at all, leading to total welfare  $W(0)/(\rho - g)$ . In this section, which ignores transition dynamics, the increase in available varieties (equal to the growth rate of the economy) is dictated by progress in RoW (equal to  $g$ ). The next section demonstrates not only that the LDC economy evolves over time to the balanced growth path, but also that the change in the LDC growth rate and the level of income can be substantial if we allow for changes in government policy and incorporate transition dynamics.

**Proposition I.** *The LDC balanced growth path is given in Eqs. (A1)–(A3). Income, welfare, and the share of introduced intermediate goods all increase if the level of trade restrictions falls.*

## 5. Policy changes and transition dynamics

A crucial aspect of our model is the sunk cost nature of the set-up costs. This implies that once a good has been introduced on the LDC market it will continue to be supplied independently of subsequent changes in the level of trade restrictions. The income level is therefore path-dependent (hysteresis) and the economic response to changes in government policy is asymmetric, see [van Marrewijk and Berden \(2004\)](#) for further details on this section.

### 5.1. Policy change experiment

Suppose the government of the developing country imposes a tariff level  $T_0$  from time 0 to time  $t_1$ . We assume that (i) within this time frame it is *expected* that this tariff level will be maintained indefinitely, (ii) a positive fraction of newly invented goods is introduced on the LDC market ( $0 \leq T_0 < T_{\text{upper}}$ ), and (iii) the LDC economy is initially on a balanced growth path ( $M(A(0)) = \beta(T_0) N_0 \equiv M_0$ ). At time  $t_1$ , as the measure of active firms is  $M(A(t_1)) \equiv M_1$ , the LDC government unexpectedly changes its policy to a tariff level  $T_1$ . We furthermore assume that (iv) the LDC government henceforth maintains  $T_1$  indefinitely, which (v) is immediately expected from time  $t_1$  onwards. The notation  $|t_1^+$  indicates a rise in the level of trade restrictions ( $T_1 > T_0$ ) and the notation  $|t_1^-$  indicates a fall ( $T_1 < T_0$ ).

### 5.2. An increase in trade restrictions

We distinguish between two groups of intermediate goods producers, which together give rise to the measure of active firms given in Eq. (14).

- The first group consists of all intermediate goods producers who entered the LDC market *before* the policy change at time period  $t_1$ . Since the set-up costs are sunk costs, they will remain active despite the policy change. Consequently, some of these producers will *ex post*

<sup>5</sup> There is a strictly positive level of trade restrictions,  $T_{G-\text{max}} \in (0, T_{\text{upper}})$  say, which maximizes the present discounted value of government revenue. Myopic government revenue maximization (given the measure of active firms) leads to  $T_{\text{myopic}} = 1/(\varepsilon - 1)$ , larger than  $T_{G-\text{max}}$  due to the term  $\beta'/\beta$  in Eq. (A2).

conclude that they have made the wrong decision as the discounted value of operating profits turns out to be lower than the set-up costs.

- The second group consists of all intermediate goods producers who may enter the LDC market *after* the policy change at time period  $t_1$ . They know their instantaneous profits are  $\pi(T_1)$  and will enter the market if the discounted profits are higher than the set-up costs. A fraction  $\beta(T_1)$  will enter the market from time period  $t_1$  onwards, see Eq. (14). Income and government revenue are given in Appendix B, as summarized in Proposition II.

$$M(A(t)|t_1^+) = \begin{cases} M_0 e^{gt}, & \text{if } t \in [0, t_1) \\ \beta(T_1) e^{gt} N_0 + [\beta(T_0) - \beta(T_1)] e^{gt_1} N_0, & \text{if } t \in [t_1, \infty) \end{cases} \quad (14)$$

**Proposition II.** *After an increase in the level of trade restrictions in accordance with the policy change experiment, the economy adjusts over time to a new balanced growth path. The transition dynamics are given in Eqs. (14), (A4), and (A5).*

### 5.3. Static and dynamic costs of an increase in trade restrictions

The main economic implications for the LDC are illustrated in Fig. 2. At the time of the policy change there is an immediate reduction in the income level (indicated by the arrow in the figure), not because the number of intermediate goods available on the LDC market changes instantaneously, but because the higher price reduces demand and the income level. We label this the *static* costs of increasing trade restrictions and measure it as the percentage reduction in income at time  $t_1$ . (This is the same as calculating the fall in discounted income under the *assumption* that the measure of active firms grows at the constant rate  $g$  after the policy change.) Note that, at time  $t_1$  of the policy change, our static costs are equal to Romer’s (1994, p. 33) *unexpected/unanticipated* costs of trade restrictions. After the policy change, the LDC economy adjusts over time to a new asymptotic balanced growth path dictated by the new level of trade restrictions  $T_1$ . The economic growth rate falls at  $t_1$  and increases gradually thereafter until the old growth rate  $g$  is reached asymptotically. We measure the *dynamic* costs of an increase in trade restrictions as the percentage reduction in the discounted value of income relative to its value without the policy change. These costs are not the same as Romer’s (1994, p. 34) *expected/anticipated* costs of trade restrictions, which at the time of the policy

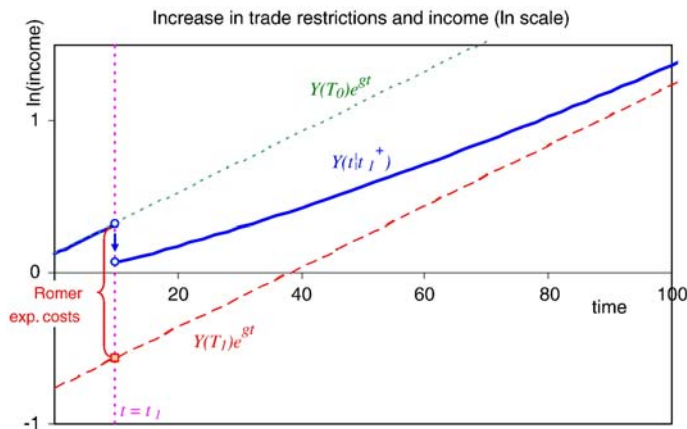


Fig. 2. Dynamic effects of an increase in trade restrictions. Parameter values:  $\alpha=0.8$ ;  $L=60$ ;  $\rho=0.05$ ;  $g=0.02$ ;  $t_1=10$ ;  $T_0=0.5$ ;  $T_1=0.6$ , combined with a beta distribution function with support  $[2,10]$  and parameters equal to 2.

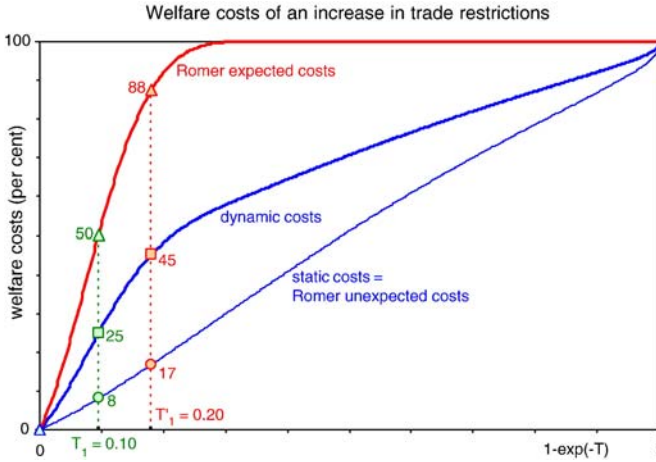


Fig. 3. Welfare costs of an increase in trade restrictions: an example. Parameter values:  $\alpha=0.7$ ;  $L=15$ ;  $\rho=0.05$ ;  $g=0.02$ ;  $T_0=0$ ; beta cdf, parameters 4, support [5,14].

change  $t_1$  would indicate by how much income falls relative to policy  $T_0$  if the policy change to  $T_1$  had been fully anticipated, which is equal to the difference in balanced growth paths at time  $t_1$ , see Fig. 2. Note that we assumed that the policy change was unexpected at time  $t_1$ , giving us the following relationships between the costs:<sup>6</sup>

$$\text{static costs} = \text{Romer's unexpected costs} \leq \text{dynamic costs} \leq \text{Romer's expected costs} \tag{15}$$

Fig. 3 illustrates the static, dynamic, and Romer’s expected costs in terms of welfare loss, starting from free trade ( $T_0=0$ ) and depicted in a compact space (for  $1 - e^{-T}$ , which ranges from 0 to 1 as  $T$  increases).<sup>7</sup> Most importantly, we note that the dynamic costs are in general substantially larger than the static costs. A tariff level of 10% leads to an 8% fall in static welfare and a substantially larger 25% fall in dynamic welfare. Romer’s fully anticipated expected welfare costs are as high as 50%. An increase of the tariff level to 20% leads to a static welfare loss of 17%, a dynamic welfare loss of 45%, and a Romer expected cost of 88%.

5.4. Reducing trade restrictions: Asymmetry in adjustment

The results discussed above on the effects of an increase in trade restrictions would hold in reverse for a decrease in trade restrictions, that is lead to an increase in income and welfare gains mimicking the discussion above, if we assume that intermediate goods producers can only enter the LDC market at the moment the new intermediate good is invented. This, however, is a too restrictive assumption. The crucial difference between an increase and a decrease in the level

<sup>6</sup> Also note that if the policy change was already anticipated  $t$  periods prior to its implementation (‘partial anticipation’), there would be an adjustment path of the economy starting at  $t_1 - t$  with associated higher ‘partially-anticipated dynamic costs’. The dynamic costs discussed in the paper and illustrated in Fig. 3 provide the lower bound for such ‘partially-anticipated dynamic costs’, while Romer’s expected costs provide the upper bound. Both are therefore useful benchmarks for the likely true range of dynamic costs.

<sup>7</sup> See Appendix A for the difference between income costs and welfare costs.

of trade restrictions is that intermediate goods producers will not exit the LDC market once they entered it if restrictions increase (as operating profits are always positive), but may decide to enter the LDC market if they earlier opted not to do so if restrictions decrease. This asymmetry has implications for the adjustment path of the economy, as the LDC economy immediately jumps to a new balanced growth path if trade restrictions are decreased, see Eq. (14'), Appendix B, and Proposition III.

$$M(A(t)|t_1^-) = \begin{cases} \beta(T_0)N_0e^{gt}, & \text{if } t \in [0, t_1) \\ \beta(T_1)N_0e^{gt}, & \text{if } t \in [t_1, \infty) \end{cases} \quad (14')$$

**Proposition III.** *After a decrease in the level of trade restrictions in accordance with the policy change experiment, the economy immediately jumps to a new balanced growth path, as summarized by Eqs. (14'), (A4'), and (A5').*

## 6. Discussion

We extended Romer's (1994) argument on the importance of endogenously determining the number of varieties available on the LDC market for a proper understanding of the potentially devastating consequences of imposing trade restrictions, to a simple dynamic setting which allowed us to derive balanced growth paths and explicit transition dynamics. The (short-run) static costs of trade restrictions take the number of varieties as given, whereas the (long-run) dynamic costs take the endogenous determination of future access to successful R&D projects

Table 1  
Welfare costs of increase in trade restrictions (per cent reduction in welfare)

Initial tariff: $T_0=0.10$	$T_1=0.10$			$T_1=0.20$		
	Welfare costs			Welfare costs		
	Static	Dynamic	Romer expected	Static	Dynamic	Romer expected
Default setting	8.1	24.9	50.3	16.9	45.2	87.7
<i>Share of intermediate goods and elasticity parameter <math>\alpha</math>; default <math>\alpha=0.7</math></i>						
$\alpha=0.6$	6.2	6.2	6.3	12.5	14.7	18.0
$\alpha=0.8$	11.8	47.0	99.9	26.1	55.6	100
<i>Rate of time preference; default <math>\rho=0.05</math></i>						
$\rho=0.04$	8.1	10.5	12.9	16.9	35.2	53.6
$\rho=0.06$	8.1	30.3	74.8	16.9	43.8	97.6
<i>Rate of innovation; default <math>g=0.02</math></i>						
$g=0.01$	8.1	16.5	50.3	16.9	31.0	87.7
$g=0.03$	8.1	33.4	50.3	16.9	59.4	87.7
<i>Minimum set-up costs; default <math>a=5</math></i>						
$a=4$	8.1	21.2	40.9	16.9	41.4	78.3
$a=6$	8.1	29.7	62.3	16.9	48.3	95.6
<i>Maximum set-up costs; default <math>b=14</math></i>						
$b=13$	8.1	20.8	40.0	16.9	43.5	83.4
$b=15$	8.1	27.7	57.2	16.9	46.2	90.3

Default parameters: see Fig. 3.

undertaken elsewhere into due consideration. As illustrated in Figs. 2 and 3 and in Table 1 for some alternative parameter settings, the dynamic costs of trade restrictions can be substantial in our model even for tariff rates of 10–20% and are generally much larger than the static costs of trade restrictions. Table 1 also illustrates that the static costs do not vary with the rate of time preference, the rate of innovation, and the minimum or maximum set-up costs, whereas the dynamic costs increase if the set-up costs rise (implying that a smaller range of varieties is introduced on the LDC market) or if the rate of innovation rises. As usual in this kind of setting, the impact of an increase in the rate of time preference is ambivalent as the higher long-run future welfare loss may be offset by the higher preference for consuming today. The most important parameters for determining the dynamic costs are the rate of innovation  $g$  and the parameter  $\alpha$ . Interpreting changes in the latter is complicated, however, in view of its dual role in our model.<sup>8</sup>

In modeling the intermediate goods market while making sure that not all firms are active on the LDC market we have two options.<sup>9</sup> First, intermediate goods can be homogenous, in which case the number of active firms must negatively affect profits of each firm to ensure that entry decreases profitability among importers of intermediate goods. The problem is that, once the imported quantity is sufficiently high, profits fall to zero and there is no growth in imports. Second, intermediate goods can be heterogeneous and parameters are chosen such that variety has no direct effect on the profitability of importing intermediate goods. This is the case if the elasticity of substitution is equal to the inverse of the share of labor ( $\varepsilon = 1/(1-\alpha)$ , see Appendix C). The disadvantage of this approach is that the parameter  $\alpha$  serves two roles, namely as the cost share of intermediate goods and as a parameter determining the elasticity of substitution between varieties. The advantage of this approach is that variety does not affect the profitability of individual importers, which yields the nice result that net profits derived from introducing a variety on the LDC market depend only on the tariff and the set-up cost for that particular variety. Within the heterogeneous goods approach there are, finally, two more options: (i) heterogeneity can be at the level of the cost of introducing goods to new markets, or (ii) goods may be heterogeneous in quality, cost, or demand. We analyze option (i) in this paper, but as shown by Klenow and Rodriguez-Clare (1997) the welfare effects tend to be larger under option (i) than under option (ii) because of the larger Dupuit triangles at the (extensive) margin.

Our model predicts an asymmetric adjustment process, with a potentially more rapid increase in GDP growth after a decrease in trade restrictions than the decrease in GDP growth after an increase in trade restrictions. To test this implication of the model we combined Sachs and Warner's (1995) trade openness indicators with the Maddison (2003) per capita GDP data. Sachs and Warner classify a country as closed or open based on tariff rates, non tariff barriers, a black market exchange rate, a state monopoly on major exports, and a socialist economic system. The emphasis in this work is on trade liberalization, as it is in Wacziarg and Welch's (2003) update, who conclude (p. 3): "the effects of increased policy openness within countries through time are positive, economically large, and statistically significant." Using a similar, within-country-through-time analysis, we are equally interested in the opposite movement from an open to a closed trading system. Maddison (2003) provides GDP per capita data (measured in 1990 international Geary-Khamis dollars) for the period 1950–2001. We analyze the time trend of ln

<sup>8</sup> See below and Appendix C. Also note that for  $\alpha=0.6$  and  $T_1=0.10$  there is no deviation between the static and dynamic welfare costs in Table 1. Indeed, if  $T_1 < T_{\text{lower}}$  all intermediate goods are available on the LDC market. This theoretical possibility is probably of little practical importance, since usually only a (small) fraction of all intermediate varieties is available on the LDC market and an increase in trade restrictions immediately leads to a deviation between static and dynamic welfare costs.

<sup>9</sup> We are grateful to an anonymous referee for providing the structure and arguments of this paragraph.

Table 2

Asymmetric trade policy adjustment; time trend of  $\ln(\text{income per capita})$ , 1950–2001

	From open to closed <sup>a</sup>	From closed to open <sup>b</sup>
Number of observations	15	32
Average time trend 10 years before policy change plus year of policy change	0.0191	0.0053
Average time trend 10 years after policy change plus year of policy change	0.0162	0.0233
Average change in time trend	−.0030	0.0179
Standard error of change in time trend	0.0076	0.0036

Source: calculations based on [Sachs and Warner \(1995\)](#) and [Maddison \(2003\)](#).

<sup>a</sup> Sri Lanka (1957), Venezuela (1960), El Salvador (1961), Nicaragua (1961), Costa Rica (1962), Guatemala (1962), Honduras (1962), Morocco (1965), Syria (1966), Kenya (1968), Peru (1968), Jamaica (1974), Bolivia (1979), Ecuador (1984), Sri Lanka (1984).

<sup>b</sup> Japan (1962), Taiwan (1964), South Korea (1969), Indonesia (1971), Chile (1976), Sri Lanka (1978), Botswana (1979), Morocco (1985), Bolivia (1986), Columbia (1986), Gambia (1986), Ghana (1986), Costa Rica (1987), Guinea (1987), Guinea-Bissau (1987), Mexico (1987), Uganda (1988), Guatemala (1989), Philippines (1989), Tunisia (1989), Benin (1990), El Salvador (1990), Jamaica (1990), Paraguay (1990), Turkey (1990), Venezuela (1990), Argentina (1991), Brazil (1991), Hungary (1991), Mali (1991), Poland (1991), and Uruguay (1991).

(GDP/cap) for the year of the policy change and the 10 years before and after the policy change separately for all developing countries going through a regime change as indicated by Sachs and Warner for which these data are available, see [Table 2](#). There are 15 developing countries going from an open to a closed trade regime. The average *decrease* in the time trend of the rate of growth was 0.3% per year. There are 32 developing countries going from a closed to an open trade regime. The average *increase* in the time trend of the rate of growth was 1.79% per year. This increase is statistically significant at the 10% level, as is the difference between the decrease following a rise in trade restrictions and the increase following a decline in trade restrictions, thus providing support for an asymmetric adjustment process.

In line with our theoretical approach, [Klenow and Rodriguez-Clare \(1997\)](#) argue that Costa Rica's 1986–1991 trade liberalization was accompanied by a surge in import variety, where a 1% larger market is associated with about 0.2% more varieties and a 1% lower tariff with an increase in variety of about 0.5%. Similarly, [Haveman et al. \(2003\)](#) analyze the effect of tariffs and non-tariff barriers (NTBs) on international trade flows and argue that higher multilateral tariffs tend to shift trade towards larger exporters, which indicates that the desire to minimize on the fixed (set-up) costs of trade flows is empirically important. In our approach the benefits of trade are reflected in increases in total factor productivity. [Pavcnik \(2002\)](#) analyzes the effect of trade liberalization on plant productivity in the case of Chile. Her estimates suggest the existence of increasing returns to scale in all sectors and show that productivity of plants in the import-competing sectors grew 3 to 10% more than in the non-traded goods sectors. In line with our asymmetry argument she also notes the importance of commitment and expectations by arguing that (p. 264):<sup>10</sup> “plants might not instantaneously react to an implementation in a change in trade policy...[but only]... after they were convinced of the government's lasting commitment.”

## 7. Conclusion

We analyze the static and dynamic costs of a change in trade restrictions for a small developing economy (LDC) which combines labor and intermediate goods in its final goods production process. The LDC economy depends on successful R&D projects undertaken elsewhere (RoW)

<sup>10</sup> [van Marrewijk and Berden \(2004\)](#) provide a brief discussion of expectations in this model.

and introduced on the LDC market for an increase in the range of available intermediate goods. A new intermediate good is only introduced on the LDC market if the (expected) discounted value of operating profits is larger than the set-up costs. Since operating profits decline as the level of trade restrictions rises, the share of intermediate goods introduced on the LDC market also declines as the level of trade restrictions rises.

The developing economy evolves over time to a balanced growth path. As a result of the sunk-cost nature of the set-up costs, there is an asymmetric adjustment path for the LDC economy after a change in trade restrictions. An increase in the level of trade restrictions will slow-down economic growth and put the LDC economy on a transition path to the new balanced growth rate. If the new level of trade restrictions exceeds a critical value, the new growth rate will be zero and stagnation occurs. During this process the dynamic costs of a rise in trade restrictions are generally much larger than the static costs as a result of the fall in the share of new goods introduced on the LDC market. If trade restrictions fall, on the other hand, the LDC economy may embark on a rapid catch-up process of economic growth by benefiting from the backlog of previously-invented-but-not-yet-introduced intermediate goods which may now, as a result of the increase in operating profits, be introduced on the LDC market. This is also discussed, for example, in Romer (2007), who notes: “After independence, India’s commitment to closing itself off and striving for self-sufficiency was as strong as Taiwan’s commitment to acquiring foreign ideas and participating fully in world markets. The outcomes – grinding poverty in India and opulence in Taiwan – could hardly be more disparate.” In general, our model predicts that a decline in prosperity following increases in trade restrictions is more gradual than the possible increases in prosperity following reductions in trade restrictions. We provide some empirical support for this implication.

## Appendix A. Balanced growth

Using Eqs. (7), (12), and (13) gives Eq. (A1). Government revenue  $G$  is given in Eq. (A2). Instantaneous welfare  $W$  for the small developing economy is the sum of government revenue and labor income, see Eq. (A3), where the first inequality follows from ignoring some negative terms, after which we use sequentially  $(1-\alpha)\varepsilon=1$ , the fact that  $\beta N_0$  is equal to the measure of active firms at time 0 together with the second part of Eqs. (4), (6), and (7), and again the optimal pricing rule (Eq. (6)).

$$\begin{aligned} Y(t|T) &= L^{1-\alpha}M(A(t))x(T)^\alpha = L^{1-\alpha}x(T)^\alpha\beta(T)N_0e^{gt} \equiv Y(T)e^{gt} \\ Y'(T) &= [(\beta'/\beta)-\alpha\varepsilon/(1+T)]Y(T)<0 \end{aligned} \quad (A1)$$

$$\begin{aligned} G(t|T) &= M(A(t))Tx(T) = \beta(T)Tx(T)N_0e^{gt} \equiv G(T)e^{gt} \\ G'(T) &= \beta x N_0 + [(\beta'/\beta)-\varepsilon/(1+T)]G(T); \quad G(0) = G(T_{\text{upper}}) = 0; \quad G'(0)>0 \end{aligned} \quad (A2)$$

$$\begin{aligned} W(t|T) &= G(t|T) + (1-\alpha)Y(t|T) = [G(T) + (1-\alpha)Y(T)]e^{gt} \equiv W(T)e^{gt} \\ W'(T) &= \beta x N_0 + (\beta'/\beta)W(T) - \varepsilon G(T)/(1+T) - \alpha\varepsilon(1-\alpha)Y(T)/(1+T) < \\ &< \beta x N_0 - \alpha\varepsilon(1-\alpha)Y(T)/(1+T) = \beta x N_0 - \alpha Y(T)/(1+T) = \\ &= xM(A(0)) - pxM(A(0))/(1+T) = xM(A(0))[1-1/\alpha]<0 \end{aligned} \quad (A3)$$

## Appendix B. Policy change dynamics

Using Eq. (14) for an increase in trade restrictions gives:

$$Y(t|t_1^+) = \begin{cases} Y(T_0)e^{gt}, & \text{if } t \in [0, t_1) \\ L^{1-\alpha}x(T_1)^\alpha M(A(t)|t_1^+), & \text{if } t \in [t_1, \infty) \end{cases} \quad (\text{A4})$$

$$G(t|t_1^+) = \begin{cases} G(T_0)e^{gt}, & \text{if } t \in [0, t_1) \\ T_1x(T_1)M(A(t)|t_1^+), & \text{if } t \in [t_1, \infty) \end{cases} \quad (\text{A5})$$

Similarly, using Eq. (14') for a decrease in trade restrictions, we get:

$$Y(t|t_1^-) = \begin{cases} Y(T_0)e^{gt}, & \text{if } t \in [0, t_1) \\ Y(T_1)e^{gt}, & \text{if } t \in [t_1, \infty) \end{cases} \quad (\text{A4}')$$

$$G(t|t_1^-) = \begin{cases} G(T_0)e^{gt}, & \text{if } t \in [0, t_1) \\ G(T_1)e^{gt}, & \text{if } t \in [t_1, \infty) \end{cases} \quad (\text{A5}')$$

## Appendix C. Elasticity of substitution and share of intermediate goods<sup>11</sup>

Suppose the production function is given by Eq. (A6), where  $\alpha$  is the cost share of intermediate goods and  $\gamma$  determines the elasticity of substitution between varieties (equal to  $\varepsilon \equiv 1/(1-\gamma)$ ). The demand for an individual variety is then governed by Eq. (A7). If  $x(i)=x$  for all  $i$ , then  $X=n^{1/\gamma}x$ . With  $x$  fixed, then  $x(i)$  is independent of  $n$  if and only if  $\alpha=\gamma$ .

$$Y = L^{1-\alpha}X^\alpha; \quad X = \left( \int_0^n x(i)^\gamma di \right)^{1/\gamma}; \quad \alpha, \gamma \in (0, 1) \quad (\text{A6})$$

$$\frac{dY}{dx(i)} = \alpha L^{(1-\alpha)} X^{\alpha-\gamma} x(i)^{\gamma-1} \quad (\text{A7})$$

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<sup>11</sup> We are grateful to an anonymous referee for simplifying this appendix.

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