Can Comparative Advantage Explain the Growth of US Trade?\(^1\)

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Final draft: December 3rd, 2005

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\(^1\)We are grateful to Óscar Afonso, Don Davis, Tim Kehoe, Morten Ravn, Matt Slaughter, Tony Venables, Jaume Ventura, David Weinstein, Kei-Mu Yi and two anonymous referees for valuable discussions; seminar participants at Århus, Bocconi, Cambridge, University College Dublin, Essex, Geneva, LSE, Mainz, the New York Fed, Nottingham, SED 2003, Southampton, Toulouse, Vigo, and SPIE 2004 for helpful comments; and Kwok-Tong Soo for superb research assistance. We gratefully acknowledge research funding from CICYT (SEC 2002-0026) and Università Bocconi. All errors remain ours.
Abstract

We present a dynamic comparative advantage model in which moderate reductions in import tariffs can generate sizable increases in trade volumes over time. A fall in tariffs has two effects. First, for given factor endowments, it raises the degree of specialization, leading to a larger volume of trade in the short run. Second, it raises the factor price of each country’s abundant factor, leading to diverging paths of relative factor endowments and a rising degree of specialization. A simulation exercise shows that a fall in tariffs produces a disproportional increase in the trade share of output as in the data.

Keywords: International Trade, Heckscher-Ohlin, Dynamic Macroeconomics.

JEL codes: E13, F11, F43.
1 Introduction

One of the most remarkable economic phenomena of the last 40 years is the large increase of the world’s trade volume. International economists tend to agree about lower import tariffs being the natural explanation to this fact, since the second half of the 20th century has been a period of worldwide trade liberalization. Figure 1 illustrates this idea by plotting the time paths of the world’s average import tariff and the US GDP share of its trade volume with non-OPEC countries for the period 1960-1997.\(^1\) While the former has fallen by almost a 50% (from 0.16 to 0.09), the latter has almost trebled (from 0.06 to 0.18). Econometric evidence by Baier and Bergstrand [2] also supports the idea that the reduction of tariffs is by far the most important contributor to the rise of the trade share in GDP.\(^2\)

On the theoretical side, however, linking the fall of import tariffs to the rise of world trade does not seem to be such a trivial exercise. As Yi [50] points out, any attempt to explain the growth of the world trade on the basis of falling trade barriers with any of the standard trade models available in the literature (comparative advantage, increasing returns, Armington assumption) is challenged by the magnitudes of these variables. Generating a three-fold increase in the volume of trade relative to GDP with just a 7 percentage-point fall of the average tariff requires unrealistically high elasticities of substitution between goods.\(^3\) Besides, the relationship between import tariffs and trade volume is far from being linear, as the standard models would suggest. Figure 2 plots the US trade share in GDP against

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\(^1\)The world’s average import tariff is based on tariffs (i.e. import duties over imports) from 35 countries, both developed and developing. See Clemens and Williamson [9]. We are grateful to Jeff Williamson for kindly sharing these data. Data on volumes of trade come from the IMF’s DOTS database.

\(^2\)“New trade” theory links increased similarity of countries’ incomes to higher trade shares (see Helpman [22]), but the empirical evidence in Baier and Bergstrand [2] and Hummels and Levinsohn [26] does not seem to lend strong support to this view. Bergoeing and Kehoe [3] calibrate a “new trade” theory model in the spirit of Helpman and Krugman [23] and Markusen [33], obtaining mixed results about the ability of the model to match the impressive growth of intra-OECD trade in the second half of the 20th century.

\(^3\)Yi [50] calculates that standard trade models need an elasticity of above 10 or 13 for observed tariff reductions to generate an increase of the trade share in GDP proportional to what we see in the data. Estimated and calibrated elasticities are usually between 2 and 3.
the world’s average tariff. Notice the increase in the volume of trade from the mid-70s to the early 90s despite the approximately constant tariff over the same period. Alternative explanations to the growth of world trade have not been entirely successful at accounting for the increasing trade volume. Yi [50], for example, explains these puzzles on the basis of vertical specialization only occurring after trade costs have reached a critical value. However, as Yi himself acknowledges, his calibration exercise cannot account for an important share of the observed increase in world trade.

This paper goes back to comparative advantage to address these issues. We profit from an obvious yet important consideration that has been ignored so far in this context, namely that both trade liberalization and the growth of trade have got a time dimension. We produce a model based on standard workhorses in the areas of international trade (the Heckscher-Ohlin model) and economic growth (the Ramsey model). We argue that a disproportional increase in the volume of trade in the face of a moderate reduction in trade barriers over time is quite a natural fact once one allows for a dynamic response on the factor accumulation side, even when elasticities of substitution are low.

In a nutshell, the argument goes as follows: a fall in trade barriers has two effects on the volume of trade. First, for given relative factor endowments, it raises the degree of specialization of countries, leading to a larger volume of trade in the short run. Second, in a Stolper-Samuelson-like manner, it raises (lowers) the factor price of each country’s abundant (scarce) production factor, leading to diverging paths of relative factor endowments across countries and a rising degree of specialization over time. This creates an additional effect on the future volume of trade that adds to the static and dynamic effects of future reductions in trade barriers. From a qualitative point of view, the observed sequence of reductions in trade barriers over time brings about a disproportional response of the trade share in GDP. From a quantitative perspective, the dynamic response of the export share in GDP to trade
liberalization when we allow for factor accumulation is three times larger than in
the static trade model.

Our assumption that specialization is driven by cross-country differences in rel-
ative factor endowments is motivated by the empirical evidence: a recent stream of
research has highlighted the relevance of factor endowments for specialization and
trade. See, among other references, Davis and Weinstein [12], [13], [14], Romalis
[43], and Schott [44]. Notably, Davis and Weinstein [13] show that, against pop-
ular belief, factor endowments are quantitatively important even for North-North
trade. At the same time, this does not rule out other reasons for trade, such as
technological differences, increasing returns, or vertical specialization. Any of these
elements could be combined with our stylized Heckscher-Ohlin model to provide a
more realistic view of international trade.

In fact, some of these elements may add to the mechanism we highlight, since
our theory rests on the more general principle that an increase in specialization may
reinforce the factors that lead countries to specialize initially. In our case, this is
achieved through the combination of factor price divergence in response to trade
liberalization (a feature of the Heckscher-Ohlin model) and factor accumulation as
a function of factor prices (i.e., the Ramsey model), which leads to the divergence of
factor endowment ratios.\footnote{The association of trade liberalization with factor price divergence in the context of Heckscher-
Ohlin model might surprise those who associate it with factor price equalization. To be precise, in
our model countries have the same initial return to capital (determined in the steady state by the
rate of time preference), but different productivity levels, which lead to a higher capital-labor ratio
in the more productive country. As in the standard Heckscher-Ohlin model’s comparison between
autarky and free trade, trade liberalization does reward each country’s abundant factor; but in
our case this leads to factor-price divergence, as the return to capital increases (decreases) in the
capital abundant (labor abundant) country.} A Ricardian model with learning-by-doing driven tech-
nical progress as in Lucas [30], for example, is likely to generate dynamic responses to
trade liberalization qualitatively similar to the ones our model produces. In this case,
specialization would enhance technical progress in the exporting industries, hence
reinforcing comparative advantage and the incentives to trade relative to import
tariffs.
A sketch of the Heckscher-Ohlin model with many goods and trade costs that we use can be found in Mundell [37]; Dornbusch et al. [17] provide an elegant formalization of the continuum of goods; Romalis [43] introduces trade costs into the model. The combination of the neoclassical growth and Heckscher-Ohlin models has got a long history in economic theory: Findlay [18], Oniki and Uzawa [39], and Stiglitz [46], for example, are classics in this literature. Some recent references comparing neoclassical growth under autarky and free trade are Ventura [48], Atkeson and Kehoe [1] and Cuñat and Maffezzoli [11]. In comparison with these models, we depart from the rather unrealistic autarky/free trade dichotomy by introducing a trade friction that can change over time. This key feature enables us to uncover some new insights on the effects of trade integration when the latter takes place over a long time span.

In more general terms, this paper adds to the literature that explores the role of trade frictions in determining patterns of trade. The role of FDI in explaining the link between trade and trade barriers, for example, has been studied by Horstman and Makusen [25], Brainard [5], [6], Markusen and Venables [34], and Helpman, Melitz and Yeaple [24]. The interaction between trade barriers and increasing returns has also yielded a large literature; e.g., see Fujita, Krugman and Venables [19] and references therein. Finally, our paper is also related to a growing literature that studies how the presence of trade frictions influences a number of macroeconomic issues, either on the nominal or the real side. See, for example, Obstfeld and Rogoff [38] and Ravn and Mazzenga [40].

The rest of the paper is structured as follows: Section 2 presents our analytical setup, which is used in Section 3 to analyze the link between trade integration and relative factor endowment divergence, and the effects of the fall of trade costs over time on the export share in GDP. Section 4 concludes.
2  The Model\(^5\)

This section presents the dynamic trade model we use for studying the long-run effects of trade liberalization and technical change. The dynamic component is a standard Ramsey model, into which we integrate a Heckscher-Ohlin comparative advantage framework.

2.1 Consumption and Capital Accumulation

Assume the world has two countries, the United States and the rest of the world, denoted by \( j = A, W \), respectively. Each country is populated by a continuum of identical and infinitely lived households, each of measure zero, that can be aggregated into a single country-level representative household. There are two internationally immobile factors, capital \( K \) and labor \( L \). For simplicity, we assume that the labor endowment does not respond to changes in factor prices. Each country produces a nontraded final good, which is used for both consumption \( C \) and investment \( I \). The representative households’ preferences over consumption streams can be summarized by the following intertemporal utility function:\(^6\)

\[
U_{jt} = \sum_{s=t}^{\infty} \beta^{s-t} C_{js}^{1-\frac{1}{\sigma}} - 1
\]

where \( \beta \) is the subjective intertemporal discount factor and \( \mu \) the elasticity of intertemporal substitution. The representative households maximize equation (1) subject to the following intratemporal budget constraint

\[
P_{jt} (C_{jt} + I_{jt}) = w_{jt} L_{jt} + r_{jt} K_{jt} + T_{jt},
\]

\(^5\)A detailed Technical Appendix is available from the authors upon request.
\(^6\)In general, we denote aggregate variables with capital letters.
where \( P \) is the price of the final good, \( r \) and \( w \) are factor prices, and \( T \) denotes government transfers, to be discussed below. Factor prices are taken as given by the representative household. The capital stocks evolve according to the following accumulation equation:

\[
K_{jt+1} = (1 - \delta) K_{jt} + I_{jt}.
\]

The first order conditions

\[
\beta C_{jt+1}^{-\frac{1}{\alpha}} \left( \frac{T_{jt+1}}{P_{jt+1}} + 1 - \delta \right) = C_{jt}^{-\frac{1}{\alpha}},
\]

\[
K_{jt+1} = \frac{w_{jt}}{P_{jt}} L_j + \left( \frac{r_{jt}}{P_{jt}} + 1 - \delta \right) K_{jt} + \frac{T_{jt}}{P_{jt}} - C_{jt},
\]

and the usual transversality conditions are necessary and sufficient for the representative household’s problem. A recursive competitive equilibrium for this economy is characterized by equations (4)-(5) and the equations that characterize the static trade equilibrium.

### 2.2 Static Trade Equilibrium

Assume all markets are competitive. The final good is produced with a continuum of intermediates \( z \in [0, 1] \), with the following Cobb-Douglas production function:

\[
Y_j = \kappa \exp \left[ \int_0^1 \ln x_j (z) \, dz \right],
\]

where \( x_j (z) \) denotes the quantity of intermediate good \( z \) used in the production of the final good \( Y_j \) in country \( j \), and \( \kappa \) is a positive constant.\(^7\) Demand for intermediate goods is given by \( x_j (z) = \frac{P_j Y_j}{p_j (z)} \), where \( P_j \) is the aggregate price index

\[
P_j = \kappa^{-1} \exp \left[ \int_0^1 \ln p_j (z) \, dz \right].
\]

\(^7\)\( \kappa \) is just used for normalization purposes and plays no major role in the model.
Intermediate goods are produced using capital and labor with the following Cobb-Douglas technologies:

$$y_j(z) = \phi_j k_j(z)^z l_j(z)^{1-z},$$  

(8)

where $y_j(z)$ denotes the quantity of intermediate good $z$ produced in country $j$; $\phi_j$ denotes country-specific factor efficiency levels; $k_j(z)$ and $l_j(z)$ denote, respectively, the capital and labor allocated to the production of intermediate good $z$ in country $j$. Capital-labor intensities are increasing in $z$. Technologies are identical across countries, but for the exogenous factor augmenting coefficients $\phi_j$. The assumption of unitary elasticities is meant to show how our model’s dynamic dimension can lead to large long-run trade volumes even when we ‘cripple’ the static model’s ability to do so.\footnote{Given our “Cobb-Douglas” specification, the factor efficiency levels $\phi_j$ can be interpreted as Hicks-neutral technology parameters assumed to be equal across sectors. We favor an alternative interpretation, inspired by Treffer \cite{47}, which considers $\phi_j$ as the efficiency level of capital and labour in each country. In contrast with Treffer, though, and for the sake of simplicity, we assume this efficiency level to be the same for both factors.}

In contrast with the final good, intermediate goods can be traded. Trade in intermediates, however, is not frictionless: we assume that governments levy an \textit{ad valorem} tariff $m > 0$ on imports. The tariff is assumed to be equal across goods and countries. We assume that governments transfer tariff revenue $T$ to domestic consumers in a lump-sum fashion.

Let us assume $K_A/L_A > K_W/L_W$, so that country $A$ has a comparative advantage in capital-intensive goods. In general, the model’s equilibrium is characterized by a range of very capital-intensive goods and a range of very labor-intensive goods produced exclusively by country $A$ and the rest of the world, respectively; a range of nontraded goods produced by both countries; and factor prices such that $w_A/r_A > w_W/r_W$. We choose $p_W(0) = 1$ as the numeraire. Given $\phi_j$, $K_j$, $L_j$, and $\tau \equiv 1 + m$, the unknowns of the model are $w_j$, $r_j$, $P_j$, and $z_j$. The two cut-off values $z_A$, $z_W$, $0 \leq z_A < z_W \leq 1$, divide the range $[0, 1]$ in the three ranges mentioned

\footnote{The assumption that each sector’s capital share equals its index ($\alpha(z) = z$) is admittedly strong, but very helpful to solve the model.}
above (see Figure 3):

1. For \( z \in [0, z_A) \), \( z \) is produced exclusively by the rest of the world, and exported to country \( A \). Therefore \( p_A(z) = \tau p_W(z) \), and \( p_W(z) = \phi_W^{-1} Z(z) r^{-z}_W w_1^{1-z} \), where \( Z(z) = z^{1-z} (1 - z)^{z-1} \). Market clearing implies \( y_A(z) = 0 \), and \( p_W(z) y_W(z) = \frac{p_A Y_A}{\tau} + P_W Y_W \).

2. For \( z \in [z_A, z_W] \), \( z \) is produced in both countries, and nontraded. Therefore \( p_j(z) = \phi_j^{-1} Z(z) r_j^{1-z} \). Market clearing implies \( p_j(z) y_j(z) = P_j Y_j \).

3. For \( z \in (z_W, 1] \), \( z \) is produced exclusively by the country \( A \), and exported to the rest of the world. Therefore \( p_A(z) = \phi_A^{-1} Z(z) r_A^{1-z} \), and \( p_W(z) = \tau p_A(z) \). Market clearing implies \( p_A(z) y_A(z) = P_A Y_A + \frac{p_W Y_W}{\tau} \), and \( y_W(z) = 0 \).

We can solve for the unknowns from the definition of \( P_j \) and the following system of equations:\(^{10}\)

1. Factor market clearing conditions:

\[
\int_0^1 \frac{\partial p_j(z)}{\partial w} y_j(z) \, dz = L_j, \quad (9)
\]

\[
\int_0^1 \frac{\partial p_j(z)}{\partial r} y_j(z) \, dz = K_j. \quad (10)
\]

2. Marginal commodity conditions:

\[
\phi_j^{-1} Z(z_j) r_j^{1-z} w_j^{1-z} = \tau z_j^{1-z} \phi_j^{-1} Z(z_j) r_j^{1-z} w_j^{1-z}. \quad (11)
\]

Given factor prices, the marginal commodity conditions imply there is a range of commodities that are not worth shipping from one country to another despite comparative advantage. This is due to the price wedge the trade cost introduces between countries.

\(^{10}\)By Walras Law, one of these conditions is redundant.
3. Numeraire:

\[ p_W(0) = 1 = \phi_W^{-1} w_W. \]  

(12)

If \((K_A/L_A) / (K_W/L_W)\) is ‘too small’ relative to \(\tau\), countries will not trade and the equilibrium will be like under autarky, with \(z_A = 0\) and \(z_W = 1\). In this case, from the factor and good market clearing conditions,

\[ \frac{w_j^a}{r_j^a} = \frac{K_j}{L_j}, \]  

where the index \(a\) distinguishes autarky equilibrium prices from trade equilibrium prices. For the autarky equilibrium to be sustainable, it must be true that at autarky prices transport costs make it pointless to ship goods across countries. That is, the marginal commodity conditions implied by equation (11) must not hold for \(z \in (0, 1)\):

\[ \phi_W^{-1} r_W^a \leq \tau \phi_A^{-1} r_A^a, \]  

(14)

\[ \phi_A^{-1} w_A^a \leq \tau \phi_W^{-1} w_W^a. \]  

(15)

Thus, if \((w_A^a/r_A^a) / (w_W^a/r_W^a) = (K_A/L_A) / (K_W/L_W) \leq \tau^2\), autarky will take place. If, on the other hand, \((K_A/L_A) / (K_W/L_W) > \tau^2\), autarky will not be sustainable and countries will trade.

2.3 Steady State

Under the assumption that countries trade, we can combine the marginal commodity conditions with the expressions for the price levels to obtain, after some tedious manipulation,

\[ \frac{r_A/P_A}{r_W/P_W} = \frac{\phi_A}{\phi_W} \frac{\frac{z_A^2 - z_W^2 + 2(z_W - 1)}{z_W - z_A}}{\frac{z_A^2 - z_W^2 + 2(z_W - 1)}{z_W - z_A}}. \]  

(16)

It is easy to see that \(\frac{z_A^2 - z_W^2 + 2(z_W - 1)}{z_W - z_A} < 0\). Thus, for \(K_A/L_A > K_W/L_W\) and \(\phi_A = \phi_W\), \(r_A/P_A < r_W/P_W\). Given the assumption that \(\beta\) and \(\delta\) are equal across countries,
the steady state is characterized by the same interest rate for both of them: \( r_j/P_j = r/P \equiv \frac{1}{\beta} - 1 + \delta \). Hence, the model cannot yield a steady state in which countries trade, if technologies are identical across countries. Since we want to depart from the autarky-vs-free trade thought experiment, let us impose enough structure so as to have an initial steady state with some trade. Assume \( \phi_A > \phi_W \).\(^{11}\) Then \( r_A/P_A = r_W/P_W \) if

\[
\phi_W \frac{z^2_A - z^2_W + 2(z_W-1)}{z^2_W z^2_A} = \phi_A. \quad (17)
\]

Thus, provided \( \phi_A > \phi_W \), we may find a steady state in which countries trade.\(^{12}\) The system of equilibrium equations and the condition \( r_A/P_A = r_W/P_W \) can be solved numerically for \( K_A, K_W, z_A, \) and \( z_W \). A similar procedure enables us to solve for the \( \phi_j \)'s that generate a particular steady-state distribution of capital stocks such that \( K_A/L_A > \tau^2 K_W/L_W \).

### 2.4 Solution Procedure

The recursive structure of our problem guarantees that the solution can be represented as a couple of time-invariant policy functions expressing the optimal level of consumption in each country as a function of the two state variables, \( K_A \) and \( K_W \). These policy functions have to satisfy the following functional equations:

\[
\beta C_j (K_A', K_W')^{-\frac{1}{\beta}} (r_j'/P_j' + 1 - \delta) = C_j (K_A, K_W)^{-\frac{1}{\beta}}, \quad (18)
\]

\(^{11}\)A large literature on cross-country comparison of TFP levels, summarized in Caselli [7], provides empirical evidence that supporting the existence of international differences in TFP levels.

\(^{12}\)Note that we introduce cross-country differences in TFP levels only to guarantee the existence of international trade in steady state: the actual trade flows are generated by the induced differences in relative factor endowments. Hence, if TFP levels were equal across countries, trade could nonetheless emerge during converge towards the steady state. There are other ways to generate different steady-state capital-labor ratios. E.g., one can assume that the investment good may have a different price relative to the consumption good across countries. In terms of the intratemporal budget constraint,

\[
P_{jt} (C_{jt} + \gamma_j I_{jt}) = w_{jt} L_{jt} + r_{jt} K_{jt},
\]

where \( \gamma > 0 \). Cross-country differences in \( \gamma \) may be justified in terms of taxation, institutions, etc. Another possibility is to assume differences in discount factors, as in Stiglitz [46].
where $K'_j = [(w_j/P_j) L_j + (1 - \delta + r_j/P_j) K_j + T_j/P_j - C_j (K_A, K_W)]. w_j/P_j, r_j/P_j$
and $T_j/P_j$ are obtained by numerically solving the appropriate equilibrium conditions.\footnote{It is easy to show that tariff revenue is given by $T_A = \frac{\tau}{2} z_A P_A Y_A$ and $T_W = \frac{\tau}{2} (1 - z_W) P_W Y_W$.} The policy functions must generate stationary time series in order to satisfy the transversality conditions. To solve equation (18) numerically, we apply the Orthogonal Collocation projection method described in Judd \[27\].

We choose parameter values that yield an initial steady state in which country $A$’s trade share in GDP and the import tariff $m$ approximate, respectively, the US trade share (0.06) and the world average import tariff (0.17). Following Cooley and Prescott \[10\], we set $\mu = 1$, $\beta = 0.96$ and $\delta = 0.048$ - standard values in the quantitative macroeconomics literature which implicitly assume that the unit time period is a year. We assume $L_A + L_W = 2$. We choose $\kappa = 0.15$, which implies an autarky steady-state world capital stock $\bar{K} = 2$ when $\phi_j = 1$. We fix $\tau_0 = 1.17$ and numerically solve for the $\phi_j$’s that yield a trade share in GDP equal to 0.06 for country $A$. The resulting coefficients are $\phi_A = 1.09$ and $\phi_W = 0.93$, which imply $\bar{K}_A + \bar{K}_W = 2$, and $(\bar{K}_A/L_A) / (\bar{K}_W/L_W) = 1.88 > \tau_0^2$. (We choose a symmetric situation such that $\bar{K}_A = L_W$ and $\bar{K}_W = L_A$.)

3 Results

3.1 Trade Liberalization and Factor Accumulation

To study the effects of a reduction in trade barriers, we assume the world is in the steady state described above, and let $\tau$ fall to $\tau_1 = 1.16$ suddenly and permanently. Figure 4 displays the time paths of real per-capita income, consumption, investment, and capital for both countries, as percentage deviations from the original steady state. (The first ten years correspond to the original steady state.) On impact, income per capita increases by 0.03 percentage points for country $A$ and by 0.04
points in the rest of the world.\footnote{The static effect is so small that it cannot be read off Figure 4.} This effect is due to the static gains from trade integration, which reduces the price wedge between countries. Countries can now exploit their comparative advantages better for given factor endowments. That is, both countries find it optimal to reduce the range of goods they produce and exchange a wider range of commodities. This enables both of them to “consume” more intermediate goods and thus produce more of the final good.

The static effect is quite small in comparison with the long-run effect, since the dynamics leads to a remarkable process of long-run divergence in capital-labor ratios. To understand the mechanics of the exercise, let us look at the time path of factor prices in terms of the final good in Figure 5. Notice that right after the fall in $\tau$ interest rates diverge, rising in country $A$ and falling in the rest of the world. This raises the incentive to delay consumption and accumulate capital in country $A$, whereas the opposite happens in the rest of the world. This is what causes the initial upward (downward) jump of investment, and the initial downward (upward) jump of consumption in country $A$ (the rest of the world).\footnote{The cross-country interest rate differential is very small, (never greater than 0.08 percentage points): the presence of moderate transaction costs might therefore be enough to prevent international capital flows.}

Why do interest rates change in different directions after a fall in $\tau$? Country $A$ ceases to produce the most labor-intensive goods it used to produce, since they become cheaper to import from the rest of the world. This implies capital and labor need to be reallocated from labor-intensive towards capital-intensive goods. In this case, full employment requires the use of lower capital-labor intensities, which imply a higher marginal productivity of capital, and thus a higher $r_A$. A symmetric argument leads to a lower $r_W$. Figure 6 shows that the range of non-traded goods shrinks immediately after the fall in $\tau$: $z_W$ falls, \textit{i.e.} country $W$ ceases to produce its most capital-intensive goods, and $z_A$ rises, \textit{i.e.} country $A$ stops producing its most labor-intensive goods.\footnote{Kehoe and Ruhl [32] show that actual episodes of trade liberalizations increased trade along both the intensive (more trade in the same goods) and the extensive margins (trade in new goods).} Notice that both countries’ shares of trade in income,
\[ V_A = 2z_A / \tau \] and \[ V_W = 2(1 - z_W) / \tau, \] increase.

The different reaction of interest rates implies that investment increases in country \( A \) and decreases in country \( W \). Country \( A \) (the rest of the world) raises (reduces) its capital-labor ratio and drives the interest rate back to its steady-state level over time. This leads to an increasing difference in their capital-labor ratios, and reinforces their respective patterns of comparative advantage, reducing the range of nontraded goods even more, and raising the share of trade in GDP. In fact, the dynamic response of the two countries’ trade volumes is much larger than the static one. For example, 50 years after the fall in \( \tau \), the increase in the trade share is more than double as large as the short-run (static) increase.

It is worth noting that both countries gain from trade integration in terms of welfare. A comparison of their utility levels with and without the fall in the import tariff shows that both countries achieve a higher level of utility in the new scenario. Although the long-run income per capita level of the rest of the world falls, the fact that it can attain a higher level of consumption in the first periods after the change in \( \tau \) compensates for the discounted long-run losses in consumption.\(^{17} \) On the other hand, country \( A \) experiences an initial fall in consumption, but is more than compensated by the discounted future gains.

In the model, divergence in factor endowment ratios is accompanied by income per capita divergence, which seems to be at odds with recent empirical evidence on the effects of trade liberalization on economic growth by Dollar and Kraay [15].\(^{18} \) Two remarks are opportune here. First, trade liberalization generates income convergence in the short run (on impact) due to the countries’ different sizes: the static gains from trade liberalization are larger in the smaller country, which experiences

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\(^{17}\) This empirical evidence is in line with our model’s predictions.

\(^{18}\) Interpreting the model in a loose way, trade liberalization redistributes from future to current ‘generations’ in the labor abundant country.

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One can even find empirical papers that claim a negative relationship between trade liberalization and income convergence, such as Slaughter [45].
larger changes in prices. Second, the result on long-run income and consumption divergence depends crucially on the assumption that one of the two factors is not accumulable. A similar model with two accumulable factors (say two types of capital) would predict diverging relative factor endowments and growing volumes of trade over time, but not necessarily cross-country income per capita divergence. Trade liberalization would produce a factor price differential in favor of each country’s relatively abundant factor. Within each country, therefore, investment would be reallocated towards the abundant factor, exacerbating cross-country relative factor endowment differences. Whether such a model predicts income convergence or divergence depends, among other things, on the relative sizes of countries (which affects the response of factor prices to trade liberalization) and the relative costs of the two types of investment goods.

### 3.2 A Fall in Import Tariffs over Time

Yi [50] argues that the growth of the trade share in GDP is hard to explain by standard trade models on the basis of falling trade barriers, since these have not decreased that much over the same time period. The discussion in the previous section suggests that a large increase in the volume of trade in the face of a protracted reduction in trade barriers is quite a natural fact once one takes into account the dynamic response on the factor accumulation side. In our model, a fall in trade costs raises the volume of trade immediately, but also leads to diverging paths of relative factor endowments through its effect on factor prices. This creates an additional effect on the future volume of trade, that adds to the static effect of subsequent reductions in trade barriers.

We perform a simulation exercise with our dynamic trade model to illustrate this argument. We feed the time path of the world average import tariff into our model, and compare the predicted time paths for country A’s trade share in GDP with that of the US. For this purpose, however, we first have to decide whether the fall in the
trade cost over time is unexpected or anticipated. This is a matter of relevance, given that permanent changes in the trade cost lead to changes in steady states. We assume that trade liberalization is a decision about the future path of $\tau$, which is made at time $0$ and is known by economic agents. The process that determines the time path of $\tau$ after trade liberalization is agreed is assumed to be

$$\tau_{t+1} = (1 - \theta) \bar{\tau} + \theta \tau_t + e_{t+1}, \quad (19)$$

where $\bar{\tau}$ denotes the long-run value for $\tau$, and $e$ is an error term.\(^{19}\) Given the observed time path for $\tau$, we use nonlinear least squares to estimate $\theta$ ($\hat{\theta} = 0.96$) and $\bar{\tau}$ ($\bar{\tau} = 1.08$). The model fits remarkably well: all coefficients are highly significant.\(^{20}\) These estimates and equation (19) enable us to obtain the “expected” time path $\hat{\tau}$. Any differences between the expected and observed time paths are treated as unexpected changes in the trade cost.\(^{21}\)

This assumption is admittedly extreme: it requires a lot of farsightedness. Therefore, we compare the corresponding results with simulations based on less stringent assumptions. In particular, we provide two alternative scenarios: one in which the capital endowments do not respond at all to changes in $\tau$ - in other words, we consider a sequence of static HO models - and one in which the variations in $\tau$ are treated as unexpected permanent changes, so that after each decrease the representative households expect $\tau$ to remain constant from that point onwards. Hence, we are actually solving our model under two extreme assumptions about the infor-

\(^{19}\)A gradual fall in $\tau$ seems to correspond to historical experience better. Governments tend to liberalize slowly over time, due probably to political reasons.

\(^{20}\)The $p$-values for the standard $t$-tests, calculated using the Newey-West HAC estimator of the residuals’ variance-covariance matrix, are almost zero. The adjusted $R^2$ is 0.88. The Jarque-Berra test generates a $p$-value equal to 0.11: the null hypothesis of normal distributed residuals cannot be rejected. Furthermore, the Breusch-Godfrey serial correlation LM test (two lags included) generates a $p$-value equal to 0.58 so that also the null hypothesis of serial uncorrelation cannot be rejected. Finally, the White $F$-test for heteroskedasticity (cross terms included) generates a $p$-value equal to 0.45: also the null hypothesis of homoskedasticity cannot be rejected.

\(^{21}\)More formally, we treat $\tau$ as an exogenous state variable that evolves according to (19), and solve the model under a certainty equivalence assumption. The representative agents know the law of motion that governs the evolution of $\tau$, and forecast the future value of $\tau$ from $\hat{\tau} = (1 - \theta) \bar{\tau} + \theta \tau_t$; the errors $e = \hat{\tau} - \tau$ are treated as unexpected permanent shocks to $\tau$.  

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mation set available to our representative agents: in the first case, we assume that from the very beginning of the transition the agents were able to forecast the future path of $\tau$ (but for some unexpected shocks); in the second case, we assume that our agents are unable to draw any inference about the future path of $\tau$ by observing its current dynamics. It is left to the reader to take a stance on which approach (or convex combination of the two) is empirically more sensible.

To perform our experiment, we assume that the world is in the steady state associated with $\tau_0 = 1.17$ and $\left( \bar{K}_A/L_A \right) / \left( \bar{K}_W/L_W \right) = 1.88$, which implies a trade share in GDP equal to 0.06 for country $A$, and that at time 0 a trade liberalization agreement is reached, whereby the future time path of $\tau$ is determined according to equation (19). Figure 7 plots the actual (solid line) and predicted (dotted line) time paths of the US trade share in GDP. Our simulation approximates the actual time path for the US trade share very accurately. The predicted export share rises over time due to both the change in the long-run value $\bar{\tau}$ and to the variation in $\tau_t$. The fall in $\bar{\tau}$ implies a change in the steady states of countries, and therefore triggers a process of long-run relative factor endowment divergence. The successive reductions in $\tau_t$ cause a sequence of increases in the trade share (through both the static and dynamic mechanisms discussed in the previous section) that build upon the effect generated by the change in steady states. Notice that during the period 1975-1990, the volume of trade rises in spite of $\tau$ being roughly constant. This is due to the divergence in relative factor endowments triggered by the liberalization process.

To show the extent to which the trade share in GDP is responding to the dynamics triggered by trade integration, Figure 7 also reports the predicted trade share in GDP when we keep factor endowments constant at their initial levels (dotted line). In this case, the response of the trade share to the fall in the trade cost is much weaker: the trade share in GDP rises by 0.04, whereas in the factor accumulation case it rises by almost three times as much. Figure 7 also reports the trade share predicted by the dynamic model under the assumption that the whole time path of
\(\tau\) is unexpected (dash-dotted line), \textit{i.e.} when \(\theta = 1\) in equation (19). Its qualitative behavior is quite similar to that obtained under \(\hat{\theta} = 0.96\). The predicted time path of the export share generated with \(\theta = 1\) also displays an increasing trend. However, the mechanism here is much less powerful than above: when agents do expect future changes in the tariff, they also forecast future changes in factor prices (rental rates in particular). Hence, the model starts adjusting towards the new steady state even before the tariff actually changes. This implies a much larger process of factor endowment divergence (and, subsequently, trade growth) at the early stages of the simulation than under the assumption that agents cannot predict changes in the tariff.

A look at figure 1 suggests why different assumptions on expectations about \(\tau\) can make such a big difference over the transition path: notice that until 1972 the average import tariff remained almost constant, triggering basically no dynamics under the assumption \(\theta = 1\). Under \(\theta < 1\), instead, expectations of future trade liberalization gives the model a whole decade to start adjusting towards the new steady state. Needless to say, the steady-state share of trade in GDP is the same in both scenarios.

Figure 8 revisits the relationship between the import tariff and the trade volume we explored in Figure 2, which we copy in the top-left panel of 8. The other three panels plot the results of our three simulations. Notice that the static model (bottom-right panel) displays a linear relationship between the import tariff and the trade share. Our dynamic model reproduces instead the pattern observed in the data. Again, the simulation under the assumption that the whole time path of the import tariff is known from the very beginning (top-right panel) produces a larger response than the simulation in which agents are assumed to learn slowly about the time path of the tariff (bottom-left panel).
3.2.1 Robustness

The effect of trade liberalization on trade volumes depends on the reaction of factor prices to changes in $\tau$, as well as on the dynamic responses triggered by these changes. In what follows we discuss how departures from our benchmark model above affect the theory’s predictions.

The elasticity of intertemporal substitution Any change in parameters that affect the pace of capital accumulation, like the elasticity of intertemporal substitution $\mu$, or the subjective discount factor $\beta$, would influence the trade volume dynamics through the evolution of relative capital-labor ratios. Figure 9, for instance, compares the observed US trade share with two simulated trade shares for country $A$ under alternative values for $\mu$. (We assume the perfect foresight scenario discussed above, and keep all other parameter values constant.)

Not surprisingly, a higher elasticity of intertemporal substitution ($\mu = 1.5$) enhances the model’s dynamic response to changes in $\tau$; the opposite happens when the elasticity is low ($\mu = 0.5$). Our baseline parameterization, following Cooley and Prescott [10], sets $\mu$ to unity. This assumption is in line with a long standing tradition in quantitative macroeconomics, going back to Kydland and Prescott [28], Weil [49], and Lucas [30]. Recent empirical evidence by Mulligan [36] seems to corroborate this view.\(^{22}\)

The elasticity of substitution between intermediate goods Our choice of unitary elasticities in equation (6) was meant to make the case that one need not assume large elasticities of substitution to make a conventional model yield large increases in trade volumes after trade liberalization episodes, provided the dynamics are taken into account. Needless to say, a higher elasticity of substitution

\(^{22}\)Mulligan [36] uses the US after-tax return on capital instead of the usual return on commercial papers, and estimates $\mu$ equal to 1.13, with a 95-percent confidence interval ranging from 0.6 to 1.7. Another strand of the empirical literature, originating in Hall [21], typically finds a low (close to zero) value for the elasticity. Guvenen [20] is a recent attempt to reconcile the two approaches.
here would reduce the effect of a fall in $\tau$ on factor price divergence, as smaller price effects would generate the changes in quantities required to reestablish market equilibrium. This would in turn reduce the dynamic response of the volume of trade. However, this would be compensated by an increase in the size of the static effect, as shown by Yi [50]. Thus, regarding the size of the elasticity of substitution between goods, the static and dynamic responses to trade liberalization are substitutes: the higher the elasticity, the larger the importance of the static effect relative to the dynamic effect.

The elasticity of substitution between capital and labor Similarly, a sectoral elasticity of substitution between capital and labor larger (smaller) than one would mitigate (enhance) the response of factor prices to trade liberalization: production factors would be better (worse) substitutes and the excesses of factor demand and supply generated by a fall in $\tau$ would thus be easy (difficult) to clear with small factor price changes. The empirical evidence on factor substitution elasticities suggests they are in the neighborhood of $1$ (see Lucas [29] and Berndt [4]) or below $1$ (see Chirinko, Fazzari and Meyer [8]).

Capital mobility Given that the mechanics of our model relies on the reaction of capital accumulation to the divergence in rental rates generated by trade liberalization, allowing for international financial flows would speed up the cross-country divergence in relative capital endowments: trade liberalization would raise the rental rate on capital in the capital abundant country and reduce it in the capital scarce country, encouraging the migration of capital towards the former. In the model we avoid this issue by assuming capital is not mobile across countries. It remains to be seen, however, whether actual frictions to international capital flows are large enough relative to the interest rate differential so as to prevent capital from flowing
towards the capital abundant country.\textsuperscript{23}

\textbf{Trade barriers} Needless to say, our measure of $\tau$ is rather crude, since we ignore other types of policy-induced trade barriers and trade frictions (such as transport costs). However, additional simulations (not reported in the paper) show that the model produces similar tariff elasticities of the trade share regardless of the initial level of the tariff. For calibration purposes, this means that the model can produce results similar to the ones we report for different levels of $\tau$, provided the proportional change in $\tau$ is similar. One only has to recalibrate $\phi_W$ and $\phi_A$ so as to generate the correct initial trade volume.

\section{Concluding Remarks}

This paper illustrates the importance of using dynamic models to better understand phenomena that take place over time. The standard static trade model cannot explain the large effect of trade liberalization on the volume of trade over the last 50 years without very unrealistic assumptions on elasticities of substitution. However, a dynamic version of the same model can achieve this goal more credibly by taking into account the dynamic effects of trade liberalization.

In the same spirit, trade policies should not be evaluated on the basis of their immediate effects exclusively. All-across-the-board trade liberalizations are likely to affect the long-run comparative advantages of countries through their effects on factor prices and accumulation. In the current context of Chinese and Indian integration into the world economy, we wonder how large and long lasting the effects of this will be, given the size of these countries.

Our model is very stylized in a number of ways, and encourages extensions in several directions to better understand the growth of world trade and the dynamics

\textsuperscript{23}As an example, Figure 10 reports the time path of the interest rate differential produced by this section’s perfect foresight model. All along the simulation, the interest rate differential remains below 0.6 percentage points.
of particular countries. First, extending the analysis to a many-country world would help us understand the dynamics of preferential trade agreements and the effects of trade creation and diversion. Secondly, allowing for different types of trade (inter-and intra-industry) in both theory and data might help add realism to the analysis, as well as clarify whether different mechanisms (divergence versus convergence) operate at the same time across different country-pairs. Finally, introducing a second accumulable factor would qualify the model’s strong predictions on the relationship between trade liberalization and growth, and perhaps shed light on this topic.
References


Figure 1: Average import tariff and US GDP share of volume of trade. (Time paths)

Figure 2: Average import tariff and US GDP share of volume of trade.
Figure 3: Equilibrium trade pattern

Figure 4: Income, consumption, investment, and capital.
Figure 5: Factor prices (deviations and differentials).

Figure 6: Trade shares and specialization (levels and deviations).
Figure 7: Trade integration and the US trade share. (1)

Figure 8: Trade integration and the US trade share. (2)
Figure 9: The elasticity of intertemporal substitution

Figure 10: Interest rate differentials