On the Dynamics of Trade Reform

Rui Albuquerque and Sergio Rebelo

Rochester Center for Economic Research
Working Paper No. 454

July 1998
On The Dynamics of Trade Reform

Rui Albuquerque and Sergio Rebelo*

July, 1998

Abstract

The empirical evidence on trade reforms suggests that these have a surprisingly small impact on the country’s industrial configuration. This industrial structure inertia is difficult to rationalize in standard trade models. This paper develops a two-sector industry dynamics model in which industrial composition inertia arises naturally. The model is then used to study the consequences of different types of trade reforms (e.g. permanent, temporary, gradual, pre-announced) on investment, employment composition and income distribution.

J.E.L. Classification: F11

Keywords: Trade reform, industry dynamics, income distribution.

*University of Rochester and Northwestern University. We are thankful to Ronald Jones, Enrique Mendoza, Kent Kimbrough and to seminar participants at the Bank of Portugal, Duke University, MIT, New York University, University of Toronto, the World Bank, and the 1997 Meetings of the Society for Economic Dynamics for their comments. Financial support from the National Science Foundation and the Doctoral Scholarship Program of the Banco de Portugal is gratefully acknowledged.
1. Introduction

Over the last two decades numerous countries have implemented reform packages that sought to improve the efficiency of their economies. Trade reform, liberalization of capital flows, changes in tax legislation, improvements in the protection of property rights, and de-regulation of the financial intermediation sector, have been widely used to try to improve economic performance.

Every time these reforms are implemented agents debate the extent to which they are likely to be temporary or permanent. Why is this important? Calvo and Mendoza (1994) stress two reasons. The duration of the reform is relevant: (i) in determining the size of the wealth effect experienced by the private sector; and (ii) in setting in motion intertemporal substitution effects in reforms perceived as temporary. Both of these mechanisms affect consumption and labor supply decisions as well as the economy’s trade balance.

In this paper we analyze a third mechanism through which the temporariness of the reform may have important consequences. Reforms tend to induce important sectoral reallocations of investment. If investment decisions are costly to reverse, the duration of the reform becomes a critical determinant of capital and labor reallocation, firm entry, and firm exit.

A model where investment is reversible and capital can be freely re-allocated across sectors predicts that trade reforms—even temporary ones—should have very large effects on investment and on the industrial configuration. These predictions stand in sharp contrast with the evidence collected in numerous case studies by Papageorgiou et al. (1990) and Helleiner (1994) which suggests that there is substantial inertia in the process of firm creation and firm destruction. To give two examples, Rayner and Lattimore (1991, page 119) summarize the effects of trade reform in New Zealand as follows: “The 40 years covered by this study of trade liberalization in New Zealand saw many changes, some gradual and some extraordinarily swift and even drastic. But beneath these surface movements the structure of the economy has been remarkably resistant to change”. Ros (1994) provides the following summary of the Mexican experience with trade reforms in the 1980’s: “For those expecting a large, painful, but greatly beneficial reallocation of resources in favour of traditional exportable goods, and labour—and natural resource-intensive goods, the experience with trade liberalization to date will have been greatly disappointing. [...] the 1980’s have witnessed an extrapolation of past trends in trade and industrial patterns.”

Introducing adjustment costs into an otherwise frictionless model of capital
allocation preserves the prediction that trade reforms have an impact on capital allocation, however these effects take place gradually over time. In contrast, the industry dynamics model with irreversible investment that lies at the core of our analysis implies naturally that there is substantial inertia in the response of an economy to trade reforms. Firms that have previously been protected may not exit, even when trade reforms are permanent. And certain reforms—both temporary and permanent—may fail to elicit changes in industrial configuration. Ours is an economy in which the industrial structure is difficult to change and, in which the changes that do occur tend to be persistent.

Our emphasis on the role of fixed costs and investment irreversibilities in determining the outcome of trade reforms accords with the recent investment literature which stresses the importance of these features for understanding the episodic nature of investment dynamics (see, for example, Doms and Dunne (1993), Caballero, Engel and Haltiwanger (1995), and Eberly (1997)).

We use our model to address a set of questions that always emerges every time a reform plan is implemented: (i) should the reform be sudden or pre-announced?; (ii) are there advantages to gradual reforms?; (iii) if several policy measures are being considered is the sequence of implementation relevant?; (iv) do failed reforms condition the success of future reforms?; (v) what is the role of initial conditions in determining the reform outcome?; and (vi) is there a relation between the size of the reform and its outcome?

We discuss at length the effects of different reforms on the distribution of income across factors of production and across the sectors of the economy. Both theoretical work (Fernandez and Rodrick (1991), Hillman (1989)) and empirical studies (Little et al. (1970), Krueger (1978), and Papageorgiou et al. (1990)) have pointed clearly to the impact on the distribution of income as a key consideration in the design and implementation of reforms.

Section 2 lays out the basic model that forms the backdrop for our investigation. Section 3 studies the effects of different deterministic reforms in an economy with free access to international capital markets. Section 4 studies the implications of similar reforms in an economy without access to international capital markets. A final section summarizes the main results.

2. The Model

The economy is populated by a large number of agents with identical preferences. These agents own domestic firms and supply inelastically one unit of labor in
every period. They can borrow and lend in the international capital market at a
real interest rate $r^*$. For this reason consumption and savings decisions can be
separated from production and investment decisions. The latter seek to maximize
the economy's wealth. Given the level of wealth thus obtained households choose
optimally their consumption bundle and their savings rate. Since we are interested
in analyzing production and investment decisions we can do so by focusing on the
wealth maximization problem and abstract from the household's consumption and
savings decisions.

Domestic firms take prices as given in the world goods market and produce
either good $a$ or $b$. Domestic prices do not coincide with prices in the world market
due to the presence of import tariffs. Our economy has a comparative advantage
in the production of good $a$, so it will tend to export good $a$ and import good $b$.

Firms choose to enter or exit in response to changes in their industry's prof-
itatibility. We normalize the time that it takes to enter or exit the industry to one
period. It is thus appropriate to interpret each time period in the model as being
longer than one year.

In both sectors production is organized in firms as in Hopenhayn (1992). To
set up a firm it is necessary to make a one-time investment of $\phi$ units of good $a$.
If this cost is paid at time $t$ the firm will be able to operate at time $t+1$. Plants
produce according to the following technology:

$$Y_{it} = Z_i N_{it}^\alpha, \quad 0 < \alpha < 1, \quad i = a, b,$$

where $Y_{it}$ denotes the output of sector $i$ and $N_{it}$ the number of units of labor that
this sector employs. To simplify we assume that the production functions in the
two sectors differ only with respect to the level parameter $Z_i$. The elasticity of
production with respect to labor ($\alpha$) is assumed to be identical in both sectors.

In every period each firm must pay a overhead cost of $\psi$ units of good $a$. This
cost plays two roles. First, it keeps the number of firms bounded. Given the
presence of decreasing returns to scale the equilibrium number of firms would be
infinite with $\psi = 0$. Second, the overhead cost will induce firms to exit in response
to a sufficiently large deterioration in the relative price of their product. With
$\psi = 0$ firms would never exit since they would always earn positive profits.

At the end of every period, a firm can choose to produce or to discontinue its
operation. To simplify we assume that a firm which discontinues its operations for
one period cannot resume its operations in future periods and has a liquidation
value of zero. The problem facing an incumbent firm in sector $i$ can be described
in terms of the following dynamic programing problem, where $\pi_{it}$ represents time-$t$ maximal profits in the $i$ sector:

$$V_{it} = \pi_{it} + \frac{1}{1 + r^*} \max(V_{it+1}, 0).$$

The problem facing a potential entrant in sector $i$ is:

$$\tilde{V}_{it} = \max \left( \frac{1}{1 + r^*} V_{it+1} - \phi, 0 \right), \quad i = a, b.$$  

Optimal profits in the two sectors (in units of $a$) are given by:

$$\pi_{at} = \max_{N_{at}} (Z_a N_{at}^\alpha - \psi - w_{at} N_{at}),$$

$$\pi_{bt} = \max_{N_{bt}} (p_t Z_b N_{bt}^\alpha - \psi - w_{at} N_{bt}).$$

In these expressions $w_{at}$ represents the real wage rate measured in units of good $a$, and $p_t$ is the domestic relative price of good $b$ in units of good $a$. To simplify we assume that the international relative price of good $b$ ($p^*$) is constant. The domestic relative price is given by:

$$p_t = p^*(1 + \tau_t), \quad (2.1)$$

where $\tau_t$ is a tariff rate imposed by the government and whose revenue is rebated to the households in a lump sum fashion.\(^1\) We assume for now that $\tau_t$ is constant over time.

The real wage in this economy is a weighted average of the two product wages, $w_a$ and $w_b$, which is the real wage measured in units of good $b$:

$$w_b = w_a/p = \alpha Z_b N_b^{\alpha-1}. \quad (2.2)$$

If momentary utility from consumption of goods $a$ and $b$ ($C_a$ and $C_b$) had the Cobb-Douglas form $u = [(C_a^\gamma C_b^{1-\gamma})^{1-\sigma} - 1]/(1 - \sigma)$, the real wage (deflated by the consumer price index) would be a geometric average of the two product wages: $w_a^{\gamma} w_b^{1-\gamma}$. Since we want to be agnostic about the weights used in the construction of the consumer price index, we analyze separately the evolution of both $w_a$ and $w_b$.

\(^1\)The results we will discuss continue to hold if we assume, as in Section 4 below, that these tariffs are used to finance public expenditures that do not affect the productivity of the private sector or the marginal utility of private consumption.
Optimal labor hiring decisions in the two sectors are characterized by:

\[ \alpha Z_a N_a^{\alpha-1} = w_a, \]
\[ p\alpha Z_b N_b^{\alpha-1} = w_a. \]

It is useful to define \( \theta \) as the ratio of labor allocation in the two sectors,

\[ \theta \equiv \frac{N_a}{N_b} = \left( \frac{Z_a}{Z_b p} \right)^{1/(1-\alpha)}. \]

**Assumption 1:** \( \theta > 1. \)

This assumption is just a normalization that means that the economy has a comparative advantage at producing good \( a. \)

Denote the number of incumbents in sector \( i \) by \( M_i. \) Using the adding up condition for labor,

\[ M_a N_a + M_b N_b = 1, \]

we can write the values of \( N_a \) and \( N_b \) as:

\[ N_a = \frac{\theta}{M_a \theta + M_b}, \]
\[ N_b = \frac{1}{M_a \theta + M_b}. \]

Note that when the economy specializes in good \( a, \) so that \( M_b = 0, \) the variable \( \theta \) is still well defined since it gives us the ratio of labor employed by a type \( a \) firm relative to the labor employed by a potential entrant into the \( b \) sector. When \( M_b = 0 \) equation (2.6) implies that the available labor is evenly divided among sector \( a \) firms.

The values of \( \pi_a \) and \( \pi_b \) are:

\[ \pi_a = (1 - \alpha) Z_a \left( \frac{\theta}{M_a \theta + M_b} \right)^{\alpha} - \psi, \]
\[ \pi_b = p(1 - \alpha) Z_b \left( \frac{1}{M_a \theta + M_b} \right)^{\alpha} - \psi. \]
Combining these two equations and using (2.4) we obtain a simple relation between the optimal profits of the two sectors:

\[
\pi_{at} = \theta(\pi_{bt} + \psi) - \psi. \tag{2.10}
\]

The problem of finding the investment and exit decisions in the two sectors that maximize the wealth of the economy can be expressed in a recursive fashion:

\[
W(M_a, M_b) = \max_{M'_a, M'_b \geq 0} \left\{ M_a \pi_a + M_b \pi_b + w_a 
- \phi \max(M'_a - M_a, 0) + \max(M'_b - M_b, 0) 
+ \frac{1}{1 + r^*} W(M'_a, M'_b) \right\}. \tag{2.11}
\]

Here we used primes to denote the value of a given variable in the next period.

**Proposition 2.1.** For each \( \theta \) there exists a unique, bounded and continuous function \( W \). The value function \( W \) is strictly concave and differentiable almost everywhere, and the decision rules are continuous, single-valued functions.\(^2\)

**Proof.** See appendix. \( \blacksquare \)

There is an explicit analytical solution to the value function \( W \) which is described in the appendix.

**Lemma 2.2 (Specialization).** The economy has a comparative advantage in good \( a \): if we start the economy with \( M_a > 0 \) and \( M_b = 0 \) we will not observe entry in sector \( b \); the economy will remain specialized in the production of good \( a \).

**Proof.** See Lemmas 6.1 and 6.2 in the appendix. \( \blacksquare \)

2.1. The Steady State Set

In the steady state of this economy the number of firms in both sectors remains constant. There are multiple \((M_a, M_b)\) combinations consistent with the steady state. These combinations can be characterized by studying the firm entry and exit decisions for both sectors of the economy.

\(^2\)When \( \theta = 1 \) the value function can be written as \( W(M_a + M_b) \), that is, plants in sector \( a \) are in this case perfect substitutes for plants in sector \( b \).
A pair \((M_a, M_b)\) belongs to the steady state set if it satisfies two properties: (i) the value of firms in both sectors is non-negative \((V_{it} \geq 0, i = a, b)\), which implies that there is no incentive to exit; and (ii) the value of existent firms is lower than the cost of entry \((V_{it} \leq \phi(1 + r^*)\), \(i = a, b)\), which implies that there is no incentive to enter.

For latter reference it is useful to define \(\bar{M}_a\) as the highest number of \(a\) firms compatible with the steady state requirements. The number \(\bar{M}_a\) is such that \(\pi_a = 0\) in an economy with no \(b\) firms:

\[
(1 - \alpha)Z_a(1/\bar{M}_a)^\alpha - \psi = 0.
\]

\(M_a\) is defined as the number of \(a\) firms such that profits compensate the annuitized entry cost \((\pi_a = \phi r^*)\) in an economy with no \(b\) firms:

\[
(1 - \alpha)Z_a(1/M_a)^\alpha - \psi = \phi r^*.
\]

Consider first the case in which we start the economy with \(M_a > 0\) and \(M_b = 0\). Lemma 2.2 implies that there will be no entry of \(b\) firms; the labor force will be divided equally among firms in sector \(a\) and profits will be given by:

\[
\pi_a = (1 - \alpha)Z_a(1/M_a)^\alpha - \psi.
\]

Thus, \(M_a\) is a steady state if:

\[
\begin{align*}
\pi_a & \geq 0, \\
\pi_a & \leq \phi r^*.
\end{align*}
\]

that is,

\[
M_a \leq M_a \leq \bar{M}_a.
\]

Suppose now that we start the economy with \(M_a > 0\) and \(M_b > 0\), so the fixed costs of setting up \(M_b\) firms in sector \(b\) have already been incurred. Will the firms in sector \(b\) remain in operation? There are two possibilities. Figure 2.1 depicts the case in which firms of type \(b\) survive in the steady state. In this case the steady state set is determined by the intersection of the areas defined by the following four conditions: \(\pi_a \geq 0, \pi_b \geq 0, \pi_a \leq \phi r^*\) and \(\pi_b \leq \phi r^*\). This set includes elements in which both \(M_a\) and \(M_b\) are positive. We call these “non-specialized steady states”.

Figure 2.2 depicts the “specialized steady state” case. In this case there are no elements of the steady state set such that \(M_a > 0\) and \(M_b > 0\). Points in which \(b\)
firms would be willing to continue producing because $\pi_b \geq 0$ will trigger entry of firms in the $a$ sector to the point where $b$ firms will become unprofitable and be driven to exit.

To determine whether we will have a specialized steady state we ask whether a marginal incumbent in the $b$ sector would survive when the number of $a$ firms is the lowest number consistent with sector $a$'s no-entry condition. This value of $M_a$ is determined by the condition $\pi_a = \phi r^*$. A value of $M_a$ lower than the one implied by this condition would mean lower wages and hence higher profits in the $a$ sector. The present value of profits in the $a$ sector would then rise above the entry cost $\phi$, thus triggering entry of $a$ firms. The profits of a marginal firm in sector $b$ in this scenario can be determined using equation (2.10):

$$\pi_{bt} = \frac{\tau^* \phi + \psi}{\theta} - \psi.$$

If we define $\bar{\theta}$ as the value of $\theta$ consistent with $\pi_{bt} = 0,$

Figure 2.1: Non-Specialized Steady State
Figure 2.2: Specialized Steady State
\[ \bar{\theta} = 1 + \frac{r^*\phi}{\psi}, \]

we obtain the following lemma.

**Lemma 2.3.** The steady state is specialized when \( \theta > \bar{\theta} \) and non-specialized otherwise.

Before we study the transition dynamics of the model it is useful to summarize the properties of the set of industry configurations that satisfy \( \pi_a = r^* \phi \).

**Lemma 2.4.** Denote by \( \Omega(\theta) \) the set of pairs \( (M_a, M_b) \) that satisfy the condition \( \pi_a = r^* \phi \). \( \Omega(\theta) \) is given by:

\[
\Omega(\theta) = \left\{ (M_a, M_b) : M_b = \theta \left( \frac{(1 - \alpha) Z_a}{\psi + r^* \phi} \right)^{1/\alpha} - \theta M_a \right\}.
\]

For a given value of \( \theta \) the real wage rate measured in units of good \( a \), \( w_a \) is the same for all \( (M_a, M_b) \in \Omega(\theta) \); denote this value as \( w_a(\theta) \). The value of \( w_a \) is also the same across loci with different \( \theta \), that is \( w_a(\theta_1) = w_a(\theta_2), \forall \theta_1, \theta_2 \).

**Proof.** Expression (2.12) can be obtained by using equations (2.8), and \( \pi_a = r^* \phi \). To show the constancy of \( w_a \) note that (2.8) implies that \( w_a \) is constant if \( N_a \) is constant. To complete the proof note that (2.12) and (2.6) imply that along a locus \( \Omega(\theta) \) the value of \( N_a \) is constant and independent of \( \theta \).

Figure 2.3 illustrates this result. Suppose that there is a decrease in \( p \). Equation (2.4) implies that \( \theta \) increases from \( \theta_1 \) to \( \theta_2 \). This leads to a rotation of the \( \Omega(\theta) \) locus from \( \Omega(\theta_1) \) to \( \Omega(\theta_2) \). The product wage \( w_a \) is the same for all points in \( \Omega(\theta_1) \). It is also identical in all points along \( \Omega(\theta_2) \). Finally \( w_a \) is the same in both of these loci.\(^3\)

\(^3\) A symmetric result holds for sector \( b \). In all the points \( (M_a, M_b) \) such that \( \pi_b = r^* \phi \) the value of \( w_b \) is constant and independent of \( \theta \).
Figure 2.3: The $\Omega(\theta)$ Locus
2.2. Transition Dynamics

Since the economy can borrow and lend freely in the international capital market and there are no adjustment costs to investment, the transition to the steady state occurs in a single period. The transition dynamics summarized in the following proposition can be read straight out of the value function $W$ described in the appendix.

**Proposition 2.5.** When $\theta < \bar{\theta}$ the economy converges to a non-specialized steady state. Entry of $b$ firms never occurs. For industry configurations where $\pi_a > r^*\phi$ there is entry of firms in sector $a$ with $M_b$ remaining constant. For all other non-specialized state configurations in which $M_a < \bar{M}_a$, $b$ firms make losses and hence exit while $M_a$ remains constant. For industry configurations in which $M_a > \bar{M}_a$ the economy converges to $M_a = \bar{M}_a, M_b = 0$.

When $\theta > \bar{\theta}$ the economy converges to a specialized steady state. Transition dynamics always involve the immediate exit of all $b$ firms. $M_a$ remains constant when $\bar{M}_a < M_a < \bar{M}_a$, converges to $\bar{M}_a$ when $M_a < \bar{M}_a$, and to $\bar{M}_a$ when $M_a > \bar{M}_a$.

These transition dynamics are depicted in Figure 2.4 for the “non-specialized steady state” and in Figure 2.5 for the “specialized steady state” case.

3. Trade Reforms with Free Capital Mobility

We now discuss the effects of different types of trade liberalization reforms to provide answers to some of the questions posed in the introduction. Trade reforms are a potential Pareto improvement in our economy—if the government could make appropriate transfers among agents everybody could be made better off. Since in practice lump sum transfers are not available and factor ownership is unevenly distributed, trade reforms can result in dramatic changes in income distribution. To study these distribution effects we focus on the impact of reforms on $\pi_a, \pi_b$ and on the real wage.

We start by studying two permanent reforms, one that is unanticipated by private agents and one that is pre-announced. The dynamics of entry and exit associated with these reforms are characterized using the results in Proposition 2.5. We then turn to reforms that are gradual and to temporary reforms.
Figure 2.4: Transition Dynamics, Non-Specialized Steady State
Figure 2.5: Transition Dynamics, Specialized Steady State
3.1. A Permanent Unanticipated Reform

We will now discuss the effects of a permanent unanticipated reform that lowers tariffs thus reducing $p$, the domestic price of good $b$. We study two distinct cases: (i) the economy departs from a situation where $\pi_a = \phi r^*$ before the reform; and (ii) the economy departs from an interior point in the steady state set. Since the differences between these two scenarios are similar in all the other reforms we will study we will later focus only on the first case.

3.1.1. Case 1 ($\pi_a = \phi r^*$ in the initial steady state)

The five panels of Figure 3.1 show the effects of a permanent unanticipated reform in the first case. The top panel shows the locus $\Omega(\theta)$ which gives the $(M_a, M_b)$ combinations such that $\pi_a = r^*\phi$. This will be used to analyze the incentive for $a$ firms to enter. Given that the reform favors the $a$ sector we already know from our analysis of transition dynamics that there will be no entry of $b$ firms.

Suppose that $p$ declines from $p_1$ to $p_2$. This raises $\theta$ from its initial value $\theta_1$ to a new value $\theta_2$ (see equation (2.4)) producing a clockwise rotation in the $\pi_a = r^*\phi$ line. Suppose that the pre-reform industry configuration was a point in $\Omega(\theta_1)$, such as point 1 in Figure 3.1. The decline in $p$ increases the profits of sector $a$ to the point where it justifies entry into this sector. What happens in sector $b$? If the new steady state involves complete specialization all $b$ firms will exit. Otherwise they will continue to make positive profits and hence they will all remain in operation.

The reform exerts two distinct effects on the real wage. The first is a static effect associated with the change in $p$. The second reflects the consequences of firm entry. The static effect takes place because when $p$ decreases there is a reallocation of labor toward the sector $a$ (see (2.6)). Thus $N_a$ increases leading to a reduction in $w_a$ (see (2.3)). The reform made good $a$ more expensive and hence wages measured in units of $a$ fall while wages measured in units of $b$ rise.

If $M_a$ and $M_b$ were fixed this would be the end of the story. However, there will be entry in sector $a$ and the economy will move from point 1 to point 2 in Figure 3.1. Recall from Lemma 2.4 that $w_a$ is identical along $\Omega(\theta_1)$ and $\Omega(\theta_2)$. This means that entry will exactly offset the initial decline in $w_a$, restoring $w_a$ to its pre-reform level. Entry of $a$ firms leads to a reduction in $N_b$ (see (2.7)) and to a second increase in $w_b$ (see (2.2)).

The last two panels of Figure 3.1 depict the effects of the reform on the profits of the two sectors. In the first period of the reform $a$ firms receive a profit windfall
Figure 3.1: A Permanent Unanticipated Reform
associated with the decline in \( w_a \) at the same time that profits decline in sector \( b \) (see (2.9)). Entry of \( a \) firms in the second period restores profitability in sector \( a \) to pre-reform levels and leads to a further reduction in the profits of sector \( b \). When this reduction is severe enough profits in the \( b \) sector may become negative. This happens when the new value of \( \theta \) is higher than \( \bar{\theta} \) (Lemma 2.2). In this case the new steady state will entail complete specialization in the production of good \( a \), that is, the economy moves from point 1 to point 3 in Figure 3.1. \(^4\)

Note that the effects of reform are non-linear with respect to the level of tariffs. Small changes in \( \tau \) tend to produce correspondingly small effects in terms of entry into sector \( a \) and no effects on exit from sector \( b \). However, once tariffs move enough that the new steady state entails specialization \( (\theta > \bar{\theta}) \) there is a watershed effect involving potentially large entry of \( a \) firms with exit of all \( b \) firms. Figure 3.2 shows how the industry configuration changes in response to changes in the level of tariffs. Suppose the economy starts with a value of \( \theta \) equal to \( \theta_0 \), which corresponds to a level of tariffs \( \tau_0 \). Suppose also that the initial conditions \( M_{a0} \) and \( M_{b0} \) lie on the schedule \( \Omega(\theta_0) \). The Figure shows the number of \( a \) firms that will enter if tariffs are reduced from \( \tau_0 \) to a new lower value \( \tau \). For tariffs lower than \( \tau \) (the value of \( \tau \) consistent with \( \theta = \bar{\theta} \)) the economy specializes completely—all \( b \) firms exit while the number of \( a \) firms increases to \( M_a \).

To summarize the main results: an unanticipated reform that lowers tariffs, thus lowering the price of good \( b \), leads to entry in the \( a \) sector, motivated by the initial increase in the profitability of this sector. Profitability falls in sector \( b \). The product wage measured in units of good \( a \) falls initially but is then restored to its pre-reform level. The values of \( w_a \) and \( \pi_a \) are the same in period 2 as before the reform. In contrast, sector \( b \), which was more protected in the pre-reform era features higher product wages \( (w_b) \) and correspondingly lower profits. The effects of reforms are non linear in \( \tau \); if the new level of tariffs is low enough to be compatible with a specialized steady state this has large effects on firm entry and firm exit.

3.1.2. Case 2 (initial steady state is an interior point)

Consider now the case in which the economy starts off at an interior point in the steady state set, such as point 1 in Figure 3.3. In this case if the change in the

\(^4\)The implication that all firms \( b \) exit at the same time creating a large watershed effect would be mitigated in a version of the model where firms have heterogenous productivities, as in Bacchetta and Dellas (1997). In such an environment the least productive, smaller firms would tend to exit but more efficient units could remain in operation.
Figure 3.2: The Effect of Tariffs on Firm Entry, Initial Industrial Configuration: $M_a > M_{a0}$. 

![Diagram](image)
domestic price is small enough to cause no entry in sector $a$, all we observe are static effects: a permanent decline in $w_a$ and in $\pi_b$ and a permanent rise in $w_b$ and $\pi_a$. The economy remains at point 1 despite the reform. The same dynamic effects discussed before will be added if the decline in $p$ from $p_1$ to $p_3$ leads to entry in sector $a$, moving the economy from point 1 to point 2. (For simplicity we ignore the case where the change in price is large enough to induce specialization.) Figure 3.3 also depicts what happens in this case. Notice that, because we started the economy off at a point where $\pi_a < r^* \phi$, entry in sector $a$ does not restore $w_a$ to its pre-reform level. Relative to the situation before the reform we now observe a permanent decline in $w_a$ and an increase in profits to the level $r^* \phi$.

In the non-specialized steady state case, the higher the pre-reform steady state value of $M_b$ for a given value of $M_a$ the lower the impact of the trade reform. In other words, if the initial industry configuration is significantly biased away from the economy’s comparative advantage, the effects of trade reform will be small in
the sense that few firms of type \( a \) will enter. Policies that try to tilt the economy away from its comparative advantage lead to smaller effects of trade reform.

### 3.2. A Permanent Pre-Announced Reform

A common alternative to a surprise reform involves announcing in advance the policy changes associated with the reform. Figure 3.4 depicts the effect of a reform that takes place in period 1 and is pre-announced in period 0. In this case entry of \( a \) firms eliminates the static effects in period 1. The only effects of the reform on sector \( a \) are an expansion in the number of firms and in the number of workers employed by each firm. Sector \( b \) experiences a decline in profits (which become negative if the new steady state is specialized) and an increase in its product wage, \( w_b \).

This reform is clearly worse in welfare terms than the previous one because the
economy waits one period to implement a reform that is welfare improving. To see this note that the total value of firms at time 0, \( W(M_{a0}, M_{b0}) \), is strictly higher when the reform is unanticipated than with a pre-announced reform since keeping \( M_a \), and \( M_b \) constant for next period is feasible, but not optimal. However, pre-announcing the reform may have some advantages for a policy maker concerned with short term effects on the income distribution. While the real wage can fall in an unanticipated reform if good \( a \) has a high enough weight in the consumption basket, the real wage is guaranteed to rise in a pre-announced reform.

Pre-announcing also has an important effect on profits. The fact that sector \( a \) receives a profit windfall at the same time that sector \( b \) is made less profitable may make the unanticipated reform more difficult to sustain. Pre-announcing eliminates the profit windfall to sector \( a \).

In the experiment just described we assumed that the reform has perfect credibility. While it is possible that pre-announcing the reform hurts its credibility (e.g. Stockman (1982)), in the case studies compiled by Papageorgiou et al. (1991) the majority of the pre-announced reforms survived either fully or partially.

3.3. A Permanent Gradual Reform

Policy makers often entertain the possibility of pre-announcing a schedule of reforms that are implemented gradually over time. The liberalization of trade within Europe brought forth by the European Union took this gradualist approach. What does gradualism buy us? Suppose that at time zero we announce a gradual reduction in tariffs starting immediately in period zero. The result, depicted in Figure 3.5, is a combination of the two reforms that we just studied. At time zero we have the impact of the unanticipated change in \( p_0 \). This produces our familiar static effect: a decline in \( w_a \), a rise in \( \pi_a \), an increase in \( w_b \), and a reduction in \( \pi_b \). From period 1 on the profitability of sector \( a \) remains constant at \( \pi_a = \tau^a \phi \) since firm entry offsets exactly the increase in profits produced by a drop in \( p \). Since at time \( t \) the industry configuration is on the locus \( \Omega(\theta_t) \), \( w_a \) remains constant from period 1 on (see Lemma 2.4).

In the \( b \) sector the decline in \( \pi_b \) and the rise in \( w_b \) which in the previous reform occurs in period 1 now takes place gradually over time in tandem with changes in \( p \).

In terms of welfare this reform is worse than the unanticipated reform because the implementation of welfare improving changes in tariffs is further delayed in time. As far as its short term impact on income distribution this reform seems
Figure 3.5: A Gradual Permanent Reform
also dominated by the pre-announced reform. In a gradual unanticipated reform the real wage can potentially fall, and there is a profit windfall to sector $a$.

Gradual reforms have often been recommended as a way of achieving a smoother reallocation of factors across sectors (Little et al. (1970) and Michaely (1985)). Since these benefits can just as well be achieved through pre-announcement, the case for gradualism must depend on potential credibility effects associated with a gradual implementation of the reform.

3.4. A Temporary Unanticipated Reform

Consider now a temporary unanticipated decline in tariffs announced at time zero that lasts for two periods (the results of longer lasting temporary reforms are similar). After two periods tariff levels return to their pre-reform level. Experiments of this type are common in the temporariness literature (see e.g. Calvo (1988)). Suppose that the pre-reform industry configuration was a point in $\Omega(\theta_0)$, such as point 1 in Figure 3.6.

In this case we will observe entry in the $a$ sector. Without entry in the first period the temporary price decline would raise the present value of profits above the entry threshold $\phi(1+r^*)$. In period 0 we observe the familiar static effects associated with the unanticipated nature of the reform: $w_a$ and $\pi_b$ decline at the same time that $w_b$ and $\pi_a$ increase. In the permanent reform firm entry into sector $a$ offsets completely the static effects on $w_a$ and $\pi_a$. In the temporary reform entry is restricted by the fact that once the reform ends the present discounted value of profits from period 2 on, $V_{a2}$, is lower than the entry threshold $\phi(1+r^*)$ therefore the marginal entrant into sector $a$ will have excess profits in period 1 since:

$$\frac{\pi_{a1}}{1+r^*} + \frac{V_{a2}}{(1+r^*)^2} = \phi.$$ 

Given that there will be fewer firms $a$ entering some of the static effect will remain. When the reform is reversed in period 2 the economy will look "uncompetitive". Because the number of firms in the $a$ sector is larger than before the reform, the wage rate is higher measured both in units of $a$ and in units of $b$. Also, profits are lower in both sectors as compared to the pre-reform era.

Is it possible to observe entry of firms $a$ that is later reversed by exit when the reform ends? The following Lemma states that the answer to this question is negative.

**Lemma 3.1.** Consider a temporary reform that lasts for $T > 1$ periods. During the reform period $p$ declines from $p_1$ to $p_2$. At time $T + 1$, $p$ reverts back to $p_1$. 

24
Figure 8.6: A Temporarily Uninitialized Register

\[ \text{Time} \]

\[ \text{Sim entry (pass 2)} \]

\[ \text{Sim effect} \]

\[ \text{Sim effect} \]

\[ \text{W} \]

\[ \text{W} \]

\[ \text{W} \]

\[ \text{W} \]

\[ \text{W} \]

\[ \text{W} \]

\[ \text{W} \]
is useful to assume:

Since later on we will discuss the implications of capital flows liberalization it is useful to assume:

\[ 1 > \lambda > 0 \quad 0 < \omega \]

\[
\sum_{i=0}^{\infty} \left( \frac{1}{1-\rho_c} \right) \rho_c^i = \frac{1}{1-\rho_c} \left( \frac{\rho_c^0}{1-\rho_c} \right) = \frac{1}{1-\rho_c}
\]

\[ \frac{1}{1-\rho_c} \]

Households choose the path of consumption of goods $a$ and $b$ ($c_a$ and $c_b$) so as to maximize their lifetime utility, which is given by:

Hence we need the explicit separable intertemporal utility function for each household. Hence we need to be explicit about the separate interest rate is determined endogenously in this economy. Hence we can no longer trade internationally, but has no access to world capital markets. Since the real interest rate is determined endogenously in this economy, we can no longer trade internationally, but have no access to world capital markets. Since

We now study a version of the model presented in Section 2 in which the economy

Markets

4. Trade Reform Without Access to International Capital

Neither contaminated nor did the structure change in any obvious ways.

Trade reform.


The 1990-62 import reform was undertaken by the Department of Trade and Industry. For example.

The impetus of the model—temporarily reform generated no cost from the

Problems. Thus far the way for future reforms.

Temporarily reform.

We will not observe exit of a firm at any point in time as a response to this
referred to as the domestic price by Equation (2).

\[ c_i = \left( \frac{\pi_{IM} - \pi_p}{\pi_p} \right) d_i \]

where, as before, \( p \) represents the relative price of \( p \) in world markets which is

The constraint can be written as:

The economy exports good \( a \) and imports good \( q \) and the government budget constraint \( I < \theta \) does not influence the marginal utility of private consumption. When \( I \) are non productive government expenditures \( (C) \) are not productive in the economy. These government expenditures \( (C) \) are not used by the government to produce public goods at the same time that these funds are used by the government to ensure public purchase of the two units of goods \( a \) and \( q \).

The government collects taxes on imports at rate \( \tau \). To simplify, we assume that the government collects on imports at rate \( \tau \).

The units of goods \( a \) and \( q \) are used by other firms. Thus, no resources are recycled by reducing the number of goods used by other firms. This is, when a firm exits, it cannot operate again and its capital cannot be

... (Continued from previous page)

\[
\begin{align*}
(0^1 \pi_{IM} - 1^1 \pi_{IM}) & \text{ (max}_{\phi < 0} \phi + (0^1 \pi_{IM} - 1^1 \pi_{IM}) \text{ (max}_{\phi < 0} \phi) } \\
& + \theta^2 \pi_{IM} \pi_{IM} = \theta^2 \pi_{IM} \pi_{IM} - \theta^2 \pi_{IM} \pi_{IM} \pi_{IM} + \pi_{IM} \pi_{IM}
\end{align*}
\]

... (Continued from previous page)

The government collects taxes on imports at rate \( \tau \). To simplify, we assume that the government collects on imports at rate \( \tau \).

The units of goods \( a \) and \( q \) are used by other firms. Thus, no resources are recycled by reducing the number of goods used by other firms. This is, when a firm exits, it cannot operate again and its capital cannot be

... (Continued from previous page)

\[
\begin{align*}
(0^1 \pi_{IM} - 1^1 \pi_{IM}) & \text{ (max}_{\phi < 0} \phi + (0^1 \pi_{IM} - 1^1 \pi_{IM}) \text{ (max}_{\phi < 0} \phi) } \\
& + \theta^2 \pi_{IM} \pi_{IM} = \theta^2 \pi_{IM} \pi_{IM} - \theta^2 \pi_{IM} \pi_{IM} \pi_{IM} + \pi_{IM} \pi_{IM}
\end{align*}
\]

... (Continued from previous page)

The government collects taxes on imports at rate \( \tau \). To simplify, we assume that the government collects on imports at rate \( \tau \).

The units of goods \( a \) and \( q \) are used by other firms. Thus, no resources are recycled by reducing the number of goods used by other firms. This is, when a firm exits, it cannot operate again and its capital cannot be

... (Continued from previous page)

\[
\begin{align*}
(0^1 \pi_{IM} - 1^1 \pi_{IM}) & \text{ (max}_{\phi < 0} \phi + (0^1 \pi_{IM} - 1^1 \pi_{IM}) \text{ (max}_{\phi < 0} \phi) } \\
& + \theta^2 \pi_{IM} \pi_{IM} = \theta^2 \pi_{IM} \pi_{IM} - \theta^2 \pi_{IM} \pi_{IM} \pi_{IM} + \pi_{IM} \pi_{IM}
\end{align*}
\]
Proposition 4.1. For each \( \theta \neq 0 \), there exists a unique, bounded and continuous function \( \lambda \) such that:

\[
\lambda \phi - (\beta W + \gamma W) \phi - (\beta W - \gamma W) \phi = \frac{\lambda}{\beta} \quad \text{s.t.} \quad (\forall \theta) \quad \left\{ (\beta W - \gamma W) \phi - \frac{\rho - 1}{1 - \gamma C(d) \lambda} \right\} \max_{\phi} = (\beta W, \gamma W) \phi
\]

We can write the dynamic problem of the stand-in representative household recursively as:

\[
(i + 1), d = \frac{\lambda}{\beta C(\lambda - 1)}
\]

Then across the two goods is:

The efficiency condition that characterizes the optimal allocation of consumption and how to allocate those savings to investment in the two sectors of the economy are also two intertemporal choices involving how much to save in the two industries. There are also two intertemporal choices involving two intertemporal decisions to the sequence of constraints (ii) and (iii) involve two intertemporal decisions:

The problem of the stand-in representative household of maximizing subject (i) subject

\[
[(\beta W - (0 + \gamma W - 1 + \gamma W)) \phi + (0 + \beta W - 1 + \gamma W) \phi + (\beta W + \gamma W) \phi + \gamma C] U = \lambda
\]

subject to

When \( \lambda > \lambda \), the economy imports a and exports \( b \) and the government budget
state. The results are formally stated in Proposition 6.3 in the Appendix. The real interest rate depends on a term that can be derived from solving the equation:

\[ \frac{\phi}{1+\rho + \rho t} = \rho \phi + \rho t \]

In this case, the real interest rate must be above the steady state value of \( \rho \). Whenever the entity of a firm occurs, the value of each firm in the economy decreases. In terms of foreign consumption, to have an instantaneous adjustment toward the steady state, the foreign consumption must have a value of foreign consumption that is too costly or firms into sector a takes place gradually over time because it is too costly. The above is the steady state is the same as that of the pattern of adjustment toward the steady state is the same as that of the pattern of adjustment toward the steady state. However, as before, there is no entry of firms, while a firms increase whenever adjustment towards the steady state since no international borrowing is allowed.

The transition dynamics in this economy are characterized by a slower ad-

national Capital Markets

Figure 4.1: Transition Dynamics for any \( M_0^+ \) Economy Without Access to Inte-

\[ M^+ \]

\[ M^0 \]

\[ M^0 \]

\[ \phi \]

\[ 45^\circ \]
The results in Proposition 6.c. in the Appendix will ensure that every sector will take place only in sector a.

Suppose now that trade reforms take place first, at the same time that the government announces a future capital market liberalization. This sequence will ensure that every sector will take place only in sector a.

This sequence also results in powerful portfolio adjustment by the capital markets. Liberalization may also result in the port of trims. The larger the sector expanded, the larger the sector produced. The capital markets adjust to this change in the interest rate, raising the interest rate on the capital markets. The capital markets adjust to this change in the interest rate, raising the sector's portfolio. When the capital markets adjust, the interest rate on the capital markets increases, raising the interest rate on the capital markets.

The trade reform.

International economic theory with no access to international capital markets. Where international capital markets are not accessible, the trade reform can change investment to the sector that is currently protected. Liberalizing trade can change investment to the sector that is currently protected.

Weber (1986) in a two-period model: Liberalizing capital flows sector a, where standort both of the reforms should be implemented immediately. The effects of a permanent multilateralized trade reform in this economy are described in Figure 4.2. These effects are similar to those obtained by Edwards. The effects of a permanent multilateralized trade reform in this economy are described in Figure 4.2. These effects are similar to those obtained by Edwards.

4.2. Sequence
International Capital Markets

Figure 4.2: A Permanently Unსečipated Reform Economy Without Access to
5. Conclusions
Reforms take place.

Reforms within a political economy model that determine why and when these

Finally, it would be desirable to integrate our model of the outcome of trade

shocks such as those emphasized in Reinhart and Végh (1994).

Indeed, the model can be better to technology how the economy responds to terms of trade

with the search for new jobs and the loss of sector-specific human capital may

higher reallocation costs, namely the presence of unemployment spells associated

With the exception of many trade reforms that have been undertaken, including

Paperstone et al. (1991) and Edwards (1994) which suggest that the short-

term effects of these are not costs to the reallocation of labor across sectors. We assumed that there are no costs to the reallocation of labor across sectors.

Uncertainty—The size of the steady state will in general be affected by the degree

of uncertainty. The size of the steady state will also be affected by the degree

with which uncertainty is computed in the model. The model allows for

the uncertainty to be continued to play an important role in environments with

reform outcome. The inherent effects present in the deterministic version that we

reform outcomes. The inherent effects present in the deterministic environment that we

are several extensions of our simple model that would make it a better

model of the economy. Here we observe a large discrete change in the industrial structure of the economy. Also

we observe a large discrete change in the industrial structure of the economy. Also

reforms that affect the relative weight of each of the three sectors. When reforms fall below a certain threshold

reforms that affect the relative weight of each of the three sectors. When reforms fall below a certain threshold

the relative weight of each of the three sectors. When reforms fall below a certain threshold

absolute weight of a potential for complete specialization, given a pronounced non-

presence of a potential for complete specialization, given a pronounced non-

(vi) The entry and exit of dynamic, imbedded in our model, together with the

the cooperative advantage sectors.

part that reduction in terms of entry of new firms and reallocation of resources toward

the past and has created a large protected sector, thus diluting the effects of a given

the past and has created a large protected sector, thus diluting the effects of a given

advantage sectors. If in one of the economies the trade protection were permanent in

effect on distribution of income then one is permanent.

an unemployment reform that is perceived as temporary has a stronger short-run
References


6. Appendix

We start by defining the total output function which will be used in different proofs:

\[ y(M_a, M_b) = M_aZ_a\left(\frac{\theta}{\theta M_a + M_b}\right)^\alpha + M_bZ_b\left(\frac{1}{\theta M_a + M_b}\right)^\alpha - \psi(M_a + M_b). \]

**Proof of Proposition 2.1.** The proof of these results is standard in dynamic programming problems with bounded returns (see Stokey and Lucas with Prescott (1989)). We need to show that the period return function is bounded and is strictly concave for \( \theta \neq 1 \). Let \( R(M_a, M_b, M'_a, M'_b) = y(M_a, M_b) - i(M_a, M_b, M'_a, M'_b) \) be the period return function, with

\[ i(M_a, M_b, M'_a, M'_b) = \phi[\max(M'_a - M_a, 0) + \max(M'_b - M_b, 0)]. \]

Boundedness of \( r \) can be achieved by compactifying the feasible set. Natural upper bounds on the number of firms are \( \overline{M}_a \) and \( \overline{M}_b \), with \( \overline{M}_b \) defined by:

\[ (1 - \alpha)pZ_b \left(\frac{1}{\overline{M}_b}\right)^\alpha - \psi = 0 \] (remember that \( p \) is fixed).

We now show that \( R \) is strictly concave. The Hessian of the function \( y \) can be shown to be

\[ D^2y = -\alpha(1 - \alpha)\begin{bmatrix} Z_aN_a^{1+\alpha} & Z_aN_a^\alpha N_b \\ Z_aN_a^\alpha N_b & pZ_bN_b^{1+\alpha} \end{bmatrix} \]

using (2.3), and (2.5)-(2.7). When \( \theta \neq 1 \), \( D^2y \) is clearly negative definite for all pairs, except for \((0, 0)\), where it is not defined. (Remember that when \( \theta = 1 \), \( N_a = N_b \), and \( Z_a = pZ_b \).) Therefore, \( y \) is strictly concave for \((M_a, M_b) > 0 \) (note that the feasible set is obviously convex). It remains to show that \( i \) is weakly convex. But,

\[ i(M_a, M_b, M'_a, M'_b) = \begin{cases} 
\phi(M'_a - M_a + M'_b - M_b), & M'_a > M_a, M'_b > M_b \\
\phi(M'_a - M_a), & M'_a > M_a, M'_b \leq M_b \\
\phi(M'_b - M_b), & M'_a \leq M_a, M'_b > M_b \\
0, & M'_a \leq M_a, M'_b \leq M_b 
\end{cases} \]

Let I - IV be the regions that define \( i \). Then,

\[ I = \{(M_a, M_b, M'_a, M'_b) : M'_a > M_a, M'_b > M_b\} \]

and so on.
Clearly, if we take convex combinations of points that belong to the same region, the linearity of $i$ will be enough (for weak convexity). Suppose now that we take two points in different regions. Let $P_1 = (M_{a1}, M_{b1}, M'_{a1}, M'_{b1}) \in I$, and $P_2 = (M_{a2}, M_{b2}, M'_a, M'_{b2}) \in II$. (For simplicity we just prove that $g$ is convex for this combination of points. All other cases are similar.) Take $\lambda \in [0,1]$, and assume for now $\lambda M'_{b1} + (1 - \lambda) M'_{b2} > \lambda M_{b1} + (1 - \lambda) M_{b2}$. Then:

\[
i (\lambda P_1 + (1 - \lambda) P_2) = \phi (\lambda M'_{a1} + (1 - \lambda) M'_{a2} - \lambda M_{a1} - (1 - \lambda) M_{a2})
+ \phi (\lambda M'_{b1} (1 - \lambda) M'_{b2} - \lambda M_{b1} - (1 - \lambda) M_{b2})
= \phi (\lambda (M'_{a1} - M_{a1}) + (1 - \lambda) (M'_{a2} - M_{a2}))
+ \phi (\lambda (M'_{b1} - M_{b1}) + (1 - \lambda) (M'_{b2} - M_{b2}))
\leq \phi (\lambda (M'_{a1} - M_{a1}) + (1 - \lambda) (M'_{a2} - M_{a2})) + \phi \lambda (M'_{b1} - M_{b1})
= \lambda i (P_1) + (1 - \lambda) i (P_2)
\]

since $M'_{b2} \leq M_{b2}$, by assumption that $P_2 \in II$. If, instead $\lambda M'_{b1} + (1 - \lambda) M'_{b2} \leq \lambda M_{b1} + (1 - \lambda) M_{b2}$, then:

\[
i (\lambda P_1 + (1 - \lambda) P_2) = \phi (\lambda M'_{a1} + (1 - \lambda) M'_{a2} - \lambda M_{a1} - (1 - \lambda) M_{a2})
= \phi (\lambda (M'_{a1} - M_{a1}) + (1 - \lambda) (M'_{a2} - M_{a2}))
< \phi (\lambda (M'_{a1} - M_{a1}) + (1 - \lambda) (M'_{a2} - M_{a2})) + \phi \lambda (M'_{b1} - M_{b1})
= \lambda i (P_1) + (1 - \lambda) i (P_2)
\]

since $M'_{b1} > M_{b1}$, by assumption that $P_1 \in I$. This concludes the proof that $R$ is strictly concave.

When $\theta = 1$, $y = Za M^{1-\alpha} - \psi M$, with $M = Ma + Mb$. The industrial configuration is irrelevant except for the investment decisions, so we can trace out the relevant dynamics of the aggregate number of firms $M$ by analyzing the function $\bar{W} (M) = W (Ma, Mb)$. The function $\bar{W}$ has the same properties of function $W$, but with respect to $M$. ■

The following lemma gives an explicit analytical solution for the function $W$ for various values of $\theta$ in the case where the economy reaches a specialized steady state. Lemma 6.2 discusses the case in which a non-specialized steady state is reached. The knife-hedge case of $\theta = 1$ is a simplified version of the former case and is omitted.
Lemma 6.1. Assume $\theta > \bar{\theta} > 1$, so that the economy specializes in the steady state. Then, for any $M_b$,

$$W(M_a, M_b) = \begin{cases} 
  y(M_a, M_b) - \phi (M_a - M_a) + \frac{1}{\pi} y(M_a, 0) & , M_a < \bar{M}_a \\
  y(M_a, M_b) + \frac{1}{\pi} y(M_a, 0) & , \bar{M}_a \leq M_a \leq \bar{M}_a \\
  y(M_a, M_b) + \frac{1}{\pi} y(M_a, 0) & , M_a > \bar{M}_a.
\end{cases}$$

Proof. The proof uses the above guess with the implied decision rules to show that this function solves problem (2.11). One can show that our guess is strictly concave so that for any $(M_a, M_b)$, problem (2.11) solved with the above $W$ function admits only one solution. Instead of analyzing all feasible paths, we investigate only whether the suggested decision rules solve the first order conditions.

Pick any $M_b$, and $M_a < \bar{M}_a$. We guess that $M'_b = 0$, and $M'_a = \bar{M}_a$ is optimal.

The first-order conditions that need to be verified are:

$$\frac{1}{1 + r^*} \left((1 - \alpha) Z_a M_a^{1-\alpha} - \psi + \frac{(1 - \alpha) Z_b M_b^{1-\alpha} - \psi}{r^*}\right) = \phi$$

and

$$\mu_b = -\frac{1}{1 + r^*} \left((1 - \alpha) pZ_b \left(\frac{1}{\theta M_a}\right)^\alpha - \psi\right) > 0.$$ 

The first condition is obviously verified by definition of $\bar{M}_a$. The second condition states that the Lagrange multiplier associated with the constraint $M'_b \geq 0$, is strictly positive. Substituting for $\bar{M}_a$, we have

$$\mu_b = -\frac{1}{1 + r^*} \left(\theta^{-1} \phi r^* + (\theta^{-1} - 1) \psi\right) > 0$$

since $\theta > \bar{\theta}$.

Now, pick $\bar{M}_a \leq M_a \leq \bar{M}_a$, and any $M_b$. We guess that $M'_a = M_a$, and $M'_b = 0$. The first-order conditions that need to be verified are:

$$0 \leq \frac{1}{1 + r^*} W_{M_a} (M'_a, M'_b) \leq \phi$$

$$\mu_b = -\frac{1}{1 + r^*} \left((1 - \alpha) pZ_b \left(\frac{1}{\theta M_a}\right)^\alpha - \psi\right) > 0.$$ 

The second condition is equivalent to the one we had before, and is simply a virtue of the fact that there is specialization in sector $a$ in the steady state. The first
condition, however, states that the marginal benefit of increasing the number of firms in sector \(a\), \(\frac{1}{1+r^*} W_{M_a} (M'_a, M'_b)\), is not high enough for entry to occur, but is also not small enough to induce exit. To see that the first set of inequalities holds, we replace \(W_{M_a} (M'_a, M'_b)\) by its value at the guessed solution:

\[
0 \leq \frac{(1 - \alpha) Z_a M_a^{-\alpha} - \psi}{r^*} \leq \phi,
\]

which is true since \(\underline{M}_a \leq M_a \leq \bar{M}_a\).

Finally, let \(M_a > \bar{M}_a\), with any \(M_b\). The guess is \(M'_a = \bar{M}_a\), and \(M'_b = 0\). The associated first-order conditions are:

\[
0 = \frac{1}{1 + r^*} W_{M_a} (M'_a, M'_b)
\]

and

\[
\mu_b = -\frac{1}{1 + r^*} \left( (1 - \alpha) p Z_b \left( \frac{1}{r M_a} \right)^{\alpha} - \psi \right) > 0.
\]

The first condition requires that \((1 - \alpha) Z_a M_a^{-\alpha} - \psi = 0\), which is achieved by setting \(M'_a = \bar{M}_a\). The second condition holds because \(\theta > 1\).

To complete the proof we have to show that the value function \(W\) is recovered once we substitute the optimal solution into problem (2.11). This, however, is trivial. \(\blacksquare\)

The next lemma characterizes the value function \(W\) when \(\bar{\theta} \geq \theta > 1\). To facilitate the description of \(W\) we provide Figure 6.1, which defines the areas \(A\) through \(E\) which represent a partition of the feasible set.

In Lemma 6.2 and Proposition 6.3 we use the following notation: \(m_t(M_j, \pi)\) is next period's value of \(M_t\) that solves \(\pi'_t = \pi\), when \(M'_j = M_j\), \(i \neq j\).

**Lemma 6.2.** Assume \(\bar{\theta} \geq \theta > 1\). Then

\[
W(M_a, M_b) = \begin{cases} 
  y(M_a, M_b) - \phi(m_a(M_b, \phi r^*) - M_a) + \frac{1}{r} y(M_a(m_b, \phi r^*), M_b) & , (M_a, M_b) \in A \\
  y(M_a, M_b) + \frac{1}{r} y(M_a, M_b) & , (M_a, M_b) \in B \\
  y(M_a, M_b) + \frac{1}{r} y(M_a, M_b(M_a, 0)) & , (M_a, M_b) \in C \\
  y(M_a, M_b) + \frac{1}{r} y(M_a, 0) & , (M_a, M_b) \in D \\
  y(M_a, M_b) + \frac{1}{r} y(M_a, 0) & , (M_a, M_b) \in E 
\end{cases}
\]

39
Figure 6.1: The Domain of the $W$ Function: The Non-Specialized Steady State
Proof. The strategy of the proof is the same as in the proof of Lemma 6.1. The proof uses the above guess for the value function $W$ with the implied decision rules to show that this function solves problem (2.11). One can show that our guess is strictly concave so that for any $(M_a, M_b)$, problem (2.11) solved with the above $W$ function admits only one solution. Hence, we restrict attention to the suggested decision rules. This proof is very tedious and repetitive, and since no insight is lost, we shall limit it to the description of one case.

Suppose that $(M_a, M_b) \in A$. Then, we guess that $M'_a = m_a(M_b, \phi r^*) > M_a$, and $M'_b = M_b$, which implies $(M'_a, M'_b) \in B$. The first-order conditions that need to be verified are:

$$\frac{1}{1 + r^*} W_{M_a} (M'_a, M'_b) = \phi$$

and

$$0 \leq \frac{1}{1 + r^*} W_{M_b} (M'_a, M'_b) \leq \phi.$$ 

The first condition, when evaluated at the guessed optimum (recall the definition of $m_t(M_t, \pi)$), is equivalent to:

$$\frac{1}{1 + r^*} (\phi r^* + \phi) = \phi,$$

whereas the second condition is equivalent to:

$$0 \leq \frac{1}{r^*} \left( (1 - \alpha) p Z_b \left( \frac{1}{\theta M'_a + M'_b} \right)^\alpha - \psi \right) \leq \phi.$$ 

The left inequality is true since $\bar{\theta} \geq \theta$, whereas the right inequality is true given $\theta > 1$. It remains to show that $M'_a > M_a$. However, this is just an implication of $(M_a, M_b) \in A$, and profits of firms in sector $a$ being decreasing with $M_a$. Finally, note that with $(M'_a, M'_b) \in B$ we have,

$$W(M_a, M_b) = y(M_a, M_b) - \theta (m_a(M_b, \phi r^*) - M_a) + \frac{y(m_a(M_b, \phi r^*), M_b)}{r^*},$$

when $(M_a, M_b) \in A$. ■

Proof of Lemma 3.1: (Heuristic proof.)

Consider the following alternative reform path. Permanently reduce tariffs shifting the relative price of good $b$ from $p_1$ to $p_2$, and at time $T$, announce an unanticipated reversal of the reform bringing the relative price back to $p_1$. It is
obvious from our previous discussion that no firm in sector $a$ would exit when the reform is reversed, since exit of firms is sector $a$ from $T$ on would only occur if at time $T$, $M_a > \bar{M}_a$. (Recall that $\bar{M}_a$ is independent of $p$.) Now, consider again the trade reform path in the text of the Lemma. Since agents have more information compared to our alternative reform path above they can only do better in terms of achieving a higher value of $W$. That means that no exit of firms in sector $a$ will occur anyway. —

The remainder of the appendix explores the dynamics of the model with no access to the international capital market. We show that the only difference regarding the dynamics implied by Lemma 6.2 is that the convergence towards the steady state when there is firm growth (which is still restricted to sector $a$ because $\theta > 1$) is only asymptotic. We prove this result for the case $\bar{\theta} > \theta$, but it is easy to see that the same result holds for the case where the steady state is specialized.

**Proposition 6.3.** Assume $\bar{\theta} > \theta > 1$. The decision rules associated with problem (4.4) are the same as those implicit in Lemma 6.2 except that when the initial industry configuration is in area $A$, $M_{at} \rightarrow m_a(M_b, \phi r^*)$ as $t \rightarrow \infty$.

**Proof.** We start by noting that because of Assumption 2, the steady state sets in the models of section 2 and 4 are equivalent. Suppose then that the initial industry configuration $(M_a, M_b) \in A$. The first order conditions of problem (4.4) are the following:

\begin{align}
0 & \leq \beta U_1(M'_a, M'_b), \beta U_2(M'_a, M'_b) \\
\beta U_1(M'_a, M'_b) & \leq \phi \gamma C_a'^{-\sigma}, \text{ with equality if } M'_a > M_a \\
\beta U_2(M'_a, M'_b) & \leq \phi \gamma C_a'^{-\sigma}, \text{ with equality if } M'_b > M_b.
\end{align}

We first show that if $M'_a > M_a$, and $(M'_a, M'_b) \in A$, then $M'_b = M_b$. Next we show that if $M'_b = M_b$, then $M'_a > M_a$ is optimal, with $(M'_a, M'_b) \in A$. Assume then that in region $A$, $M_a$ is increasing over time. Then the envelope conditions are:

\begin{align*}
U_1(M'_a, M_b) &= \gamma \eta (C_a'^{-\sigma} (\pi'_a + \phi)) \\
U_2(M'_a, M_b) &= \gamma \eta (C_a'^{-\sigma} \pi'_b).
\end{align*}

Clearly, (6.1) is satisfied since $(M_a, M_b) \in A$, or $\pi'_a, \pi'_b \geq 0$. Equation (6.3) can be written, with the help of (6.2) (expressed as an equality), as:

\[ \beta \gamma \eta (C_a'^{-\sigma} \pi'_b) < \gamma \eta (C_a'^{-\sigma} (\pi'_a + \phi)). \]
Using (2.10) this inequality this inequality is equivalent to

\[ 0 < (\theta - 1) (\psi + \pi'_b) + \phi \]

which is always true given \( \theta > 1 \). Therefore \( M'_b = M_b \) is optimal.

Assume now that the optimal solution prescribes \( M'_b = M_b \). If \( M'_a = M_a \), then we must be at a steady state, but we know that since \( (M_a, M_b) \in A, \pi'_a > \phi r^* \). Therefore, \( M'_a = G(M_a, M_b) > M_a \) (where \( G \) denotes the optimal decision rule). Finally, besides showing that \( M'_a > M_a \), we’re also required to show that \( M_a \) is increasing over time, that is, that \( G \) is strictly increasing in its first argument. To see this take \( M_a < M_a \) and assume the contrary, that \( G(M_a, M_b) \leq G(M_a, M_b) \).

Taking the ratio of the first order condition evaluated at these points we have

\[
\frac{\beta U'(G(M_{a1}, M_b), M_b)}{\beta U'(G(M_{a2}, M_b), M_b)} = \frac{\phi \gamma \eta (pZ_b(\theta M_{a1} + M_b)^{1-\sigma} - \psi (M_{a1} + M_b) - \phi(G(M_{a1}, M_b) - M_{a1}))^{-\sigma}}{\phi \gamma \eta (pZ_b(\theta M_{a2} + M_b)^{1-\sigma} - \psi (M_{a2} + M_b) - \phi(G(M_{a2}, M_b) - M_{a2}))^{-\sigma}}.
\]

The left-hand-side is less than or equal than unity because \( U \) is strictly concave. However, the right-hand-side is strictly bigger than one since \( G(M_{a2}, M_b) - M_{a2} < G(M_{a1}, M_b) - M_{a1} \), and \( (M_a, M_b) \in A \). This contradiction yields the first result.

Suppose now that the initial industry configuration \( (M_a, M_b) \in C \). It is clear that the solution encompasses \( 0 \leq \beta U_1 (M_a, m_b(M_a, 0)) \leq \phi \gamma \eta C_a^{-\sigma} \), and \( \beta U_2 (M_a, m_b(M_a, 0)) = 0 \), which requires that

\[ \pi'_b = 0. \]

This is immediately verified as suggested by our construction of the function \( m_b(M_a, 0) \).

The other cases are similar and are left without proof. ■
ROCHESTER CENTER FOR ECONOMIC RESEARCH


WP#441  "What Happens When Countries Peg Their Exchange Rates? (The Real Side of Monetary Reforms)" Rebelo, Sergio, August 1997.


WP#449  “The Role of Investment-Specific Technological Change in the Business Cycle”
         Greenwood, Jeremy, Hercowitz, Zvi, Krusell, Per, May 1998

WP#450  “Constrained Egalitarianism: A New Solution for Claims Problems”
         Youngsub Chun, James Schummer, and William Thompson, July 1998

WP#451  “Guidelines on Writing Referee Reports”
         William Thomson, July 1998

WP#452  “A Revelation Principle for Competing Mechanisms”
         Larry G. Epstein, Michael Peters, July 10

WP#453  “A Definition of Uncertainty Aversion”
         Larry G. Epstein, July 1998

WP#454  “On The Dynamics of Trade Reform”
         Rui Albuquerque and Sergio Rebelo, July 1998