



Centre for International
Economic Studies

Discussion Paper
No. 0317

Open Economy Schumpeterian Growth

Raul A. Barreto and Kaori Kobayashi

May 2003

**University of Adelaide
Adelaide 5005 Australia**

CENTRE FOR INTERNATIONAL ECONOMIC STUDIES

The Centre was established in 1989 by the Economics Department of the Adelaide University to strengthen teaching and research in the field of international economics and closely related disciplines. Its specific objectives are:

- to promote individual and group research by scholars within and outside the Adelaide University
- to strengthen undergraduate and post-graduate education in this field
- to provide shorter training programs in Australia and elsewhere
- to conduct seminars, workshops and conferences for academics and for the wider community
- to publish and promote research results
- to provide specialised consulting services
- to improve public understanding of international economic issues, especially among policy makers and shapers

Both theoretical and empirical, policy-oriented studies are emphasised, with a particular focus on developments within, or of relevance to, the Asia-Pacific region. The Centre's Director is Professor Kym Anderson (kym.anderson@adelaide.edu.au).

Further details and a list of publications are available from:

Executive Assistant
CIES
School of Economics
Adelaide University
SA 5005 AUSTRALIA
Telephone: (+61 8) 8303 5672
Facsimile: (+61 8) 8223 1460
Email: cies@adelaide.edu.au

Most publications can be downloaded from our Home page: <http://www.adelaide.edu.au/cies/>

ISSN 1444-4534 series, electronic publication

CIES DISCUSSION PAPER 0317

Open Economy Schumpeterian Growth

Raul A. Barreto and Kaori Kobayashi

Centre for International Economic Studies and
School of Economics
University of Adelaide

cies@adelaide.edu.au

May 2003

Abstract

This paper examines the Aghion and Howitt [1992] “creative destruction” endogenous growth model in an open economy setting. We consider four alternative trade regimes. The first two regimes allow the monopoly producer of the intermediate good to attain worldwide monopoly rents. In the first of the two, the countries engage in trade of only the imperfectly produced intermediate good. In the second, the two countries trade in both the intermediate good as well as in ideas. The last two regimes consider two countries which are identical before and after trade opens such that pro-competitive gains from trade are achieved. We again consider when only intermediaries may be traded and thereafter when both intermediaries and ideas may be traded. We find that the effects of trade on growth and welfare depend critically on the assumptions one imposes.

Keywords: Creative Destruction, Obsolescence, Endogenous Growth, International Trade, Imperfect Competition, Schumpeterian Growth

JEL classification: F12, F15, F43, O30

1. Introduction

The goal of new growth theory is to shed light on the nature of long run growth in per capita income. Irrespective of which model one chooses to employ as the framework for analysis of growth, the Ramsey (1928) model, its more modern Lucas (1988) version, or the Diamond (1965) model, the underlying result is the same. When technological advances are assumed to be exogenous, long run per capita income growth can only result from increasing productivity of labor. In other words, GDP per capita can only grow in the long run as a result of continuous technological change. As a consequence of this theoretical regularity, several authors have considered the nature of technology and its evolution.

Two influential papers in New Growth Theory are Romer (1990) and Aghion and Howitt (1992). They are similar in that they both consider technological change to be the result of researchers whose incentive it is to capture monopoly rents from their inventions. Research firms in Romer (1990) add to the level of technology through successive innovations. The firms combine human capital effort with the existing stock of knowledge to move technology forward one innovation at a time. The new innovation enters the production process through the incumbent firm who shifts its efforts from research to monopoly production of the newest intermediate input. Final goods production combines the latest intermediate good and work effort. The only input needed to produce the latest intermediate good is the one that immediately preceded it. Once a researcher comes up with an innovation, he owns monopoly rights over its production for ever after. Furthermore, there always exists a market for every patent, however many generations back from the most current innovation it was introduced, since each

successive innovation becomes an intermediate good whose production requires its predecessor. There ultimately develops a continuum of intermediate goods, each absolutely necessary to its successor, that lead up to final goods, which of course requires the latest intermediary.

Aghion and Howitt (1992) also consider patent exploitation as the incentive to conduct research. The fundamental difference in their model is that the production of each new improved intermediate good requires only work effort. Therefore, since final goods production still depends on the most current intermediate good, the latest intermediary replaces its predecessor. Hence, technological change is the result of continuous obsolescence or “creative destruction.” Research firms compete to introduce the latest innovation at which time they cease researching and concentrate on production and consequently on profits. Unlike Romer (1990), the patents only last until the next innovation renders the current one obsolete. Although technological advances occur randomly, they do so with a discernable Poisson arrival rate. Thus on average, one may consider the likelihood of a technological advance within a given span of time.

Extensions of the above two seminal papers are numerous and cover many of the stylized facts that we observe in the world. Of particular interest here are the implications of international trade on technological change. Rivera-Batiz and Romer (1991) consider the open economy version of Romer (1990). Therein, they consider two economies that may trade in the imperfectly produced intermediate good as well as trade in ideas. Their incumbent innovator may capture monopoly rents in both the home and foreign markets. An interesting facet of their paper is that although they assume that the two countries are identical while in autarky, the countries cease to be so with integration. As a result, the

two countries take turns innovating. This issue was first noted by Devereux and Lapham (1994). They find that if either country differs even slightly in size, relative research effort would favor the larger country. At the limit, the larger country through faster growth does all of the research for the whole world. In Barreto and Kobayashi (2001), we consider the implications of the two countries remaining identical even after integration. Our findings parallel the standard trade literature results of pro-competitive gains from trade between countries where one or more of the traded goods are imperfectly produced. Thus, we find that imperfect competition is a sufficient determinant of trade even between otherwise identical countries. Other papers that have considered various aspects of Schumpeterian growth in an open economy include Verspagan and Wakelin (1997), Dinoupoulos and Syropoulos (1997), and Dinoupoulos and Segerstrom (1999).

In the following paper, we consider both assumptions. Section 2 reviews the basic Aghion and Howitt (1992) model in a closed economy setting to serve as a benchmark. Section 3 considers economic integration of two countries using their framework. Subsections 3.1 and 3.2 consider, as in Rivera-Batiz and Romer (1991), the availability of worldwide monopoly rents, first when only intermediaries may be traded and then when both intermediaries as well as ideas may be traded. Sections 3.3 and 3.4 consider, as in Barreto and Kobayashi (2001), the pro-competitive gains from trade that result from a duopoly after integration. Again, we consider first, if only intermediate goods may be traded and second, if intermediate goods as well as ideas may be traded. Section 4 compares the results across the four possible cases. Section 5 presents some conclusions.

2. Closed Economy

The following is a summary of the Schumpeterian approach to endogenous technological change introduced by Aghion and Howitt (1992). Throughout this section, we assume autarky within each country.

The economy consists of three sectors: a final goods sector, an intermediate goods sector, and a R&D sector, all of which behave to maximize the representative agent's utility function.

$$U(y) = \int_0^{\infty} e^{-r\tau} y_{\tau} d\tau \quad (0.1)$$

Only the final good, y , can only be consumed and it is subject to the discount rate, r . It is produced using only the most recent version of the intermediate goods, x , according to the following production function.

$$y = Ax^{\alpha} \quad (0.2)$$

This is the essence of the technological change resulting from obsolescence. Firms compete across time to produce an ever-improving intermediate good. When a firm develops a successful innovation, it is rewarded with monopoly profits derived from the sale of its version of x_t to the final goods producer of y_t .

The aggregate flow of labor supply, L , has two competing uses, intermediate goods production and research. Intermediate firms employ a simple one for one linear production function such that x is also the amount of labor used in producing intermediate goods. The development of new innovations is also a result of a simple linear technology such that n is the amount of labor used in research. Hence the labor-market clearing condition is

$$L = n + x \quad (0.3)$$

The level of technology, A_t , increases through successive innovations, t , that make its initial level, A_0 , ever more productive. Each new innovation raises productivity of A by a factor of γ such that

$$A_t = A_0 \gamma^t \quad \gamma > 1 \quad (0.4)$$

Innovations arrive randomly with a Poisson arrival rate of $\lambda \cdot \Phi(n)$, where $\Phi(n)$ is a constant returns to scale function of research effort, n , and $\lambda > 0$ is the productivity parameter of research technology.

$$\lambda \Phi(n) = \lambda n \quad (0.5)$$

The profit function associated with a new innovation is

$$\Pi_t^{RD} = \lambda n_t V_{t+1} - w_n n_t \quad (0.6)$$

where V_{t+1} is the discounted expected payoff to the $(t+1)^{th}$ innovation from research conducted in during period t .

$$V_{t+1} = \frac{\Pi_{t+1}^{x_{t+1}}}{r + \lambda n_{t+1}} \quad (0.7)$$

Therefore, the research firm's first order condition may then be expressed as a function of the expected payoff.

$$w_n^* \geq \lambda V_{t+1} = \frac{\lambda \Pi_{t+1}^{x_{t+1}}}{r + \lambda n_{t+1}} \quad (0.8)$$

The profit function faced by final goods producers and its consequent first order condition are defined as follows.

$$\Pi_t^y = y_t - p_x x_t = A_t x_t^\alpha - p_x x_t \quad (0.9)$$

$$p_x = \alpha A_t x_t^{\alpha-1} \quad (0.10)$$

The profit function faced by an intermediary and its consequent first order condition are defined as follows.

$$\Pi_t^x = p_x x_t - w_x x_t = \alpha A_t x_t^\alpha - w_x x_t \quad (0.11)$$

$$w_x^* \geq \alpha^2 A_t x_t^{\alpha-1} \quad (0.12)$$

Note that the wage paid by the intermediary may also be used to determine the demand for labor.

$$x_t^* = \left(\frac{A_t \alpha^2}{w_x} \right)^{\frac{1}{1-\alpha}} \quad (0.13)$$

The inverse demand for the intermediate good may be expressed simply as a function of the wage.

$$p_x^* = \alpha A_t \left(\frac{A_t \alpha^2}{w_x} \right)^{\frac{\alpha-1}{1-\alpha}} = \frac{w_x}{\alpha} \quad (0.14)$$

Therefore, the monopoly profits to the intermediary for the most recent innovation may be expressed as follows.

$$\Pi_t^{x*} = \left(\frac{1}{\alpha} - 1 \right) w_x x_t^* \quad (0.15)$$

The labor market is competitive so that $w_x^* = w_n^*$ and the labor market clearing condition may then be expressed as

$$1 = \frac{\lambda \gamma \left(\frac{1-\alpha}{\alpha} \right) (L - n_t^*)}{r + \lambda n_{t+1}^*} \quad (0.16)$$

Accordingly, the research labor input, n^* , which satisfies equation (0.16) may be expressed as

$$n^*_{AUT} = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{AUT}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)} \quad (0.17)$$

It is important to note that the interest rate, r , which is defined as the marginal product of intermediate goods in final goods production is, in the steady state equal to the discount rate.

$$r_{AUT} = \alpha Ax^{\alpha-1} \quad (0.18)$$

Finally, we are only left to determine the real time growth rate in output, $\frac{\dot{y}_\tau}{y_\tau}$. In

order to do so, consider first the flow of final output, y_t , between two successive innovations, t and $(t+1)$. The level of output, for any given innovation, is defined simply as

$$y_t = A_t x_t^\alpha = A_t (L - n_t)^\alpha \quad (0.19)$$

Technology changes at the fixed rate per innovation equal to γ . Therefore, the relationship of output between consecutive innovations is defined as

$$y_{t+1} = \gamma y_t \quad (0.20)$$

We may then interpret the log of equation (0.20) to imply that the real time output level, y_τ , increases by $(\ln \gamma)$ with each new innovation. The real time growth of output is determined by the number of innovations between period τ and $(\tau+1)$. Therefore

$$\ln y_{\tau+1} = (\ln \gamma) \varepsilon_\tau + \ln y_\tau \quad (0.21)$$

where ε_τ equals the number of innovations between period τ and $(\tau+1)$ and is distributed randomly with a Poisson arrival rate of λn_t . Simple substitution yields that

the average growth rate of output is defined as follows.

$$g^*_{AUT} = \frac{\dot{y}_t}{y_t} = \lambda n^*_{AUT} (\ln \gamma) \quad (0.22)$$

3. Open Economy

In the closed economy, the intermediary solely owns and therefore exploits the leading-edge technology as a monopolist. However, once trade opens, the effects on the welfare and the growth rate of the economies in question depend critically upon the assumption that one adopts covering the nature of the two economies and their subsequent trade. One may either assume that trade allows each innovating firm to garner worldwide monopoly rents or that each country has its own imperfectly competitive intermediary that produces a perfect substitute for its foreign counterpart. Trade under the latter assumption results in cross border duopolistic competition and pro-competitive gains from trade.

Trade in which the intermediate firm establishes a worldwide monopoly over its innovation is described in Rivera-Batiz and Romer (1991). Therein, they consider knowledge driven endogenous technological change, as is described in Romer (1990), where trade in intermediate goods without trade in ideas has no growth or welfare effects whatsoever. Their premise is intuitively simple. If the intermediate goods market is defined by imperfect competition, and the uniqueness of innovations extends worldwide, trade in a two-country model exactly doubles the size of the market faced by incumbent innovators. But since the incumbent innovator, whether home or foreign, faces twice the competition from both home and foreign R&D firms, the larger market is only available for half the time. One effect cancels the other such that trade in goods without trade in

ideas has no net growth or welfare effects. Once trade in ideas is allowed, in addition to trade in intermediate goods, both positive welfare and growth effects result.

Alternatively, if one considers two identical countries in autarky and then maintains that they are still identical even after economic integration, trade in goods without trade in ideas results in pro-competitive gains. The result is intuitively similar to that which is found in the trade literature on imperfect competition as a determinant to trade between identical countries.¹ When two identical countries trade and the traded good is produced by local monopolies, the result is a duopoly where the two imperfect competitors share the worldwide market. This alternative, again using the Romer (1990) framework, is explored by Barreto and Kobayashi (2001). We find that trade in goods without trade in ideas has a negative growth effect but a positive welfare effect. Furthermore, once trade in ideas is also allowed, we show that the growth benefits of trade in ideas outweigh the negative growth effects of the pro-competitive gains from trade in intermediate goods.

There are analytic strengths as well as weaknesses to either lines of reasoning.² The main strength of Rivera-Batiz and Romer (1991) relates to the concept a worldwide monopoly as the incentive to innovate. The main weakness therein is the stepwise nature of trade where each country is forced to take turns innovating. The main strength of Barreto and Kobayashi (2001) is the pro-competitive gains result and its relation to the trade literature. The main weakness in our paper is that even without trade in ideas, each country comes up with identical competing innovations.

In the following analysis of economic integration in a Schumpeterian growth model, we consider both assumptions. Sections 3.1 and 3.2 consider trade in both intermediate goods and ideas under the same assumptions as Rivera-Batiz and Romer (1991). Sections

3.3 and 3.4 consider trade in both intermediate goods and ideas under the same assumptions as Barreto and Kobayashi (2001).

3.1 Trade in Intermediate goods ($x^H \neq x^F$)

Suppose that there are two monopolists, one per country, producing x_t at any given innovation, t . Let x^F be the foreign intermediate goods and x^H be the home intermediate good. Assume that the two countries are identical only until the time of integration. Once trade commences, the countries become differentiated such that $x^H \neq x^F$ and each incumbent intermediate good producer can garner monopoly rents across the entire world.³

Each country produces final goods according to the following production function.

$$y = f(x^H \text{ or } x^F) = Ax^\alpha \quad (1.1)$$

Thus output, at any given time, is a function of the most current innovation. That innovation may originate from home or abroad. As before, the interest rate and in the steady state, the discount rate, is the marginal product of intermediate goods used in final production.

$$r = \alpha Ax^{\alpha-1} \quad (1.2)$$

The profit function faced by final goods producers and its consequent first order condition are the same as before.

$$\Pi_t^y = y_t - p_x x_t = A_t x_t^\alpha - p_x x_t \quad (1.3)$$

$$p_x = \alpha A_t x_t^{\alpha-1} \quad (1.4)$$

Note that p_x is the monopoly price of the latest innovation, x_t , as determined by the

incumbent intermediate producer who may be foreign or domestic.

The monopolist intermediate goods producer, whether home or foreign, maximizes the following profit function and yields the subsequent first order conditions.

$$\Pi_t^x = p_x(2x_t) - w_x(2x_t) \quad (1.5)$$

$$w_x^* = \alpha^2 A_t x_t^{\alpha-1} \quad (1.6)$$

$$x_t^* = \left(\frac{\alpha^2 A_t}{w_x} \right)^{\frac{1}{1-\alpha}} \quad (1.7)$$

The monopoly profits can further be expressed as follows.

$$\Pi_t^{x*} = 2 \left(\frac{1}{\alpha} - 1 \right) w_x x_t^* \quad (1.8)$$

The profit function faced by each R&D firm, whether home or foreign, is defined as

$$\Pi_t^{RD} = \lambda n_t V_{t+1} - w_n n_t \quad (1.9)$$

The effect of the larger market again enters the system analytically through the V_{t+1} term, which is defined as the discounted expected payoff to the $(t+1)^{th}$ innovation from research conducted in during period t .

$$\begin{aligned} r(2V_{t+1}) &= \Pi_{t+1}^{x_{t+1}} - \lambda n_{t+1} (2V_{t+1}) \\ V_{t+1} &= \frac{\Pi_{t+1}^{x_{t+1}}}{2r + 2\lambda n_{t+1}} \end{aligned} \quad (1.10)$$

Therefore, the research firm's first order condition may be expressed as

$$w_n^* \geq \lambda V_{t+1} = \frac{\lambda \Pi_{t+1}^{x_{t+1}}}{2r + 2\lambda n_{t+1}} \quad (1.11)$$

The competitive labor market where $w_x^* = w_n^*$, yields the market clearing condition.

$$1 = \frac{2\lambda\gamma\left(\frac{1-\alpha}{\alpha}\right)(L-n^*_t)}{2(r+\lambda n^*_{t+1})} \quad (1.12)$$

Accordingly, the labor input, n^* , for R&D which satisfies this (1.12) may be expressed as follows.

$$n^*_{3.1} = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.1}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)} \quad (1.13)$$

Notice that equation (1.13) is identical to equation (0.17). The optimal allocation of work effort toward research is the same under autarky as it is under trade in intermediate goods. Therefore, the consequent growth rates of output under the two regimes must also be equal.

$$g^*_{3.1} = \frac{\dot{y}_t}{y_t} = \lambda n^*_{3.1} (\ln \gamma) \quad (1.14)$$

3.2 Trade in Intermediate goods and Ideas ($x^H \neq x^F$)

Once again we assume, that both countries are not identical upon integration. Only now, in addition to trade in intermediate goods, the countries may also trade ideas. This concept is modeled by allowing the two countries to share in each others' research efforts such that for each country, $2n = n^F + n^H$.

As before, each country produces final goods using the most current innovation, irrespective of whether that innovation originates at home or abroad. Therefore, the final goods firm's profit function is identical to that found in section 3.1. Furthermore, the intermediary monopolist's profit function is also identical to that from the previous

section. For the sake of continuity, those equations are reproduced here in summary.

$$\Pi_t^y = y_t - p_x x_t = A_t x_t^\alpha - p_x x_t \quad (2.1)$$

$$p_x = \alpha A_t x_t^{\alpha-1} \quad (2.2)$$

$$\Pi_t^x = p_x (2x_t) - w_x (2x_t) = 2\alpha A_t x_t^\alpha - 2w_x x_t \quad (2.3)$$

$$w_x^* = \alpha^2 A_t x_t^{\alpha-1} \quad (2.4)$$

$$x_t^* = \left(\frac{\alpha^2 A_t}{w_x} \right)^{\frac{1}{1-\alpha}} \quad (2.5)$$

$$\Pi_t^{x*} = 2 \left(\frac{1}{\alpha} - 1 \right) w_x x_t^* \quad (2.6)$$

As mentioned earlier, trade in ideas takes the form of countries sharing their research effort with one another. Although each country's R&D firm benefits from the other's efforts, each need only pay its own employees. The profit function faced by R&D firm therefore takes the following form.

$$\Pi_t^{RD} = \lambda (n_t^H + n_t^F) V_{t+1} - w_n n_t \quad (2.7)$$

V_{t+1} , again defined as the discounted expected payoff to the $(t+1)^{th}$ innovation from research conducted in during period t , but is determined slightly differently than before.

$$\begin{aligned} r(2V_{t+1}) &= \Pi_{t+1}^{x_{t+1}} - \lambda (n_{t+1}^H + n_{t+1}^F) (2V_{t+1}) \\ V_{t+1} &= \frac{\Pi_{t+1}^{x_{t+1}}}{2r + 4\lambda n_{t+1}} \end{aligned} \quad (2.8)$$

The research firm's consequent first order condition may be expressed as follows.

$$w_n^* \geq \lambda V_{t+1} = \frac{\lambda \Pi_{t+1}^{x_{t+1}}}{r + 2\lambda n_{t+1}} \quad (2.9)$$

The competitive labor market yields the market clearing condition, which may be

expressed as

$$1 = \frac{2\lambda\gamma\left(\frac{1-\alpha}{\alpha}\right)(L-n^*_t)}{r+2\lambda n^*_{t+1}} \quad (2.10)$$

Accordingly, the optimal labor input, n^* , for R&D which satisfies this (2.10) may be expressed as follows.

$$n^*_{3.2} = \frac{2\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.2}}{2\lambda+2\lambda\gamma\left(\frac{1}{\alpha}-1\right)} \quad (2.11)$$

Intuitively, once trade in ideas is introduced in addition to trade in intermediate goods, the period between innovations should be shorter. In other words, one would expect that through cooperation in research, one country's R&D firm can catch up and, using the foreign competitor's idea, improve upon the product in question. The analytic solution for the growth rate of income demonstrates this idea.

$$g^*_{3.2} = \frac{\dot{y}_\tau}{y_\tau} = \lambda 2n^*_{3.2} (\ln \gamma) \quad (2.12)$$

3.3 Trade in Intermediate goods ($x^H = x^F$)

In this section and the next, we consider the case where the two countries are absolutely identical in autarky as well as in trade. This mode of analysis parallels the standard trade literature's approach to imperfect competition as a determinant of trade. As in that line of research, imperfect competition in one or more traded goods leads to pro-competitive gains from trade between otherwise identical countries.

Suppose again that there are two monopolists, one per country, producing x_t at any

given innovation, t . Since they are completely identical, each monopolist produces a version of the most current innovation. The two versions are perfect substitute for one another. Once trade in intermediate goods is allowed, the final goods producer in each country effectively faces a duopoly. Just as in the trade literature, it is the ability of the final goods producer to buy from abroad that changes the market structure of intermediate goods from monopoly to duopoly. Actual trade in intermediate goods does not occur since there is no need. The firm's production function therefore takes the following form.

$$y = A(x^H + x^F)^\alpha \quad (3.1)$$

As a result of the new market structure, the interest rate, defined as the marginal product of intermediate goods in final production, takes the following form.

$$r = 2\alpha A(2x)^{\alpha-1} \quad (3.2)$$

The final goods producer's profit function and its consequent first order condition are then defined as

$$\Pi_t^y = y_t - p_x(x_t^H + x_t^F) = A_t(2x_t)^\alpha - p_x(2x_t) \quad (3.3)$$

$$p_x = \alpha A_t(2x_t)^{\alpha-1} \quad (3.4)$$

The profit function faced by duopolist is analytically similar to autarky but the consequent first order conditions change to reflect the Cournot price.

$$\Pi_t^x = p_x x_t - w_x x_t = 2^{\alpha-1} \alpha A_t x_t^\alpha - w_x x_t \quad (3.5)$$

$$w_x^* = \alpha^2 A_t (2x_t)^{\alpha-1} \quad (3.6)$$

$$x_t^* = \frac{1}{2} \left(\frac{\alpha^2 A_t}{w_x} \right)^{\frac{1}{1-\alpha}} \quad (3.7)$$

The profits to the duopolist can therefore be expressed as

$$\Pi_t^{x*} = \left(\frac{1}{\alpha} - 1 \right) w_x x_t^* \quad (3.8)$$

As in section 3.1, the profit function faced by R&D sector is defined as follows.

$$\Pi_t^{RD} = \lambda n_t V_{t+1} - w_n n_t \quad (3.9)$$

where V_{t+1} is the discounted expected payoff to the $(t+1)^{th}$ innovation from research conducted in during period t which is determined from the following.

$$\begin{aligned} rV_{t+1} &= \Pi_{t+1}^{x_{t+1}} - \lambda n_{t+1} V_{t+1} \\ V_{t+1} &= \frac{\Pi_{t+1}^{x_{t+1}}}{r + \lambda n_{t+1}} \end{aligned} \quad (3.10)$$

Therefore, the research firm's first order condition may be expressed as

$$w_n^* \geq \lambda V_{t+1} = \frac{\lambda \Pi_{t+1}^{x_{t+1}}}{r + \lambda n_{t+1}} \quad (3.11)$$

The competitive labor market clearing condition may be expressed as

$$1 = \frac{\lambda \gamma \left(\frac{1-\alpha}{\alpha} \right) (L - n_t^*)}{r + \lambda n_{t+1}^*} \quad (3.12)$$

Accordingly, the labor input in research, n^* , which satisfies this (3.12) may be expressed as follows.

$$n_{3.3}^* = \frac{\lambda \gamma \left(\frac{1}{\alpha} - 1 \right) L - r_{3.3}}{\lambda + \lambda \gamma \left(\frac{1}{\alpha} - 1 \right)} \quad (3.13)$$

Notice that the analytic solution to the optimal research effort, equation (3.13), is similar in construction to that from autarky, equation (0.17). But, it is important to note they are indeed different because of the interest rate under duopoly, equation (3.2), is not the same

as the interest rate under autarky, equation (0.18). As a result, although analytically similar to autarky, the average growth rate of income also differs with trade.

$$g^*_{3.3} = \frac{\dot{y}_t}{y_t} = \lambda n^*_{3.3} (\ln \gamma) \quad (3.14)$$

3.4 Trade in Intermediate goods and Ideas ($x^H = x^F$)

We again assume that both countries are absolutely identical before and after integration. Similar to the changes from sections 3.1 to 3.2, here we modify section 3.3 to allow trade in ideas in addition to trade in intermediate goods. Again, this concept is modeled by allowing both countries R&D firms to share in each other's research effort such that $2n = n^F + n^H$.

The final good producer's profit function, the intermediary's producer's profit functions and consequent first order conditions are the same as in section 3.3. We reproduce them here to maintain the paper's continuity.

$$y = A(x^H + x^F)^\alpha \quad (4.1)$$

$$r = 2\alpha A(2x)^{\alpha-1} \quad (4.2)$$

$$\Pi_t^y = y_t - p_x(x_t^H + x_t^F) = A_t(2x_t)^\alpha - p_x(2x_t) \quad (4.3)$$

$$p_x = \alpha A_t(2x_t)^{\alpha-1} \quad (4.4)$$

$$\Pi_t^x = p_x x_t - w_x x_t = 2^{\alpha-1} \alpha A_t x_t^\alpha - w_x x_t \quad (4.5)$$

$$w_x^* = \alpha^2 A_t(2x_t)^{\alpha-1} \quad (4.6)$$

$$x_t^* = \frac{1}{2} \left(\frac{\alpha^2 A_t}{w_x} \right)^{\frac{1}{1-\alpha}} \quad (4.7)$$

$$\Pi_t^{x*} = \left(\frac{1}{\alpha} - 1 \right) w_x x_t^* \quad (4.8)$$

The R&D firm in each country now faces a profit function that must account for the benefits of the added research productivity.

$$\Pi_t^{RD} = \lambda (n_t^H + n_t^F) V_{t+1} - w_n n_t \quad (4.9)$$

where V_{t+1} is determined as follows.

$$\begin{aligned} rV_{t+1} &= \Pi_{t+1}^{x_{t+1}} - \lambda (n_{t+1}^H + n_{t+1}^F) V_{t+1} \\ V_{t+1} &= \frac{\Pi_{t+1}^{x_{t+1}}}{r + 2\lambda n_{t+1}} \end{aligned} \quad (4.10)$$

Therefore, the research firm's first order condition may be expressed as

$$w_n^* \geq 2\lambda V_{t+1} = \frac{2\lambda \Pi_{t+1}^{x_{t+1}}}{r + 2\lambda n_{t+1}} \quad (4.11)$$

The competitive labor market results in the following market clearing condition.

$$1 = \frac{2\lambda \gamma \left(\frac{1-\alpha}{\alpha} \right) (L - n_t^*)}{r + 2\lambda n_{t+1}^*} \quad (4.12)$$

Accordingly, the analytic solution for the optimal labor input to the R&D firm which satisfies equation (4.12) may be expressed as follows.

$$n_{3.4}^* = \frac{2\lambda \gamma \left(\frac{1}{\alpha} - 1 \right) L - r_{3.4}}{2\lambda + 2\lambda \gamma \left(\frac{1}{\alpha} - 1 \right)} \quad (4.13)$$

And the average growth rate of income is defined as

$$g^*_{3.4} = \frac{\dot{y}_\tau}{y_\tau} = \lambda 2n^*_{3.4} (\ln \gamma) \quad (4.14)$$

Little can be said from simple inspection of the analytic solution for n^* or g^* . Fortunately though, careful analysis conducted in the next section, reveals that all four cases are comparable such that firm conclusions may be drawn about the effects of trade in goods and in ideas on growth and welfare when endogenous technological change is defined by creative destruction.

4. Comparisons

The following analysis considers the effects of free trade on growth rates and welfare. We compare the results of section (3.1) through (3.4). Table 1 summarizes the results from autarky and the four cases. Note that case (3.1) is exactly the same as the autarky. As mentioned before, the intuition behind this result is simple. The intermediary monopolist in the case (3.1) produces twice as much x as the intermediary monopolist in autarky but for a half the time. Thus trade in intermediate goods without trade in ideas has no growth or welfare effects whatsoever. Henceforth, we will not mention case (3.1) but instead consider only autarky as the benchmark.

To determine trade's effect on average growth rates of output, we need to compare not only the labor efforts across cases, but also all of the various components that directly and indirectly determine the average growth rate. The following presents mostly intuitive explanations for the relationships across the cases. Appendix 2 contains the analytic proofs that coincide with the following results.

First, compare the optimal relative research efforts in each of the four cases. The results may be summarized as follows.

$$n^*_{3.2} > n^*_{3.4} > n^*_{AUT} > n^*_{3.3}$$

When trade in ideas allowed, as in cases (3.2) and (3.4), the efficiency of research labor effectively doubles in both countries. With higher marginal products of research effort, both $n^*_{3.2}$ and $n^*_{3.4}$ are higher than autarky research effort, n^*_{AUT} . Since the monopolist in the case (3.2) enjoys higher profits than the duopolist in the case (3.4), the incumbent researcher in case (3.2) has that more to gain from being the next innovator. The greater incentive is reflected by more research effort, thus $n^*_{3.2} > n^*_{3.4}$. The R&D firm in case (3.3) has the least to gain as a duopolist without the benefit of shared research. His research is the least productive of all and consequently he has the lowest relative research effort.

Second, consider the relative employment by the intermediaries. Recall that since the labor markets are competitive, i.e. $L = n + x$, the following results must mirror those from the employment by the research firms.

$$x^*_{3.2} < x^*_{3.4} < x^*_{AUT} < x^*_{3.3}$$

$x^*_{3.2} < x^*_{3.4}$ and $x^*_{AUT} < x^*_{3.3}$ are easily justified as the pro-competitive gains from trade results. As the market structure shifts from monopoly to duopoly, output of x increases. The fact that $x^*_{3.4} < x^*_{AUT}$ implies that the positive wealth effect in terms of research from trade in ideas is relatively greater than the negative substitution effect from trade in intermediate goods.

Third, compare the intermediate good prices that are set by the various imperfect competitors.

$$P_{3.2} > P_{AUT} > P_{3.4} > P_{3.3}$$

Diagrams 1 through 8 compare the various price and quantities set by the imperfect competitors under the differing regimes. In Diagram 5, the international monopolist which also enjoys the benefits of trade in ideas, sets his price, $p_{3,2}$, higher and his quantity lower than the autarky monopolist. Thus the productivity benefits of trade in ideas, reflected in the marginal cost to the monopolist, outweigh the effects of reduced demand for intermediate goods. In Diagram 2, which compares the duopolist that enjoys the benefits of trade in ideas to autarky, the opposite is the case. Although the researchers in cases (3.4) gain productivity from shared ideas, those benefits are outweighed by the fall in demand for intermediate goods such that $p_{AUT} > p_{3,4}$ and $x_{AUT} > x_{3,4}$. Diagram 3 compares the two duopoly cases (3.3) and (3.4). Since the pro-competitive gains from trade affect both regimes equivalently, the net difference between the two is the trade in ideas in case (3.4). Thus $p_{3,4} > p_{3,3}$ and $x_{3,4} < x_{3,3}$. Diagram 8 summarizes all of the results. Notice that cases (3.2) and (3.4) share the same demand curve. This is because the only difference is the market structure faced by the imperfect competitor, which is reflected by movement along the curve. The same can be said of case (3.1) versus autarky.

The interest rate, r , is defined as the marginal product of intermediate goods, x , in the production of final goods.

$$r_{3,4} > \{r_{3,2}, r_{3,3}\} > r_{AUT}$$

Trade in intermediate goods, a staple in all four cases, leads to an increase in the demand for those goods, therefore the autarky marginal product of x and consequently the interest rate, r_{AUT} , must be less than all of the others. The addition of trade in ideas will increase the productivity of labor and accordingly the marginal product of intermediate goods,

thus $r_{3,4} > r_{3,3}$. Furthermore, the marginal product of x is greater under duopoly than under monopoly, thus $r_{3,4} > r_{3,2}$. Intuitively, consider one firm that takes care of a large market versus two firms that share that same market. The lower relative production of the individual duopolist implies a higher marginal product than the high relative production and low marginal product of the monopolist. It is not clear which is higher, $r_{3,2}$ or $r_{3,3}$.⁴

The results for the growth rates of per capita income are summarized as follows.

$$g^*_{3,2} > g^*_{3,4} > g^*_{AUT} > g^*_{3,3}$$

Growth rates ultimately reflect labor effort in research which in turn ultimately reflects incentives. Case (3.2) provides R&D firms the greatest incentive and consequently results in the highest growth rate. Case (3.3) provides the least incentive and growth suffers accordingly. Purely as a result of pro-competitive gains from trade, $g^*_{AUT} > g^*_{3,3}$. In other words, trade in imperfectly produced intermediate goods without trade in ideas between two identical countries results in less research effort due to the reduced incentives under duopoly versus under monopoly. Whereas, $g^*_{3,2} > g^*_{3,4} > g^*_{AUT}$ because the countries devote more effort toward research as the R&D sector becomes more competitive as well as more effective. Therefore, the greater are the incentives to the research firm, i.e. monopoly versus duopoly, the more creative destruction takes place, and the higher is the rate of technological advance which ultimately drives the long run growth in per capita income.

A final point to consider is the levels of welfare of the home and foreign representative agents at any given time across the four cases. This is a difficult comparison to make because in the long run, the economy with the highest growth rate must eventually be the best off. At best, one can comment loosely about the transition

from autarky to trade given each scenario. For example, assuming the same initial conditions, at the point at which trade opens, agents are better off in case (3.4) than (3.2) because the initial effect on welfare would have to be greater since $x_{3.4} > x_{3.2}$ and $p_{3.4} < p_{3.2}$. But given enough time, whatever discreet pro-competitive gain from trade in welfare were accrued from agents under case (3.4) would eventually be insignificant given the higher growth rate of technology in case (3.2).

5. Conclusions

The growth rate of income per capita is positively correlated with the incentives available to the respective R&D firms. There is no way to escape this simple fact. Irrespective of what drives technological change, whether it is knowledge driven as suggested by Romer (1990) or obsolescence driven as suggested by Aghion and Howitt (1992), or which methodology one assumes that trade is based upon, international monopolies as suggested by Rivera-Batiz and Romer (1991) or international oligopolies as suggested by Barreto Kobayashi (2001), the greater is the return to research, the more of it is conducted, and the faster technology will develop.

The cursory result of this therefore suggests that in the long run, monopolies are superior to competition due to the incentive to conduct research is greater. This may well be true in the long run, although it is not necessarily true for any time interval less than the long run. Herein we have presented the theoretical results of trade given a certain set of rules for its evolution. We have in no way quantified the results. Therefore, it is possible that the pro-competitive gains from trade may be so great that the short to medium term welfare benefits as well as the distributional elements of greater

competition may outweigh the long run growth considerations associated purely with incentives.

As a to the new growth literature, we add significantly. First, we develop a more simple and elegant way to consider trade between countries when growth is defined by “creative destruction.” Second, we show that irrespective of how technology evolves, it is the incentive structure to the R&D firm that has the crucial impact on growth rates. Third, we add to the trade literature by comprehensively comparing the effects of two distinct incentive structures in the context of endogenous growth and economic integration.

The possible extensions of this paper are numerous. Any change in the incentive available to the research firm will affect growth. An obvious extension is to consider barriers to trade. Another extension along public choice lines is to consider the imposition of taxes. One could consider an income tax on final production versus a value added tax on intermediaries as well as final production. And lastly, an interesting exercise given the framework presented here would be to consider differentiated countries, whether in size, market organization, base technological level.

Appendix 1 – Welfare analysis of laissez-faire versus social optimum levels of research

To understand the implications on welfare of trade when obsolescence motivates technological change, consider a social planner's problem when she attempts to maximize the expected present value of consumption, y_τ .

The social planner's problem under autarky, which exactly the same as case (3.1), is to maximize the following expected welfare.

$$U = \int_0^{\infty} e^{-r\tau} y_\tau d\tau = \int_0^{\infty} e^{-r\tau} \left(\sum_{t=0}^{\infty} \Pi(t, \tau) A_t x^\alpha \right) d\tau \quad (5.1)$$

where $\Pi(t, \tau)$ is the probability of t innovations up to time τ . The innovations process is Poisson with an arrival rate of λn , therefore

$$\Pi(t, \tau) = \frac{(\lambda n \tau)^t}{t!} e^{-\lambda n \tau} \quad (5.2)$$

The social planner must consider both technological change and the labor market equilibrium.

$$A_t = A_0 \gamma^t \quad \gamma > 1 \quad (5.3)$$

$$L = n + x \quad (5.4)$$

The utility function can therefore be rewritten as

$$U(n) = \frac{A_0 (L - n)^\alpha}{r - \lambda n (\gamma - 1)} \quad (5.5)$$

The socially optimal level of research, n_{AUT}^S , which satisfies the first-order-condition, $U'(n_{AUT}^S) = 0$, may be expressed as follows.

$$1 = \frac{\lambda(\gamma - 1) \left(\frac{1}{\alpha} \right) (L - n_{AUT}^S)}{r - \lambda n_{AUT}^S (\gamma - 1)} \quad (5.6)$$

Hence, the socially optimal level of research, n_2^S , is

$$n_{AUT}^S = \frac{\lambda(\gamma - 1) \left(\frac{1}{\alpha} \right) L - r_{AUT}}{\lambda(\gamma - 1) \left(\frac{1}{\alpha} - 1 \right)} \quad (5.7)$$

In case (3.2), expected welfare is

$$U = \int_0^{\infty} e^{-r\tau} y(\tau) d\tau = \int_0^{\infty} e^{-r\tau} \left(\sum_{t=0}^{\infty} \Pi(t, \tau) A_t x^\alpha \right) d\tau \quad (5.8)$$

where $\Pi(t, \tau)$ is modified as follows.

$$\Pi(t, \tau) = \frac{(\lambda(n + n^F) \tau)^t}{t!} e^{-\lambda(n + n^F) \tau} \quad (5.9)$$

Therefore the utility function can be rewritten as

$$U(n) = \frac{A_0(L-n)^\alpha}{r-2\lambda n(\gamma-1)} \quad (5.10)$$

And the socially optimal level of research, $n_{3.2}^S$, is

$$n_{3.2}^S = \frac{2\lambda(\gamma-1)\left(\frac{1}{\alpha}\right)L-r_{3.2}}{2\lambda(\gamma-1)\left(\frac{1}{\alpha}-1\right)} \quad (5.11)$$

In case (3.3), expected welfare function is changed to

$$U = \int_0^\infty e^{-r\tau} y(\tau) d\tau = \int_0^\infty e^{-r\tau} \left(\sum_{t=0}^\infty \Pi(t, \tau) A_t (x+x^F)^\alpha \right) d\tau \quad (5.12)$$

where $\Pi(t, \tau)$ is again defined as it was under autarky.

$$\Pi(t, \tau) = \frac{(\lambda n \tau)^t}{t!} e^{-\lambda n \tau} \quad (5.13)$$

The utility function and its consequent social optimal level of research, $n_{3.3}^S$, can be expressed as follows.

$$U(n) = \frac{2^\alpha A_0(L-n)^\alpha}{r-\lambda n(\gamma-1)} \quad (5.14)$$

$$n_{3.3}^S = \frac{\lambda(\gamma-1)\left(\frac{1}{\alpha}\right)L-r_{3.3}}{\lambda(\gamma-1)\left(\frac{1}{\alpha}-1\right)} \quad (5.15)$$

Lastly, in the case (3.4), expected welfare is

$$U = \int_0^\infty e^{-r\tau} y(\tau) d\tau = \int_0^\infty e^{-r\tau} \left(\sum_{t=0}^\infty \Pi(t, \tau) A_t (x+x^F)^\alpha \right) d\tau \quad (5.16)$$

where $\Pi(t, \tau)$ is defined as follows.

$$\Pi(t, \tau) = \frac{(\lambda(n+n^F)\tau)^t}{t!} e^{-\lambda(n+n^F)\tau} \quad (5.17)$$

and the utility function and its consequent social optimal level of research, $n_{3.4}^S$, are

$$U(n) = \frac{2^\alpha A_0(L-n)^\alpha}{r-2\lambda n(\gamma-1)} \quad (5.18)$$

$$n_{3.4}^S = \frac{2\lambda(\gamma-1)\left(\frac{1}{\alpha}\right)L-r_{3.4}}{2\lambda(\gamma-1)\left(\frac{1}{\alpha}-1\right)} \quad (5.19)$$

The parallels between the competitive optimum levels of work effort and their corresponding social optimum levels make the comparisons across the four cases straight

forward. The three effects of obsolescence, appropriability, business stealing, and intertemporal spillovers, that differentiate the social optimum from the laissez faire equilibrium depend solely on the parameters. For example, the business stealing effect is result of the relative size of innovations, γ . The larger the innovations, the more incentive for firms to research and the greater will be the laissez-faire growth rate. The appropriability effect depends on α , where the closer α is to one, the less the monopolist can appropriate the whole output flow and resulting less research than is socially optimal. Irrespective, since the parameters are the same across cases, the results are as well. If the social optimum level of research is greater than the laissez faire-level, then it will be greater in the open economy setting as well.

Appendix 2 – Technical Summary of Comparisons of Laissez Faire Analytic Equilibriums

Summary Results of Comparisons

$$n^*_{AUT} < n^*_{3.2}, \quad n^*_{AUT} > n^*_{3.3}, \quad n^*_{AUT} < n^*_{3.4}, \quad n^*_{3.2} > n^*_{3.3}, \quad n^*_{3.2} > n^*_{3.4}, \quad n^*_{3.3} < n^*_{3.4}$$

$$\rightarrow n^*_{3.2} > n^*_{3.4} > n^*_{AUT} > n^*_{3.3}$$

$$x^*_{AUT} > x^*_{3.2}, \quad x^*_{AUT} < x^*_{3.3}, \quad x^*_{AUT} > x^*_{3.4}, \quad x^*_{3.2} < x^*_{3.3}, \quad x^*_{3.2} < x^*_{3.4}, \quad x^*_{3.3} > x^*_{3.4}$$

$$\rightarrow x^*_{3.3} > x^*_{AUT} > x^*_{3.4} > x^*_{3.2}$$

$$w_{AUT} < w_{3.2}, \quad w_{AUT} > w_{3.3}, \quad w_{AUT} > w_{3.4}, \quad w_{3.2} > w_{3.3}, \quad w_{3.2} > w_{3.4}, \quad w_{3.3} < w_{3.4}$$

$$\rightarrow w_{3.2} > w_{AUT} > w_{3.4} > w_{3.3}$$

$$p_{AUT} < p_{3.2}, \quad p_{AUT} > p_{3.3}, \quad p_{AUT} > p_{3.4}, \quad p_{3.2} > p_{3.3}, \quad p_{3.2} > p_{3.4}, \quad p_{3.3} < p_{3.4}$$

$$\rightarrow p_{3.2} > p_{AUT} > p_{3.4} > p_{3.3}$$

$$r_{AUT} < r_{3.2}, \quad r_{AUT} < r_{3.3}, \quad r_{3.2} < r_{3.4}, \quad r_{3.3} < r_{3.4}$$

$$\rightarrow r_{3.4} > \{r_{3.2}, r_{3.3}\} > r_{AUT}$$

$$n^*_{3.2} > n^*_{3.4} > n^*_{AUT} > n^*_{3.3}$$

$$\rightarrow g^*_{3.2} > g^*_{3.4} > g^*_{AUT} > g^*_{3.3}$$

AUT versus 3.2

$$n^*_{AUT} = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{AUT}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)} \quad \text{vs.} \quad n^*_{3.2} = \frac{2\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.2}}{2\lambda+2\lambda\gamma\left(\frac{1}{\alpha}-1\right)}$$

where $n^*_{AUT} > n^*_{3.2}$ if $2r_{AUT} < r_{3.2}$

$$\begin{aligned} 2r_{AUT} &= 2\alpha Ax_{AUT}^{\alpha-1} < \alpha Ax_{3.2}^{\alpha-1} = r_{3.2} \\ 2x_{AUT}^{\alpha-1} &< x_{3.2}^{\alpha-1} \\ 2^{\frac{1}{\alpha-1}} x_{AUT} &> x_{3.2} \end{aligned}$$

and since $0 < 2^{\frac{1}{\alpha-1}} < 1 \quad \forall \quad 0 < \alpha < 1$, then $x_{AUT} > x_{3.2} \quad \rightarrow \quad \otimes$

therefore $n^*_{AUT} < n^*_{3.2}$ implying $2r_{AUT} > r_{3.2}$

$$\begin{aligned} 2r_{AUT} &= 2\alpha Ax_{AUT}^{\alpha-1} > \alpha Ax_{3.2}^{\alpha-1} = r_{3.2} \\ 2x_{AUT}^{\alpha-1} &> x_{3.2}^{\alpha-1} \\ 2^{\frac{1}{\alpha-1}} x_{AUT} &< x_{3.2} \end{aligned}$$

and if $n^*_{AUT} < n^*_{3.2}$, then $x^*_{AUT} > x^*_{3.2}$ which implies $r_{AUT} < r_{3.2}$

$$\begin{aligned} x^*_{AUT} &= \left(\frac{w_{xAUT}}{\alpha^2 A}\right)^{\frac{1}{\alpha-1}} > \left(\frac{w_{x3.2}}{\alpha^2 A}\right)^{\frac{1}{\alpha-1}} = x^*_{3.2} \\ w_{xAUT} &< w_{x3.2} \end{aligned}$$

recall that: $p^*_x = \frac{w_x}{\alpha} \quad \rightarrow \quad \therefore p_{xAUT} < p_{x3.2}$

if $n^*_{AUT} < n^*_{3.2}$, then $\lambda n^*_{AUT} (\ln \gamma) < \lambda 2 n^*_{3.2} (\ln \gamma) \rightarrow g^*_{AUT} < g^*_{3.2}$

\therefore Therefore, $n^*_{AUT} < n^*_{3.2}$, $x^*_{AUT} > x^*_{3.2}$, $r_{AUT} < r_{3.2}$, $w_{AUT} < w_{3.2}$, $p_{AUT} < p_{3.2}$,
and $g^*_{AUT} < g^*_{3.2}$

AUT versus 3.3

$$n^*_{AUT} = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{AUT}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)} \quad \text{vs.} \quad n^*_{3.3} = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.3}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)}$$

where $n^*_{AUT} < n^*_{3.3}$ if $r_{AUT} > r_{3.3}$

$$\begin{aligned} r_{AUT} &= \alpha A x_{AUT}^{\alpha-1} > 2\alpha A x_{3.3}^{\alpha-1} = r_{3.3} \\ x_{AUT}^{\alpha-1} &> 2x_{3.3}^{\alpha-1} \\ x_{AUT} &< 2^{\frac{1}{\alpha-1}} x_{3.3} \end{aligned}$$

and since $0 < 2^{\frac{1}{\alpha-1}} < 1 \quad \forall \quad 0 < \alpha < 1$, then $x_{AUT} < x_{3.3} \quad \rightarrow \quad \otimes$

therefore $n^*_{AUT} > n^*_{3.3}$ which implies $r_{AUT} < r_{3.3}$

$$\begin{aligned} r_{AUT} &= \alpha A x_{AUT}^{\alpha-1} < 2\alpha A x_{3.3}^{\alpha-1} = r_{3.3} \\ x_{AUT}^{\alpha-1} &< 2x_{3.3}^{\alpha-1} \\ x_{AUT} &> 2^{\frac{1}{\alpha-1}} x_{3.3} \end{aligned}$$

and if $n^*_{AUT} > n^*_{3.3}$, then $x^*_{AUT} < x^*_{3.3}$

recall that $w^*_x = \frac{\Pi^*_t}{\left(\frac{1}{\alpha}-1\right)x^*_t}$, and since $\Pi^*_{AUT} > \Pi^*_{3.3}$, therefore

$$\begin{aligned} w^*_{AUT} &= \frac{\Pi^*_{AUT}}{\left(\frac{1}{\alpha}-1\right)x^*_{AUT}} > \frac{\Pi^*_{3.3}}{\left(\frac{1}{\alpha}-1\right)x^*_{3.3}} = w^*_{3.3} \\ \therefore w_{x_{AUT}} &> w_{x_{3.3}} \end{aligned}$$

recall that: $p^*_x = \frac{w_x}{\alpha} \quad \rightarrow \quad \therefore p_{x_{AUT}} > p_{x_{3.3}}$

if $n^*_{AUT} > n^*_{3.3}$, then $\lambda n^*_{AUT} (\ln \gamma) > \lambda n^*_{3.3} (\ln \gamma) \quad \rightarrow \quad g^*_{AUT} > g^*_{3.3}$

\therefore Therefore, $n^*_{AUT} > n^*_{3.3}$, $x^*_{AUT} < x^*_{3.3}$, $r_{AUT} < r_{3.3}$, $w_{AUT} > w_{3.3}$, $p_{AUT} > p_{3.3}$ and $g^*_{AUT} > g^*_{3.3}$

AUT versus 3.4

$$n^*_{AUT} = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{AUT}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)} \quad \text{vs.} \quad n^*_{3.4} = \frac{2\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.4}}{2\lambda+2\lambda\gamma\left(\frac{1}{\alpha}-1\right)}$$

where $n^*_{AUT} > n^*_{3.4}$ if $2r_{AUT} < r_{3.4}$

$$\begin{aligned} 2r_{AUT} &= 2\alpha Ax_{AUT}^{\alpha-1} < 2\alpha Ax_{3.4}^{\alpha-1} = r_{3.4} \\ x_{AUT}^{\alpha-1} &< x_{3.4}^{\alpha-1} \\ x_{AUT} &> x_{3.4} \quad \rightarrow \quad \otimes \end{aligned}$$

therefore $n^*_{AUT} < n^*_{3.4}$ which implies $2r_{AUT} > r_{3.4}$

$$\begin{aligned} 2r_{AUT} &= 2\alpha Ax_{AUT}^{\alpha-1} > 2\alpha A(2x_{3.4})^{\alpha-1} = r_{3.4} \\ x_{AUT}^{\alpha-1} &> (2x_{3.4})^{\alpha-1} \\ x_{AUT} &< 2x_{3.4} \end{aligned}$$

and if $n^*_{AUT} < n^*_{3.4}$ then $x^*_{AUT} > x^*_{3.4}$

$$\begin{aligned} x^*_{AUT} &= \left(\frac{w_{xAUT}}{\alpha^2 A}\right)^{\frac{1}{\alpha-1}} > \frac{1}{2} \left(\frac{w_{x3.4}}{\alpha^2 A}\right)^{\frac{1}{\alpha-1}} = x^*_{3.4} \\ w_{xAUT}^{\frac{1}{\alpha-1}} &< \frac{1}{2} w_{x3.4}^{\frac{1}{\alpha-1}} \\ w_{xAUT} &> 2^{1-\alpha} w_{x3.4} \\ \therefore w_{xAUT} &> w_{x3.4} \end{aligned}$$

recall that: $p^*_x = \frac{w_x}{\alpha} \quad \rightarrow \quad p_{xAUT} > p_{x3.4}$

if $n^*_{AUT} < n^*_{3.4}$, then $\lambda n^*_{AUT} (\ln \gamma) < \lambda 2n^*_{3.4} (\ln \gamma) \rightarrow g^*_{AUT} < g^*_{3.4}$

\therefore Therefore, $n^*_{AUT} < n^*_{3.4}$, $x^*_{AUT} > x^*_{3.4}$, $w_{xAUT} > w_{x3.4}$, $p_{xAUT} > p_{x3.4}$
and $g^*_{AUT} < g^*_{3.4}$

3.2 versus 3.3

$$n_{3.2}^* = \frac{2\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.2}}{2\lambda+2\lambda\gamma\left(\frac{1}{\alpha}-1\right)} \quad \text{vs.} \quad n_{3.3}^* = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.3}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)}$$

where $n_{3.2}^* < n_{3.3}^*$ if $r_{3.2} > 2r_{3.3}$

$$\begin{aligned} r_{3.2} &= \alpha A x_{3.2}^{\alpha-1} > 4\alpha A (2x_{3.3})^{\alpha-1} = 2r_{3.3} \\ x_{3.2}^{\alpha-1} &< 4(2x_{3.3})^{\alpha-1} \\ x_{3.2} &< 2^{\frac{\alpha+1}{\alpha-1}} x_{3.3} \end{aligned}$$

and since $0 < 2^{\frac{\alpha+1}{\alpha-1}} < 1 \quad \forall \quad 0 < \alpha < 1$, then $x_{3.2} < x_{3.3} \quad \rightarrow \quad \otimes$

therefore $n_{3.2}^* > n_{3.3}^*$ which implies $r_{3.2} < 2r_{3.3}$

$$\begin{aligned} r_{3.2} &= \alpha A x_{3.2}^{\alpha-1} > 4\alpha A (2x_{3.3})^{\alpha-1} = 2r_{3.3} \\ x_{3.2}^{\alpha-1} &< 4(2x_{3.3})^{\alpha-1} \\ x_{3.2} &< 2^{\frac{\alpha+1}{\alpha-1}} x_{3.3} \end{aligned}$$

and if $n_{3.2}^* > n_{3.3}^*$ then $x_{3.2}^* < x_{3.3}^*$

$$\begin{aligned} x_{3.2}^* &= \left(\frac{w_{x3.2}}{\alpha^2 A}\right)^{\frac{1}{\alpha-1}} < \frac{1}{2} \left(\frac{w_{x3.3}}{\alpha^2 A}\right)^{\frac{1}{\alpha-1}} = x_{3.3}^* \\ w_{x3.2}^{\frac{1}{\alpha-1}} &< \frac{1}{2} w_{x3.3}^{\frac{1}{\alpha-1}} \\ w_{x3.2} &> 2^{1-\alpha} w_{x3.3} \\ \therefore w_{x3.2} &> w_{x3.3} \end{aligned}$$

recall that: $p_x^* = \frac{w_x}{\alpha} \quad \rightarrow \quad \therefore p_{x3.2} > p_{x3.3}$

if $n_{3.2}^* > n_{3.3}^*$, then $\lambda 2n_{3.2}^* (\ln \gamma) > \lambda n_{3.3}^* (\ln \gamma) \quad \rightarrow \quad g_{3.2}^* > g_{3.3}^*$

\therefore Therefore $n_{3.2}^* > n_{3.3}^*$, $x_{3.2}^* < x_{3.3}^*$, $w_{3.2} > w_{3.3}$, $p_{3.2} > p_{3.3}$, and $g_{3.2}^* > g_{3.3}^*$

Note : It is not clear which is higher, $r_{3,2}$ or $r_{3,3}$.

$$\text{if } r_{3,2} > r_{3,3} \quad r_{3,2} = \alpha A x_{3,2}^{\alpha-1} > 2\alpha A (2x_{3,3})^{\alpha-1} = r_{3,3}$$

$$x_{3,2}^{\alpha-1} > 2^\alpha x_{3,3}^{\alpha-1}$$

$$x_{3,2} < 2^{\frac{\alpha}{\alpha-1}} x_{3,3}$$

since $0 < 2^{\frac{\alpha}{\alpha-1}} < 1$, then $x_{3,2} < x_{3,3}$ \rightarrow OK

$$\text{if } r_{3,2} < r_{3,3} \quad r_{3,2} = \alpha A x_{3,2}^{\alpha-1} < 2\alpha A (2x_{3,3})^{\alpha-1} = r_{3,3}$$

$$x_{3,2}^{\alpha-1} < 2^\alpha x_{3,3}^{\alpha-1}$$

$$x_{3,2} > 2^{\frac{\alpha}{\alpha-1}} x_{3,3}$$

since $0 < 2^{\frac{\alpha}{\alpha-1}} < 1$, then $x_{3,2}$ could be more or less than $x_{3,3}$.

\therefore Therefore three cases, $r_{3,2} > r_{3,3}$, $r_{3,2} < r_{3,3}$, and $r_{3,2} = r_{3,3}$, must all be considered.

3.2 versus 3.4

$$n_{3.2}^* = \frac{2\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.2}}{2\lambda+2\lambda\gamma\left(\frac{1}{\alpha}-1\right)}\lambda \quad \text{vs.} \quad n_{3.4}^* = \frac{2\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.4}}{2\left[\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)\right]}$$

where $n_{3.2}^* < n_{3.4}^*$ if $r_{3.2} > r_{3.4}$

$$\begin{aligned} r_{3.2} &= \alpha A x_{3.2}^{\alpha-1} > 2\alpha A (2x_{3.4})^{\alpha-1} = r_{3.4} \\ x_{3.2}^{\alpha-1} &> 2^\alpha x_{3.4}^{\alpha-1} \\ x_{3.2} &< 2^{\frac{\alpha}{\alpha-1}} x_{3.4} \end{aligned}$$

and since $0 < 2^{\frac{\alpha}{\alpha-1}} < 1 \quad \forall \quad 0 < \alpha < 1$, then $x_{3.2} < x_{3.4} \quad \rightarrow \quad \otimes$

therefore $n_{3.2}^* > n_{3.4}^*$ which implies $r_{3.2} < r_{3.4}$

$$\begin{aligned} r_{3.2} &= \alpha A x_{3.2}^{\alpha-1} < 2\alpha A (2x_{3.4})^{\alpha-1} = r_{3.4} \\ x_{3.2}^{\alpha-1} &< 2^\alpha x_{3.4}^{\alpha-1} \\ x_{3.2} &> 2^\alpha x_{3.4}^{\alpha-1} \end{aligned}$$

and if $n_{3.2}^* > n_{3.4}^*$ then $x_{3.2}^* < x_{3.4}^*$

$$\begin{aligned} x_{3.2}^* &= \left(\frac{w_{x3.2}}{\alpha^2 A}\right)^{\frac{1}{\alpha-1}} > \frac{1}{2} \left(\frac{w_{x3.4}}{\alpha^2 A}\right)^{\frac{1}{\alpha-1}} = x_{3.4}^* \\ \frac{1}{w_{x3.2}^{\alpha-1}} &< \frac{1}{2} \frac{1}{w_{x3.4}^{\alpha-1}} \\ w_{x3.2} &> 2^{1-\alpha} w_{x3.4} \\ \therefore w_{x3.2} &> w_{x3.4} \end{aligned}$$

recall that: $p_x^* = \frac{w_x}{\alpha} \quad \rightarrow \quad P_{x3.2} > P_{x3.4}$

if $n_{3.2}^* > n_{3.4}^*$, then $\lambda 2n_{3.2}^*(\ln \gamma) > \lambda 2n_{3.4}^*(\ln \gamma) \quad \rightarrow \quad g_{3.2}^* > g_{3.4}^*$

\therefore Therefore, $n_{3.2}^* > n_{3.4}^*$, $x_{3.2}^* < x_{3.4}^*$, $r_{3.2} < r_{3.4}$, $w_{3.2} > w_{3.4}$, $P_{3.2} > P_{3.4}$,
and $g_{3.2}^* > g_{3.4}^*$

3.3 versus 3.4

$$n_{3.3}^* = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.3}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)} \quad \text{vs.} \quad n_{3.4}^* = \frac{2\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.4}}{2\lambda+2\lambda\gamma\left(\frac{1}{\alpha}-1\right)}$$

where $n_{3.3}^* > n_{3.4}^*$ if $2r_{3.3} < r_{3.4}$

$$\begin{aligned} 2r_{3.3} &= 4\alpha A(2x_{3.3})^{\alpha-1} < 2\alpha A(2x_{3.4})^{\alpha-1} = r_{3.4} \\ 2(2x_{3.3})^{\alpha-1} &< (2x_{3.4})^{\alpha-1} \\ 2^\alpha x_{3.3}^{\alpha-1} &< 2^{\alpha-1} x_{3.4}^{\alpha-1} \\ 2^{\frac{1}{\alpha-1}} x_{3.3} &> x_{3.4} \end{aligned}$$

and since $0 < 2^{\frac{1}{\alpha-1}} < 1 \quad \forall \quad 0 < \alpha < 1$, then $x_{3.3} > x_{3.4} \quad \rightarrow \quad \otimes$

therefore $n_{3.3}^* < n_{3.4}^*$ implying $2r_{3.3} > r_{3.4}$

$$\begin{aligned} 2r_{3.3} &= 4\alpha A(2x_{3.3})^{\alpha-1} > 2\alpha A(2x_{3.4})^{\alpha-1} = r_{3.4} \\ 2(2x_{3.3})^{\alpha-1} &> (2x_{3.4})^{\alpha-1} \\ 2^\alpha x_{3.3}^{\alpha-1} &> 2^{\alpha-1} x_{3.4}^{\alpha-1} \\ \therefore 2^{\frac{1}{\alpha-1}} x_{3.3} &< x_{3.4} \end{aligned}$$

and if $n_{3.3}^* < n_{3.4}^*$ then $x_{3.3}^* > x_{3.4}^*$ which implies $r_{3.3} < r_{3.4}$

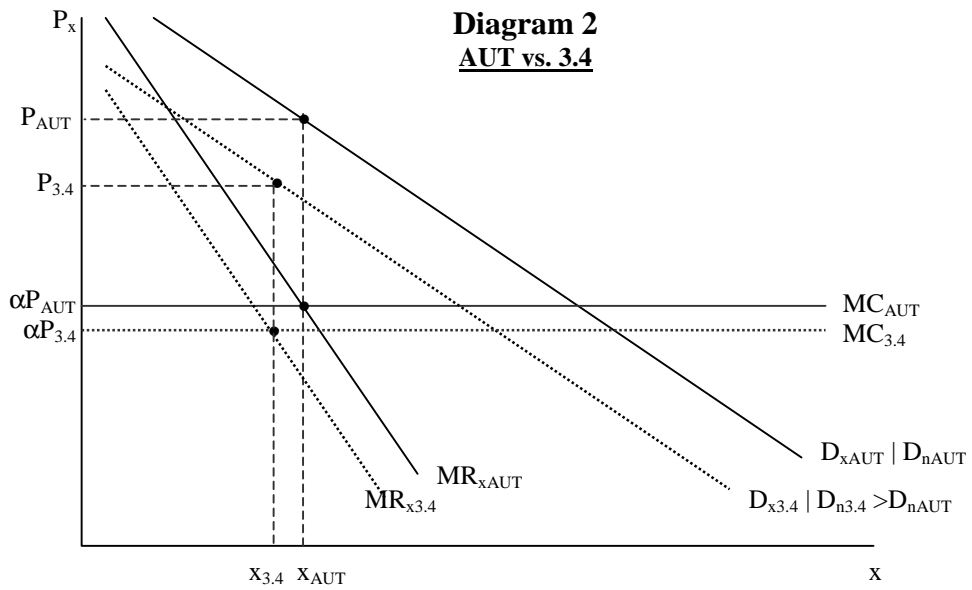
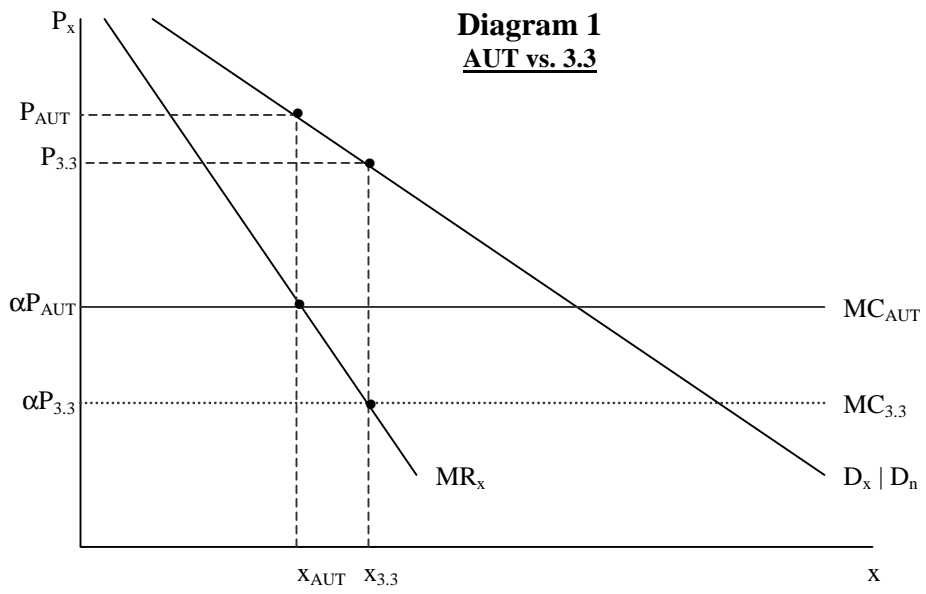
$$\begin{aligned} x_{3.3}^* &= \frac{1}{2} \left(\frac{w_{x_{3.3}}}{\alpha^2 A} \right)^{\frac{1}{\alpha-1}} > \frac{1}{2} \left(\frac{w_{x_{3.4}}}{\alpha^2 A} \right)^{\frac{1}{\alpha-1}} = x_{3.4}^* \\ w_{x_{3.3}}^{\frac{1}{\alpha-1}} &> w_{x_{3.4}}^{\frac{1}{\alpha-1}} \\ \therefore w_{x_{3.3}} &< w_{x_{3.4}} \end{aligned}$$

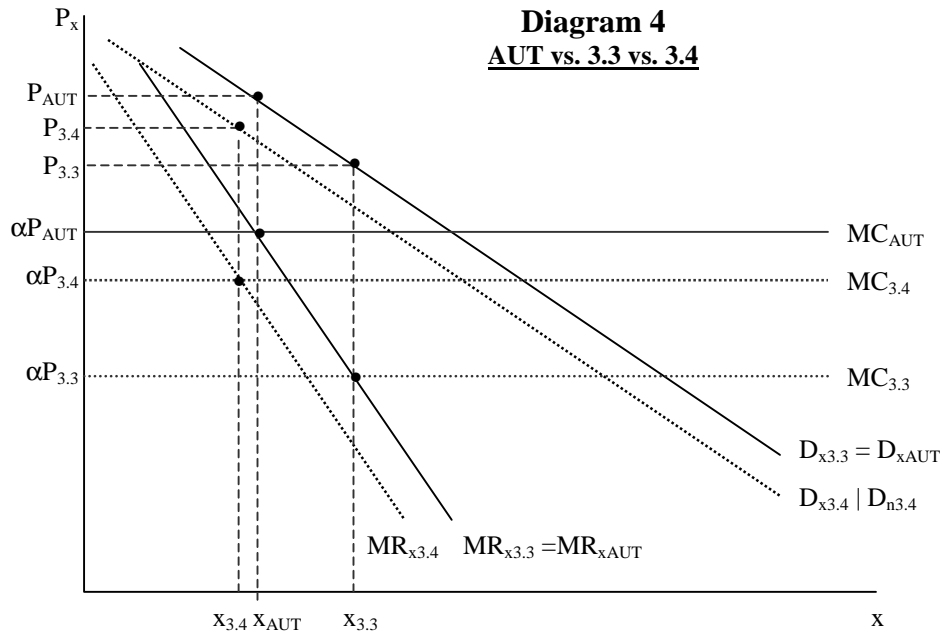
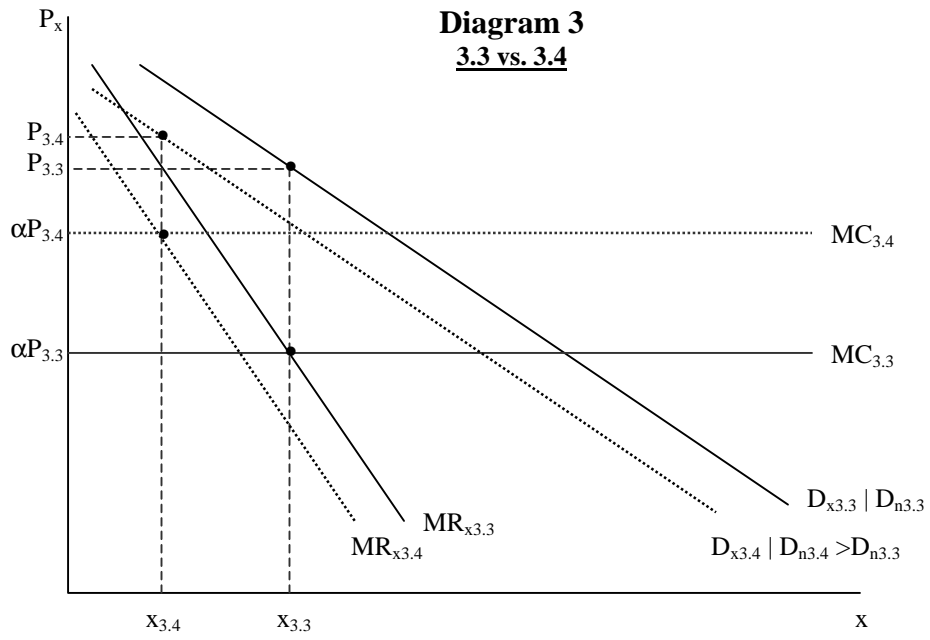
recall that: $p_x^* = \frac{w_x}{\alpha} \quad \rightarrow \quad \therefore p_{x_{3.3}} < p_{x_{3.4}}$

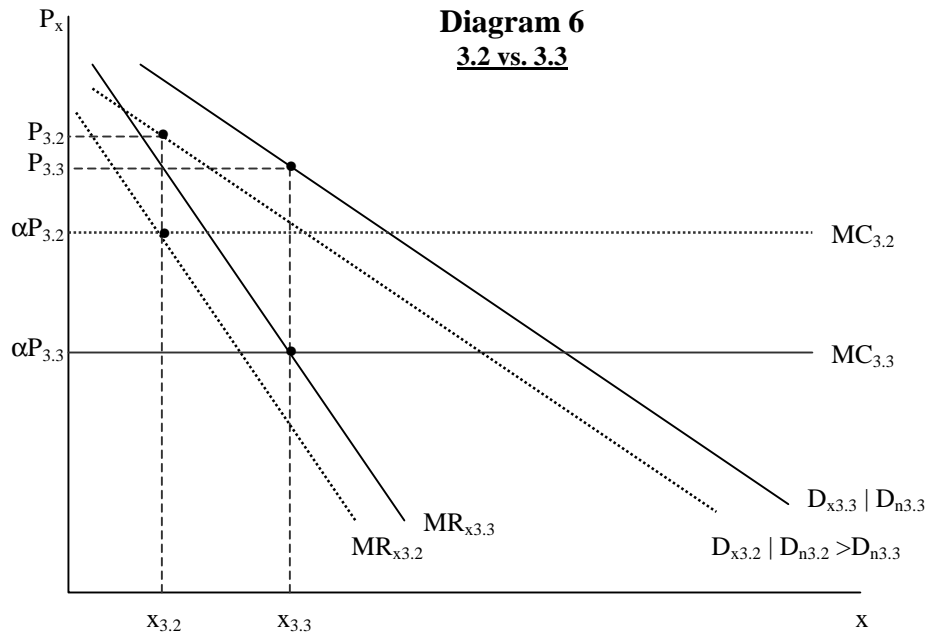
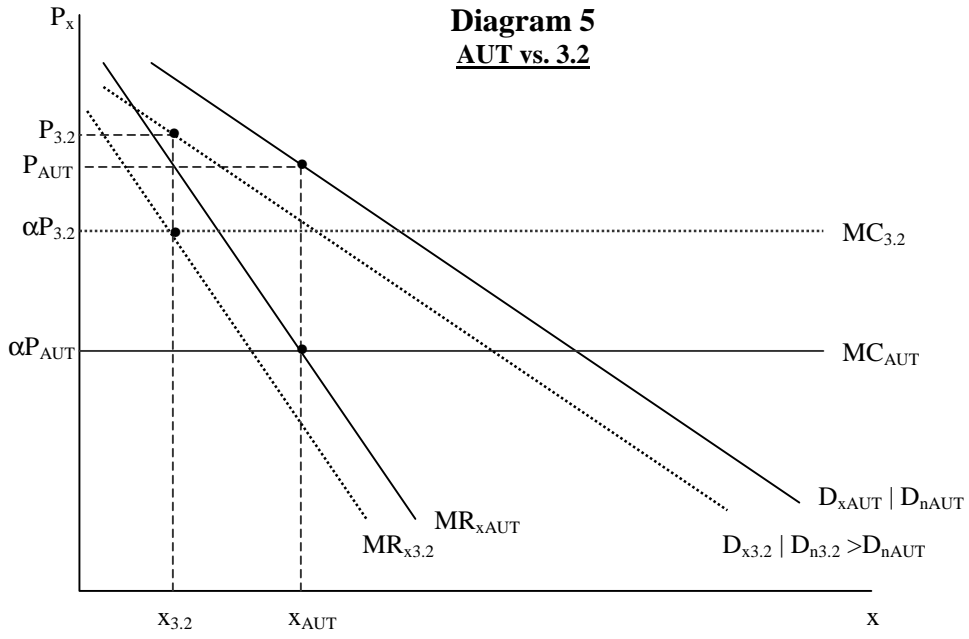
If $n_{3.3}^* < n_{3.4}^*$, then $\lambda n_{3.3}^* (\ln \gamma) < \lambda 2n_{3.4}^* (\ln \gamma) \quad \rightarrow \quad g_{3.3}^* < g_{3.4}^*$

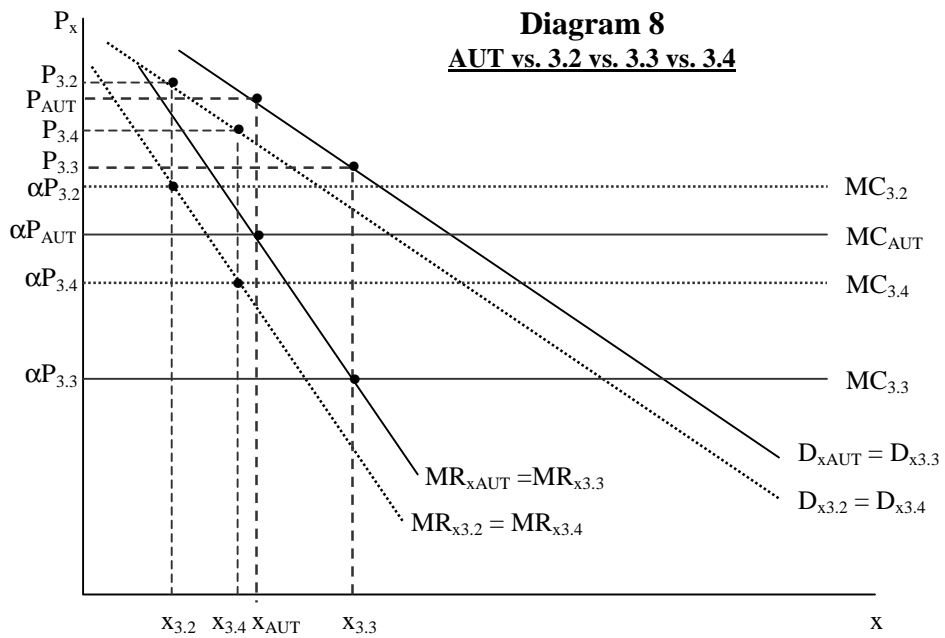
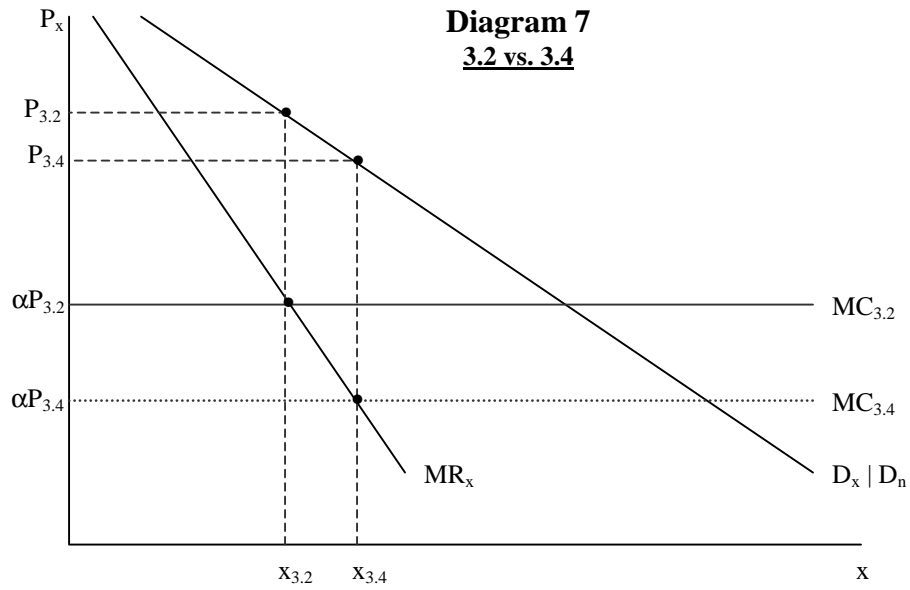
\therefore Therefore $n_{3.3}^* < n_{3.4}^*$, $x_{3.3}^* > x_{3.4}^*$, $r_{3.3} < r_{3.4}$, $w_{3.3} < w_{3.4}$, $p_{3.3} < p_{3.4}$,

and $g^*_{3.3} < g^*_{3.4}$









Autarky

$$n_{AUT}^* = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{AUT}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)}$$

$$p_{AUT} = \alpha A_t x_t^{\alpha-1}$$

$$w_{AUT} = \alpha^2 A_t x_t^{\alpha-1}$$

$$x_{AUT}^* = \left(\frac{w_x}{\alpha^2 A_t}\right)^{\frac{1}{\alpha-1}}$$

$$r_{AUT} = \alpha A x^{\alpha-1}$$

$$n_{AUT}^S = \frac{\lambda(\gamma-1)\left(\frac{1}{\alpha}\right)L-r_{AUT}}{\lambda(\gamma-1)\left(\frac{1}{\alpha}-1\right)}$$

$$g_{AUT}^* = \lambda n_{AUT}^* (\ln \gamma)$$

3.3 Trade in

Intermediaries

$(x^H = x^F)$

$$n_{3.3}^* = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.3}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)}$$

$$p_{3.3} = \alpha A_t (2x_t)^{\alpha-1}$$

$$w_{3.3} = \alpha^2 A_t (2x_t)^{\alpha-1}$$

$$x_{3.3}^* = \frac{1}{2}\left(\frac{w_x}{\alpha^2 A_t}\right)^{\frac{1}{\alpha-1}}$$

$$r_{3.3} = 2\alpha A (2x)^{\alpha-1}$$

$$n_{3.3}^S = \frac{\lambda(\gamma-1)\left(\frac{1}{\alpha}\right)L-r_{3.3}}{\lambda(\gamma-1)\left(\frac{1}{\alpha}-1\right)}$$

$$g_{3.3}^* = \lambda n_{3.3}^* (\ln \gamma)$$

Table 1

3.1 Trade in

Intermediaries

$(x^H \neq x^F)$

$$n_{3.1}^* = \frac{\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.1}}{\lambda+\lambda\gamma\left(\frac{1}{\alpha}-1\right)}$$

$$p_{3.1} = \alpha A_t x_t^{\alpha-1}$$

$$w_{3.1} = \alpha^2 A_t x_t^{\alpha-1}$$

$$x_{3.1}^* = \left(\frac{w_x}{\alpha^2 A_t}\right)^{\frac{1}{\alpha-1}}$$

$$r_{3.1} = \alpha A x^{\alpha-1}$$

$$n_{3.1}^S = \frac{\lambda(\gamma-1)\left(\frac{1}{\alpha}\right)L-r_{3.1}}{\lambda(\gamma-1)\left(\frac{1}{\alpha}-1\right)}$$

$$g_{3.1}^* = \lambda n_{3.1}^* (\ln \gamma)$$

3.2 Trade in

Intermediaries +

Ideas $(x^H \neq x^F)$

$$n_{3.2}^* = \frac{2\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.2}}{2\lambda+2\lambda\gamma\left(\frac{1}{\alpha}-1\right)}$$

$$p_{3.2} = \alpha A_t x_t^{\alpha-1}$$

$$w_{3.2} = \alpha^2 A_t x_t^{\alpha-1}$$

$$x_{3.2}^* = \left(\frac{w_x}{\alpha^2 A_t}\right)^{\frac{1}{\alpha-1}}$$

$$r_{3.2} = \alpha A x^{\alpha-1}$$

$$n_{3.2}^S = \frac{2\lambda(\gamma-1)\left(\frac{1}{\alpha}\right)L-r_{3.2}}{2\lambda(\gamma-1)\left(\frac{1}{\alpha}-1\right)}$$

$$g_{3.2}^* = \lambda 2 n_{3.2}^* (\ln \gamma)$$

3.4 Trade in

Intermediaries +

Ideas $(x^H = x^F)$

$$n_{3.4}^* = \frac{2\lambda\gamma\left(\frac{1}{\alpha}-1\right)L-r_{3.4}}{2\lambda+2\lambda\gamma\left(\frac{1}{\alpha}-1\right)}$$

$$p_{3.4} = \alpha A_t (2x_t)^{\alpha-1}$$

$$w_{3.4} = \alpha^2 A_t (2x_t)^{\alpha-1}$$

$$x_{3.4}^* = \frac{1}{2}\left(\frac{w_x}{\alpha^2 A_t}\right)^{\frac{1}{\alpha-1}}$$

$$r_{3.4} = 2\alpha A (2x)^{\alpha-1}$$

$$n_{3.4}^S = \frac{2\lambda(\gamma-1)\left(\frac{1}{\alpha}\right)L-r_{3.4}}{2\lambda(\gamma-1)\left(\frac{1}{\alpha}-1\right)}$$

$$g_{3.4}^* = \lambda 2 n_{3.4}^* (\ln \gamma)$$

Bibliography

Aghion, Phillipe and Peter Howitt (1992), "A model of growth through creative destruction," *Econometrica*, Vol. 60, No. 2, 323-351.

Barreto, Raul A. and Kaori Kobayashi (2001), "Economic integration and endogenous growth revisited: Pro-competitive gains from trade in goods and the long run benefits to the exchange of ideas," Adelaide University Working Paper Series, No. 01-12.

Devereuw, M. B. and B.J. Lapham (1994), "The stability of integration and endogenous growth," *Quarterly Journal of Economics*, 109, p. 299-395.

Diamond, Peter A. (1965), "National Debt in a Neoclassical Growth Model", *American Economic Review*, 55, 1126-1150.

Lucas, Robert E. (1988), "On the mechanics of economic development" *Journal of Monetary Economics*, 22, p. 3-42.

Ramsey, F. P. (1928), "A mathematical theory of Saving," *Economic Journal*, 38, December, p. 543-559.

Rivera-Batiz, Luis A. and Paul M. Romer (1991), "Economic Integration and Endogenous Growth," *The Quarterly Journal of Economics*, May, 530-555.

Romer, Paul M. (1990), "Endogenous Technological Change", *Journal of Political Economy*, 98, S71-S102.

ENDNOTES

¹For example, see Markusen, et.al. (1995), chapter 11 or any other intermediate to graduate level international trade textbook for a complete description imperfect competition as a determinant of trade between identical countries.

² See Barreto and Kobayashi (2001) for a complete discussion of the pros and cons.

³ See Rivera-Batiz and Romer (1991) for a thorough discussion of this assumption.

⁴⁴ See appendix 2 for details.

CIES DISCUSSION PAPER SERIES

The CIES Discussion Paper series provides a means of circulating promptly papers of interest to the research and policy communities and written by staff and visitors associated with the Centre for International Economic Studies (CIES) at the Adelaide University. Its purpose is to stimulate discussion of issues of contemporary policy relevance among non-economists as well as economists. To that end the papers are non-technical in nature and more widely accessible than papers published in specialist academic journals and books. (Prior to April 1999 this was called the CIES Policy Discussion Paper series. Since then the former CIES Seminar Paper series has been merged with this series.)

Copies of CIES Policy Discussion Papers may be downloaded from our Web site at <http://www.adelaide.edu.au/cies/> or are available by contacting the Executive Assistant, CIES, School of Economics, Adelaide University, SA 5005 AUSTRALIA. Tel: (+61 8) 8303 5672, Fax: (+61 8) 8223 1460, Email: cies@adelaide.edu.au. Single copies are free on request; the cost to institutions is US\$5.00 overseas or A\$5.50 (incl. GST) in Australia each including postage and handling.

For a full list of CIES publications, visit our Web site at <http://www.adelaide.edu.au/cies/> or write, email or fax to the above address for our *List of Publications by CIES Researchers, 1989 to 1999* plus updates.

- 0317 Barreto, Raul A. and Kaori Kobayashi,
- 0316 Barreto, Raul A. and Kaori Kobayashi, "Open Economy Schumpeterian Growth", May 2003.
- 0315 Wilson, Patrick J. and Ralf Zurbruegg, "Trends and Spectral Response: An Examination of the US Realty Market", May 2003.
- 0314 Esho, Neil and Anatoly Kirievsky, Damian Ward and Ralf Zurbruegg, "Law and the Demand for Property-Casualty Insurance Consumption", May 2003. (Forthcoming in *Journal of Risk and Insurance*, 2003).
- 0313 Wilson, Patrick J. and Ralf Zurbruegg, "Does it Pay to Diversify Real Estate Assets? - A Literary Perspective", May 2003.
- 0312 Rajan, Ramkishen, "Taxing International Currency Flows: A Financial Safeguard or Financial Bonanza?", April 2003.
- 0311 Rajan, Ramkishen, "Financial Crisis, Capital Outflows and Policy Responses: Simple Analytics and Examples from East Asia", April 2003.
- 0310 Cavoli, Tony and Ramkishen Rajan, "Exchange Rate Arrangements for East Asia Post-Crisis: Examining the Case for Open Economy Inflation Targeting", April 2003.
- 0309 Cavoli, Tony and Ramkishen Rajan, "Designing Appropriate Exchange Rate Regimes for East Asia: Inflation Targeting and Monetary Policy Rules", April 2003.
- 0308 Allsopp, Louise, "Speculative Behaviour, Debt Default and Contagion: An Explanation of the Latin American Crisis 2001-2002", March 2003.
- 0307 Barreto, Raul. A., A Model of State Infrastructure with Decentralized Public Agents: Theory and Evidence, March 2003.
- 0306 Pardey, Philip G., Julian M. Alston, Connie Chan-Kang, Eduardo C. Magalhães, and Stephen A. Vosti, "Assessing and Attributing the Benefits from Varietal Improvement Research: Evidence from Embrapa, Brazil", March 2003.
- 0305 Allsopp, Louise, "Venezuela: A Nation In Need of Reform", March 2003.

- 0304 Allsopp, Louise and Ralf Zurbuegg, "Purchasing Power Parity in East Asia: Why all the Fuss?", March 2003.
- 0303 Allsopp, Louise and Ralf Zurbuegg, "Purchasing Power Parity and the Impact of the East Asian Currency Crisis", March 2003.
- 0302 Siregar, Reza and Ramkishan Rajan, "Exchange Rate Policy and Foreign Exchange Reserves Management in Indonesia in the Context of East Asian Monetary Regionalism", March 2003.
- 0301 Jackson, Lee Ann, "Protectionist Harmonization of Food Safety Policies in the Asia-Pacific Region", January 2003.
- 0236 Damania, Richard, "Protectionist Lobbying and Strategic Investment", November 2002
- 0235 Damania, Richard and John Hatch, "Protecting Eden: Markets or Government?", November 2002.
- 0234 Anderson, Kym, "Agricultural Trade Reform and Poverty Reduction in Developing Countries", November 2002.
- 0233 Wood, Danielle and Kym Anderson, "What Determines the Future Value of an Icon Wine? Evidence from Australia", November 2002.
- 0232 Kym Anderson and Nielsen, Chantal, "Economic Effects of Agricultural Biotechnology Research in the Presence of Price-distorting Policies". November 2002.
- 0231 Jackson, Lee Ann, "Who Benefits from Quality Labelling? Segregation Costs, International Trade and Producer Outcomes". November 2002.
- 0230 Rajan, Ramkishan and Graham Bird, "Trade Liberalization and Poverty: Where Do We Stand?", November 2002.
- 0229 Rajaguru, Gulasekaran and Reza Siregar, "Sources of Variations Between the Inflation Rates of Korea, Thailand and Indonesia During the Post-1997 Crisis", November 2002.
- 0228 Barbier, Edward B, "Water and Economic Growth", October 2002.
- 0227 Barbier, Edward B, "The Role of Natural Resources in Economic Development", October 2002. (The 49th Joseph Fisher Lecture.)
- 0226 Rajan, Ramkishan and Rahul Sen, "Liberalisation of Financial Services in Southeast Asia under the ASEAN Framework Agreement on Services (AFAS)", October 2002. (Forthcoming in *Journal of International Banking Law*).
- 0225 Anderson, Kym "Building an Internationally Competitive Australian Olive Industry: Lessons from the Wine Industry," October 2002. (Since published in *Australasian Agribusiness Perspectives*, No. 56, December 2002.)
- 0224 Bentzen, Jan, Søren Leth-Sørensen and Valdemar Smith, "Prices of French Icon Wines and the Business Cycle: Empirical Evidence from Danish Wine Auctions," September 2002.
- 0223 Bentzen, Jan and Valdemar Smith, "Wine Prices in the Nordic Countries: Are They Lower Than in the Region of Origin?" September 2002.
- 0222 Rajan, Ramkishan and Graham Bird, "Will Asian Economies Gain from Liberalizing Trade in Services?" September 2002. (Forthcoming in *Journal of World Trade*).
- 0221 Siregar, Reza Y. and Gulasekaran Rajaguru, "Base Money and Exchange Rate: Sources of Inflation in Indonesia during the Post-1997 Financial Crisis" August 2002.
- 0220 Rajan, Ramkishan, "International Financial Liberalisation in Developing Countries: Lessons from Recent Experiences" July 2002. (Since published in *Economic and Political Weekly*, 37 (29): 3017-21, July 20-26, 2002).

