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Consequences of Imitation by Poor Countries on International Wage Inequalities and Global Growth

by

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Abstract: This paper presents an endogenous growth model where the level of international transaction costs may be decisive for whether the poor East specializes in agriculture production, imitates goods from the rich West, or makes its own innovations. We show that the East produces only agricultural goods if transaction costs are high, while innovation is profitable when transaction costs are low. In between we have a range of transaction costs where the East imitates, possibly resulting in a lower global growth rate and a larger international wage gap than if imitation were not possible.

Non-technical summary

Trade liberalization and imitation seem to have been key words for countries like South Korea and Taiwan when they were transformed into modern industrial nations - or for the earlier industrialization processes of Germany and France, for that matter. In this paper we set up a general equilibrium model in order to provide some insight into the following questions: First, what is the relationship between trade liberalization and imitation? Second, how does imitation affect international income inequalities? Third, how does imitation by poor countries affect innovation incentives in industrialized nations?

As for the first question, we show that imitation may not be profitable for developing countries unless trade is sufficiently liberalized. The reason is that imitation requires cheap access both to the input and output markets in the industrialized world. Other things being equal, we should thus expect a positive relationship between trade liberalization and imitation.

The last two questions above are less straightforward to answer, since it is not obvious what one should compare with when one asks about the consequences of imitation. The existing literature typically assumes that developing countries are unable to innovate, thus making it most relevant to compare an equilibrium where developing countries imitate to an equilibrium where developing countries specialize in agriculture production. In this case the theory seems to lend most support to the view that imitation tends to reduce the international wage gap and increase innovation incentives in the more advanced countries. We find a similar result. However, in the present paper the choice between imitation and innovation is endogenously determined. Thus, it may be most relevant to compare an equilibrium where developing countries imitate to an equilibrium where they innovate. When this is the basis for comparison, we find that imitation may in fact increase the international wage gap and reduce innovation incentives in developed countries.

1 Introduction

The fact that many of the newly industrialized countries have underwent a phase of trade liberalization and extensive imitation of goods from more advanced countries raises a number of important questions. For instance, what is the relationship between trade liberalization and imitation? Second, how does imitation affect international income inequalities? Third, how does imitation by poor countries affect innovation incentives in industrialized nations?

In this paper we aim at getting some insight into these questions through an endogenous growth model where the extent of international trade liberalization may be decisive for whether the poor East specializes in agriculture production, imitates goods from the rich West, or makes its own innovations. We use a framework that departs from most of the existing literature in three ways. First, we assume that the countries are intrinsically symmetric. Thus we do not have to rely on any exogenous international differences. Second, the choice between innovation and imitation is endogenously determined, and due to fixed imitation and innovation costs we allow imperfect competition in the product market. Third, we explicitly incorporate transaction costs.[1]

Consistent with empirical evidence we assume that successful imitation or innovation requires advanced intermediate goods as inputs, and that these intermediates to a large extent are produced in developed countries. This means that it is expensive both to imitate and innovate in developing countries if transaction costs are high. We further assume that even though it is less expensive to imitate than to innovate, imitation still requires some fixed investments in R&D. Thereby both imitation and

[1] The terms *trade liberalization* and *reduction of transaction costs* will be used interchangeably. As in economic geography literature, trade costs are interpreted as everything that, other things being equal, makes it more expensive to buy foreign than domestic goods. This includes factors such as pure communication and transportation costs and handling of red tape. The *de facto* international trade costs for firms in East Asia, for instance, were presumably significantly reduced when circumstantial trade procedures and bureaucratic interference were gradually abolished from the late 1960's (see, e.g., Aoki, Kim, and Okuno-Fujiwara, 1997). We do not consider income-generating tariffs.

innovation takes place under increasing returns to scale, and are unprofitable unless market demand is sufficiently high. Since the home market is typically small in developing countries, it is important for entrepreneurs in these countries to sell to the larger market in the developed countries. However, with high transaction costs it is expensive to engage in trade. Thus, cost factors as well as demand factors make it unprofitable for developing countries to invest in R&D if transaction costs are high.

For sufficiently low levels of transaction costs it will be profitable for developing countries to imitate - or even to innovate. But we also show that entrepreneurs in poor countries may prefer to imitate even if innovation might have been profitable. We thus ask whether imitation tends to speed up the global growth rate and reduce the international wage gap compared to a hypothetical situation where also poor countries innovate. The answer to this question depends on how much transaction costs are reduced by. In particular, we show that imitation is unambiguously preferable and constitutes a unique equilibrium if transaction costs are at intermediate level. For more moderate levels of transaction costs, however, we may have multiple equilibria; one where poor countries imitate goods from rich countries, and one where both poor and rich countries innovate. Economic growth is lower and international wage differences larger in the equilibrium with imitation.

We have a large array of evidence that international transaction costs are both quantitatively and qualitatively important. In a theoretical paper Samuelson (1954) showed that the home market bias may be explained by explicitly introducing international transaction costs. Later Krugman (e.g., 1991) and Krugman and Venables (e.g., 1990 and 1995) have demonstrated that introduction of transaction costs in formal models may help to explain why some countries and regions have prospered economically, while others have stagnated. In a very important and controversial paper Obstfeld and Rogoff (2000) further show that explicit consideration of transaction costs may resolve major puzzles in international macroeconomics. This is true even though they only consider OECD countries, where transaction costs are widely believed to be relatively small.[2]

[2]The most famous empirical investigation of the size of the home market bias is provided by McCallum (1995). Adjusted for geographical distance, he found that trade across Canadian

As far as we know, this is the first paper that studies how international transaction costs affect imitation and innovation incentives in poor countries. Grossman and Helpman (1991), on which the present paper builds, consider a completely integrated world in a knowledge-driven model. They presuppose that developing countries do not innovate, and have de-facto exogenous wages. Barro and Sala-i-Martin (1995, ch. 8) assume that intermediate goods are non-traded. They do not focus on how imitation affects the growth rate; their aim is rather to show convergence effects of imitation and knowledge spillovers. Currie et al. (1996) use the same framework as Grossman and Helpman, but presuppose that one region - for some reason - has an advantage over the other in knowledge assimilation. This may lead the backward region to imitate goods from the more advanced one. In effect, Currie et al. further assume increasing returns to knowledge accumulation in the imitation sector and show how the backward region eventually finds it profitable to innovate. Their primary focus is policy implications in an East-West perspective. Segerstrom (1991) deviates from both the present article and those mentioned above by assuming that there is a tacit price collusion between the original innovator and the imitator in a 'Quality Ladder' model. What Segerstrom seeks to explain is why entrepreneurs in the rich industrialized world copy goods from other firms in the same region, and his framework is not suited for analysis of interactions between rich and poor countries.

2 The model

There are two regions, W (West) and E (East), with population sizes equal to $L_j\,(j = W, E)$. In general we shall assume that $L_W = L_E$, although we allow $L_W \neq L_E$ when we derive the growth equations. Each inhabitant supplies one unit of labour, is internationally immobile, and there is no population growth. The consumers have identical preferences, and demand goods from a modern (m) and an

provinces was 20 times higher than trade between Canadian provinces and individual US states in 1988. McCallum's estimates have been adjusted downwards by more recent research, which is partly due to the fact that both informal and formal trade barriers have fallen sharply over the last decades. See Obstfeld and Rogoff (2000) for discussion and references.

agriculture (z) sector.[3] We abstract from traditional comparative advantages, and assume that (skilled) labour is the only primary input.

Demand side:

A representative consumer in region j has preferences of the form

$$U_j = \int_0^\infty \ln \left[m_j(s)^\eta z_j(s)^{1-\eta} \right] e^{-\rho s} ds, \qquad (0 < \eta < 1) \tag{1}$$

where $\rho > 0$ is the subjective discount rate.

The consumer prices for the modern and the agricultural good are given by $p_{mj}(s)$ and $p_{zj}(s)$, respectively. Each consumer inelastically supplies one unit of labour, and the intertemporal budget constraint may consequently be written as

$$\int_0^\infty \left[p_{mj}(s) m_j(s) + p_{zj}(s) z_j(s) \right] e^{-\int_0^s r_j(v)dv} ds = \int_0^\infty w_j(s) e^{-\int_0^s r_j(v)dv} ds + \frac{\Omega_j(0)}{L_j}. \tag{2}$$

The symbol $\Omega_j(0)$ denotes the present value of aggregate financial wealth in region j, w_j the wage level, and r_j the interest rate.

Let $\mathcal{E}_j$ be consumer expenditure in region j. Utility maximization then implies

$$\frac{d\mathcal{E}_j/dt}{\mathcal{E}_j} = r_j(s) - \rho.$$

The choice of nominal values does not affect the real side of the economy, and it turns out to be convenient to choose $w_W \equiv 1$. With this choice of numeraire the expenditure level in each region is constant in steady state, so that in both regions we have $r(s) = \rho$ along the balanced growth path (see Grossman and Helpman, 1991).

Supply side:

The z-good is produced with labour as the only input, and with a constant returns to scale technology. We normalize such that unit labour requirement is one,

[3] Several notations are used in the literature for what we call the agriculture sector. Basically, this sector is meant to cover those parts of the economy where economies of scale are insignificant. In this sense the Heckscher-Ohlin model, for instance, covers only traditional sectors.

and assume that the good is traded costlessly. Consequently,

$$p_z = p_{zj} = w_E. \tag{3}$$

The modern good is manufactured by using producer services, financial services, capital equipment and other differentiated intermediates as inputs. In order to keep the model analytically tractable, we will assume that all the intermediates enter symmetrically into the production function for the modern good, and that no other inputs are needed.[4] By letting x_k denote quantity of variety number k we will let the production technology for the modern good be given by the CES specification

$$M_j = \left[\sum_{k=1}^{n} x_k^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \qquad (\sigma > 1) \tag{4}$$

where $n(s) = n_W(s) + n_E(s)$ is the world-side available number of varieties at time s. We have thereby assumed that the intermediates are tradeable but, as will become clear later, it is harmless to assume that the modern good is nontraded. Thus $M_j = m_j L_j$ in equilibrium.

The restriction that the elasticity of substitution in (4) is greater than one, $\sigma > 1$, implies that no input is essential in production, and it is easy to show that the productivity of the intermediate inputs is strictly increasing in n.[5] As in Ethier (1982), Romer (1987), and Evans, Hokapohja, and Romer (1998) we interpret this as though the production process is more specialized the higher the number of intermediates that is available. We shall thus take $n(s)$ as an index of the global technological level at time s.

By choice of scale, it takes one unit of labour to make one unit of producer services. All producers in a given country will charge the same price since the inputs enter symmetrically into the production function and are produced with the same technology. We will follow Dixit and Stiglitz (1977) and assume that n is

[4] We could easily have assumed that the modern good is manufactured by using both labour and producer services, but this would not add anything new qualitatively.

[5] This is most easily seen if we assume that $x_k = \bar{x} \vee k$, in which case (4) simplifies to $M_j = n^{\frac{\sigma}{\sigma-1}} \bar{x}$. We then see that the average productivity of inputs, $\frac{M_j}{n\bar{x}} = n^{\frac{1}{\sigma-1}}$, is strictly increasing in n.

"large". This allows us to abstract from strategic interactions, and we can use the inverse elasticity rule to find that the $f.o.b.$ price equals

$$p_j = \frac{\sigma}{\sigma - 1} w_j. \tag{5}$$

The intermediates may be traded, but only at a cost. Let $q_k(s)$ be the *c.i.f.* price of good k, i.e., inclusive of international transaction costs. By taking the dual of (4) the unit cost function for the modern good can be written as

$$p_{mj} = \left[n_i q_i(s)^{1-\sigma} + n_j q_j(s)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{6}$$

Innovation technology

There will be growth in this economy if new varieties of intermediate goods are introduced to the market. As in Rivera-Batiz and Romer's (1991) lab-equipment model we will assume that the innovation technology uses existing intermediates as inputs. More specifically, we will follow Evans, Hokapohja, and Romer (1998) and let the cost function for an innovation be given by

$$P_j = \frac{1}{n_i + n_j} \left[\frac{n_i q_i^{1-\sigma} + n_j q_j^{1-\sigma}}{n_i + n_j} \right]^{\frac{1}{1-\sigma}}. \tag{7}$$

Differentiation of equation (7) shows that innovation costs decrease by one per cent if the number of varieties in each country increases by one percent, and this specification will be shown to generate a constant steady state growth rate.

The value v_j of a firm that manufactures intermediate goods must at least equal innovation costs P_j if an entrepreneur shall be willing to invest in development of a new variety. With positive growth and free entry into the innovative sector, it must therefore always be true that

$$v_j = P_j. \tag{8}$$

Imitation technology

We will assume that input requirement to actually *produce* intermediate goods is the same for an imitator and an innovator (with unit labour requirement as above), but that the actual imitation process calls for less resources than does innovation.

For analytical convenience the development costs for an imitation are specified as

$$Q_j = \kappa P_j \tag{9}$$

where $\kappa < 1$. The basic production technology for imitation is hence the same as for innovation, but with a lower input requirement for the former.[6]

There is free entry also in imitation. Denote by v_j^m the value of making an imitation. If imitation takes place, we will then have

$$v_j^m = Q_j \tag{10}$$

in equilibrium.

3 The East specialized in agricultural production

As in Baldwin, Martin, and Ottaviano (1998) and Baldwin and Forslid (2000) we assume that trade in producer services between the West and the East involves some real international transaction costs. These transaction costs are modelled in a manner which is well known from the trade literature; of each unit shipped, only $1/\tau$ reaches its destination ($\tau \geq 1$). Thus, gross demand of an imported good is τ times higher than net demand. This means that the *c.i.f.* price of an imported intermediate good is τ times higher than the *f.o.b.* price. Consequently, if the price of a domestically produced intermediate in country j is equal to p_j, the price of that good in country i equals $p_j \tau$ $(i \neq j)$.

Let $x_j \equiv x_{jj} + x_{ji}$, where x_{jj} denotes domestic demand for an intermediate good produced in region j and x_{ji} denotes gross demand from region i for the same good. Suppose that both regions are specialized; the East in the agriculture sector and the

[6] In an empirical study for the USA Mansfield et al (1981) have identified several sectors where imitation requires less effort than innovation, and found that imitation costs, on average, equal 65% of the original innovation costs. It is worth noting that they also found that patents rarely hinder imitation, but typically make it more expensive. Some part of the imitation costs may therefore be considered as costs incurred to circumvent patent laws, see also Barro and Sala-i-Martin (1995, ch.8).

West in the modern sector.[7] Labour market equilibrium in the West can then be expressed as

$$L_W = n_W x_W. \tag{11}$$

Since consumers spend a share η of their income $\mathcal{E}_j$ on the agricultural good, and each unit of z requires one unit of labour, the labour market in the East is in equilibrium when

$$L_E = (1-\eta)\left(\mathcal{E}_W + \mathcal{E}_E\right)/w_E. \tag{12}$$

Define $g \equiv \dot{n}_W/n_W$ to be the growth rate of innovations in the West. We will focus on steady state solutions, in which case the sector division of labour is constant. Then it follows from equation (11) that $g = \dot{n}_W/n_W = -\dot{x}_W/x_W$, which means that demand for each variety falls by one per cent when the number of varieties increases by one per cent. The effective discount rate is thus equal to $(\rho + g)$. Since the instantaneous profit flow received by a representative firm equals $\pi_W = (p_W - w_W)x_W = p_W x_W/\sigma$ the present value of an innovation is $\pi_W/(\rho + g)$. The free entry condition (8) may consequently be reformulated as

$$\frac{p_W x_W}{(\rho + g)\,\sigma} = P_W. \tag{13}$$

[7] Since the East and the West are assumed to be intrinsically symmetric there will obviously exist a symmetric equilibrium, i.e., an equilibrium where the two regions are identical, for all levels of international transaction costs. However, it is well known from the economic geography literature (see Krugman and Venables, 1995, and Fujitia, Krugman and Venables, 1999) that the symmetric equilibrium may be unstable. To see why, suppose that the West for some reason produces a larger set of intermediate goods than does the East. Then the West may be expected to have the majority of research firms in the future, because a smaller share of the region's inputs is subject to international transaction costs (this is a so-called cost linkage). But if the West ends up with a higher number of research firms than the East, then also future demand for innovated goods is highest in the West (demand linkage). These self-reinforcing centripetal forces may lead to an international concentration of the modern sector. On the other hand, concentration may intensify product market competition and lead to excessive demand for labour. These centrifugal forces tend to generate international decentralization, but the symmetric equilibrium is never stable in the cases we consider. The only stable equilibrium is instead one where the West ends up with the majority of the firms in the modern sector and where $w_E < w_W$.

Even though the East is relatively poor ($w_E < w_W$) and does not undertake research, the steady state growth rate in real per capita consumption is the same in the two regions. This reflects the fact that countries gain access to technologies developed by their trading partners by participating in trade.[8] In Appendix A2 we prove the following:

Proposition 1: *Suppose that both regions are specialized; the East in the agriculture sector, and the West in the modern sector. In this case the common growth rate in real consumption equals* $\mu = \eta g / (\sigma - 1)$, *where*

$$g = L_W / \sigma - \rho. \tag{14}$$

The growth rate is thus increasing in the size of the labour force of the innovating country, and this is a standard scale effect in endogenous growth models. Equation (14) moreover shows that g is decreasing in σ (because a high σ means that the goods are poor complements) as well as in ρ (since a high ρ increases the discount rate). We further see that the consumption growth rate increases in η, reflecting that technological progress takes place in the modern sector.

It should be noted that the strength of the centripetal forces that generate an international concentration of the research sector is weakened if transaction costs are reduced; entrepreneurs in the East will not be substantially disadvantaged from those in the West unless international transaction costs are relatively high. In fact, it must be equally profitable to produce intermediate goods in the two regions if $\tau = 1.0$ (trade is costless), and we cannot have an equilibrium where the East is completely specialized in production of the agricultural good if transaction costs are sufficiently low. From this it also follows that the international wage gap tends to be smaller the lower the level of international transaction costs (with $w_E = w_W$ at the limit $\tau = 1.0$).

[8] Note that this fits well with the observation that there does not seem to be any systematic relationship between long-term growth and per capita income (e.g. Lucas 1988). See also Baldwin, Braconnier and Forslid (1998) for a discussion of this point.

3.1 Does the East have incentives to imitate?

Even if is it is unprofitable for the East to innovate when transaction costs are high, it may be profitable to imitate goods from the West (since imitation costs are lower than innovation costs), We shall follow Grossman and Helpman (1991) and assume that there is Bertrand competition between two producers who manufacture the same product, and this amounts to limit pricing if the preferred monopoly price is higher than the rival's marginal cost. Therefore it is unprofitable to incur fixed costs in order to copy domestic products, which in particular precludes imitation to take place in the West.

Since it takes one unit of labour to make one unit of producer services, we know that both imitators and innovators would optimally charge the *f.o.b.* price $p_j = \frac{\sigma}{\sigma-1} w_j$ (c.f. equation (5)). The price of an imported producer service in country i will therefore never be higher than $p_j \tau$ $(i \neq j)$. Neither will it be lower than τw_j $(i \neq j)$, because that would imply a sales price below marginal costs.

Figure 1 may be useful in order to see how the level of transaction costs affects the prices that a possible imitator in the East will charge. The left-hand panel of Figure 1 illustrates the outcome in the home market (the East) for an imitator, and shows that $p_E < \tau w_W$ when transaction costs are above ca. 1.4.[9] This means that the preferred monopoly price of an imitator in the East is lower than the *c.i.f.* export cost price of the original innovator in the West. An imitator in the East would consequently charge its monopoly price domestically - and thus be unaffected by the original innovator - as long as $\tau >$1.4. Below this level of transaction costs the optimal price would be (infinitesimally lower than) τw_W. The right-hand panel of Figure 1 likewise illustrates the outcome in the West, but τp_E (not shown) is always higher than w_W for the chosen parameter values. Therefore an imitator is unable to charge the preferred monopoly price on the export market, but there is still room for a positive profit rate since $\tau w_E < w_W$ for $\tau <$1.9.

Note that reduced transaction costs tend to cut the profit margin for an imitator both domestically and abroad when τ is below approximately 1.4. Figure 1 thus

[9] See Appendix A1 for parameter values.

indicates that imitation is unprofitable if transactions costs are "low", in which case we may expect both regions to innovate. The fact that export of imitated goods to the West is unprofitable if $\tau > 1.9$ further indicates that we will see no imitation for "high" levels of transaction costs.[10] The latter also follows from the fact that it is expensive to import the inputs that are required to make an imitation if τ is high.

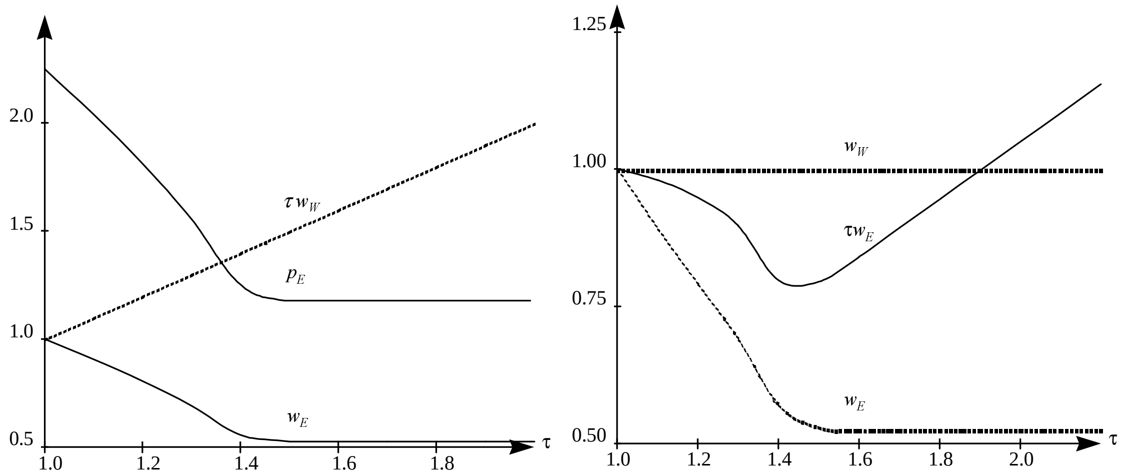

Figure 1: *Prices of an imitated good domestically and abroad.*

4 Imitation under intermediate transaction costs

Suppose that the East is specialized in production of the agricultural good, and that transaction costs are too high to make innovation profitable for the region. How can we find out if this is an equilibrium, or whether in fact it would be profitable for a single entrepreneur in the East to imitate a good from the West?

Assume first that the level of transaction costs is such that $p_E < \tau w_W$ and $\tau w_E < w_W < \tau p_E$ (c.f. Figure 1). In this case a possible imitator in the East would choose the price p_E domestically and the *c.i.f.* price w_W abroad (due to limit pricing competition). The respective profit margins are $(p_E - w_E) = p_E/\sigma$

[10]It would possibly be profitable to imitate foreign goods even at low levels of transaction costs (or copy a domestic good, for that matter) if we had assumed Cournot competition instead of Bertrand competition between innovators and imitators. However, this would make the model more complex without changing the basic results.

and $(w_W - \tau w_E)$. *Net* demand for an imported good in the East is x_{WE}/τ, with a *c.i.f.* unit price equal to τp_W. Since the elasticity of demand is σ an imitator would therefore expect to sell $(\frac{p_E}{\tau p_W})^{-\sigma}\left(\frac{x_{WE}}{\tau}\right)$ at home and, similarly, $(\frac{w_W}{p_W})^{-\sigma} x_{WW}$ abroad. The instantaneous profit flow for a potential imitator in the East (superscript m for imitation) is consequently

$$\pi_E^m = (\frac{p_E}{\tau p_W})^{-\sigma}\left(\frac{x_{WE}}{\tau}\right) + (\frac{w_W}{p_W})^{-\sigma} x_{WW}.$$

In order to make the subsequent equations easy to interpret, it is useful to find explicit expressions for x_{WE} and x_{WW}. First, we know that $n_W p_W x_{WE} = \eta \mathcal{E}_E$. The reason is that in the East producer services are only used to make consumer goods, and the consumers allocate a share η of their income to goods from the modern sector. Secondly, we know that $n_W p_W x_{WW} = p_W L_W - (1-\eta)\mathcal{E}_W$. The reason for this is that the value of production in the West is equal to $p_W L_W$ (each unit of labour produces one unit of producer services), and that $(1-\eta)\,\mathcal{E}_W$ of the region's income is spent on the agricultural good. After a slight reformulation, we thus find that

$$\pi_E^m = \left(\frac{p_E}{\tau p_W}\right)^{1-\sigma} \frac{\eta \mathcal{E}_E}{n_W \sigma} + \left(\frac{w_W}{p_W}\right)^{-\sigma} \left(\frac{w_W - \tau w_E}{p_W}\right) \left[\frac{p_W L_W - (1-\eta)\mathcal{E}_W}{n_W}\right]. \tag{15}$$

Since the cost of making an imitation is $Q_E = \kappa P_E = \kappa \tau P_W$, and the discount rate is $(\rho + g)$, it is profitable for a single entrepreneur in the East to imitate a good from the West if

$$\frac{\pi_E^m}{\rho + g} \geq \kappa \tau P_W = Q_E. \tag{16}$$

Note that there are three effects of reduced transaction costs from a potential imitator's point of view. The negative effect, shown by the first term in the expression for π_W^m in equation (15), is that the home market becomes less protected. The positive image of this, shown by the second term in (15), is that the access to the large export market improves. Finally, reduced transaction costs imply that imported inputs become less expensive, reducing the r.h.s. of inequality (16).

Suppose that imitation is profitable, and that n_E goods have been copied by entrepreneurs in the East. If n goods have been developed in the West so far, only $n_W = n - n_E$ are still produced in that region. The innovation costs in the West and the imitation costs in the East are then respectively given by

$$P_W = \frac{1}{n}\left[\frac{n_W p_W^{1-\sigma} + n_E w_W^{1-\sigma}}{n}\right]^{\frac{1}{1-\sigma}}, \text{ and}$$
$$Q_E = \frac{\kappa}{n}\left[\frac{n_E p_E^{1-\sigma} + n_W (p_W \tau)^{1-\sigma}}{n}\right]^{\frac{1}{1-\sigma}}. \tag{17}$$

The price P_W does not depend on the level of transaction costs directly, but indirectly it is a function of τ through the split of n between n_W and n_E. In section 4.1 we will discuss in detail how imitation affects innovation incentives, but we can immediately identify one positive effect; it reduces the innovation costs. This is clear from P_W in equation (17), which shows that the price of an imported (imitated) good is only w_W, while the original innovator charged p_W.

For lower levels of transaction costs the imitator must change to limit pricing strategies also domestically, because p_E exceeds τw_W. Imitation costs Q_E and innovation costs P_W are then given by

$$Q_E = \frac{\kappa}{n}\left[\frac{n_W(\tau p_W) + n_E(\tau w_W)^{1-\sigma}}{n}\right]^{\frac{1}{1-\sigma}} = \kappa\tau P_W. \tag{18}$$

In the steady state we must have the same growth rate of innovations and imitations (otherwise n_E/n_W would approach zero or one), denoted by g^m below. Independent of whether the imitator must use limit pricing only abroad or both domestically and abroad, we find (see Appendix A3):

Proposition 2: *Suppose that the East imitates goods from the West. In this case the global growth rate in real consumption equals* $\mu = \eta g^m / (\sigma - 1)$, *where*

$$g^m = \frac{p_W}{nP_W}\frac{L_W}{\sigma} - \frac{n_W}{n}\rho, \tag{19}$$

and

$$\frac{p_W}{nP_W} > 1. \tag{20}$$

By comparing equations (14) and (19) we immediately see that:

Lemma 1: *The global growth rate in real consumption is greater when the East imitates goods from the West than when the East is specialized in the agriculture sector.*

The East's disadvantage with respect to market access falls if international transaction costs are reduced. This makes imitation more profitable. Therefore a reduction of τ implies that n_E increases relative to n_W and that innovation costs P_W decreases. By inspection of equation (19) we thus immediately find:

Lemma 2: *Suppose that we are in an equilibrium where the East imitates goods from the West. In this case reduced international transaction costs increase both the imitation rate and the growth rate in real consumption.*

In order to understand the intuition behind Lemma 1 and Lemma 2, it is necessary to understand the effects of imitation in the East on the innovation incentives in the West. This is discussed mathematically in Appendix A4, while we offer a more informal treatment in the next section.

4.1 The link between innovation and imitation incentives

Suppose that we are in an equilibrium where imitation takes place, and let $m \equiv \dot{n}_E / n_W$ be the share of the goods presently produced in the West that is imitated by entrepreneurs in the East per unit of time. Since all non-imitated goods are considered identical by a potential imitator, they should also have the same probability of being copied. We can thus interpret m as the instantaneous probability that any given producer service is imitated. The consumers will hold a well diversified portfolio of shares, and in the steady state the expected value of an innovation will be equal to development costs:[11]

$$v_W = \frac{p_W x_W}{\sigma (\rho + g + m)} = P_W \tag{21}$$

Figure 2 may be useful in order to understand the interaction between innovation and imitation. All markets in the East as well as in the West are in equilibrium along the curve $L_W^d = L_W^s$, except that v_W possibly differs from P_W. Above this curve there is excess demand for labour in the West ($L_W^d > L_W^s$), and excess supply of labour below the curve ($L_W^d < L_W^s$). The curve is upward sloping because a higher

[11] A formal proof is given in Appendix A5.

rate of imitation releases labour in the West, and therefore allows a larger delivery of intermediate goods to the research sector (for any given consumer demand). This effect consequently gives us a positive relationship between m and g.[12] Along the curve $v_W = P_W$, where the labour market in the West is possibly in disequilibrium, innovations exactly break even, while the net present value of research is positive ($v_W > P_W$) below the curve and negative above the curve ($v_W < P_W$). The curve is downward sloping because the expected net present value of making an innovation decreases when the imitation rate increases. This reflects both the fact that a higher m increases the probability that a given brand is copied - implying a higher effective discount rate $(\rho + g + m)$ - and that innovators loose market shares to low price competitors. Note, however, that $v_W = P_W$ is relatively flat. The obvious reason for this is that imitation reduces innovation costs P_W. In addition, aggregate demand for intermediate goods may also increase; directly because imitators use intermediate goods as inputs, and indirectly because a higher m might increase income in the East.

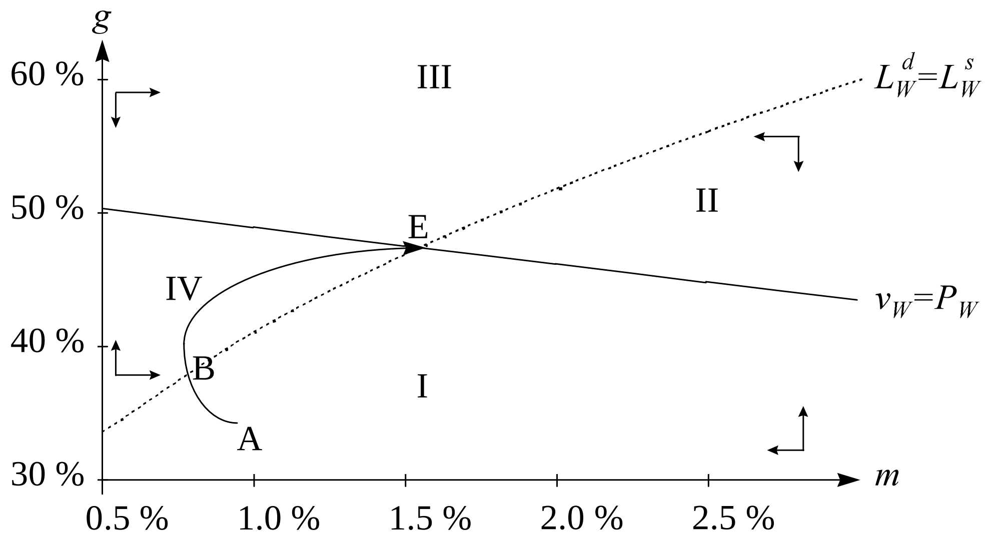

Figure 2: *Interaction between innovation and imitation.*

Both the financial market and the labour market are in equilibrium at point E in Figure 2, while there is unemployment in quadrants I and II, and pure profits

[12] Analogue "labour saving" effects in the rich region are a major reason why imitation speeds up the global growth rate in Grossman and Helpman (1991).

in quadrants I and IV.[13] Imagine that for some reason we are at a point like A where both m and g are below their equilibrium values. Here there is excess supply of labour in the West, and this puts a downward pressure on the regions wages relative to those in the East. Thereby the competitiveness of the West improves (the East's cost advantage is reduced). Consequently, it becomes less profitable for entrepreneurs in the East to provide producer services, and m decreases. Simultaneously, the growth rate in the West speeds up (g increases) because innovators observe pure profits. At point B the labour market in the West is in equilibrium, but the growth rate still increases because $v_W > P_W$. Consequently, demand for intermediate goods from the research sector increases further. Other things being equal, this causes labour shortage in the West at the prevailing wages. Therefore the competitiveness in the East improves, and imitation becomes more profitable (m increases). This process continues until we reach equilibrium point E, where more imitation in the East has caused a higher innovation rate in the West. This explains the logic behind Lemma 1.

Next consider the consequences of a reduction in τ. Reduced transaction costs give the East better market access to the large West market, and increase the wage level w_E. For any given m this implies a higher demand for modern goods, and the firm value v_W increases. The curve $v_W = P_W$ is consequently shifted upwards, as shown in Figure 3. But the higher consumer expenditure in the East also entails excess demand for labour in the West, so the $L_W^d = L_W^s$ curve is shifted downwards. Compared to the initial equilibrium, reduced transaction costs have led to pure profits for innovators and labour shortage in the West. Equilibrium is then restored by increasing both the imitation share m and the innovation rate g (similar to the process described for Figure 2, quadrant IV).[14] This explains Lemma 2.

[13] Note that Figure 2 is not really a phase diagram, and we do not attempt to explain why there should ever be disequilibrium in the labour market or in the financial market. The discussion is only meant to highlight the forces at work.

[14] In principle, these curve shifts could imply a higher m and a lower g in the new equilibrium, but we already know from equation (19) that trade liberalization has positive growth effects.

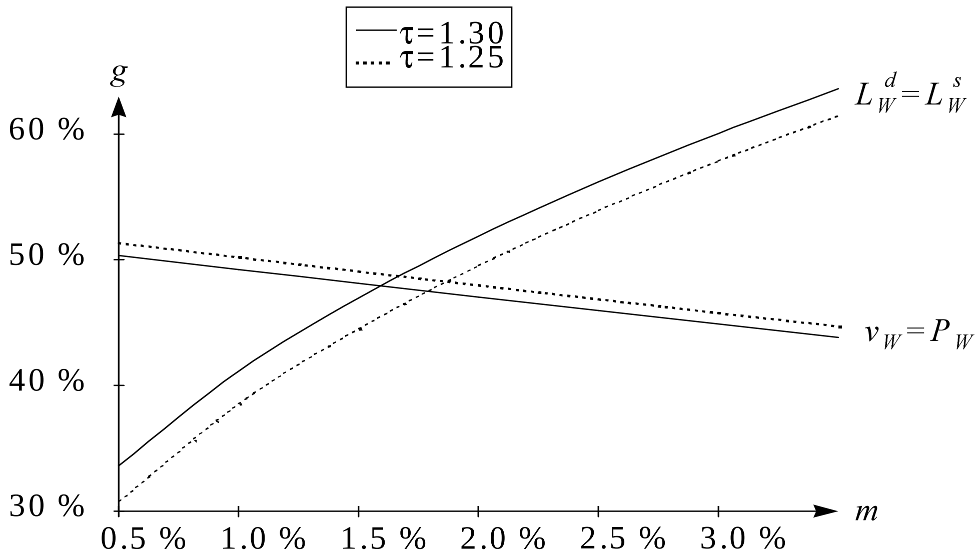

Figure 3: *Growth effects of trade liberalization.*

5 Imitation under moderate transaction costs

From Lemma 1 we know that imitation speeds up the growth rate for some intermediate level of transaction costs, due to the fact that the East otherwise would be specialized in agricultural production. For lower levels of transaction costs, however, both regions may in principle be able to innovate (see also Section 3.1). In this case Lemma 1 is no longer relevant; the question is then rather whether imitation is beneficial and profitable compared to a situation where both regions innovate.

We will show that we have a unique equilibrium where both regions innovate when international transaction costs are sufficiently low, but that there exist multiple equilibria for some moderate levels of transaction costs. In one of these equilibria the East imitates goods from the West - the imitation equilibrium, while both regions innovate in the other - the innovation equilibrium. Whether the economy ends up in the first or the second equilibrium has effects both on the global growth rate and on the international wage gap, and we will start the analysis by comparing the growth rates in the two equilibria.

5.1 Growth under imitation and innovation

Suppose that the world economy is in an equilibrium where both regions innovate. It is then straight forward to show that:

Proposition 3: *Consider an equilibrium where both the East and the West innovate. In this case the global growth rate in real consumption equals* $\mu = \eta g / (\sigma - 1)$, *where*

$$g = \frac{p_W}{n_W P_W} \frac{L_W}{\sigma} - \rho, \tag{22}$$

and

$$\frac{p_W}{n_W P_W} \lesseqgtr 1. \tag{23}$$

Comparing equations (19) and (22) we see that it is not obvious whether the growth rate is highest when the East innovates or imitates. An outcome where both regions innovate may generate higher growth than one where the East imitates if $p_W / (n_W P_W) > 1$, while the growth rate with imitation obviously is highest if $p_W / (n_W P_W) < 1$. The ambiguous growth effects of imitation are illustrated by Figure 4, where the curve $g - g$ shows the growth rate in the innovation equilibrium and the curve $g^m - g^m$ shows the growth rate in the imitation equilibrium. Along the dotted part of $g - g$ innovation in the East is no longer an equilibrium outcome if we allow imitation to take place.

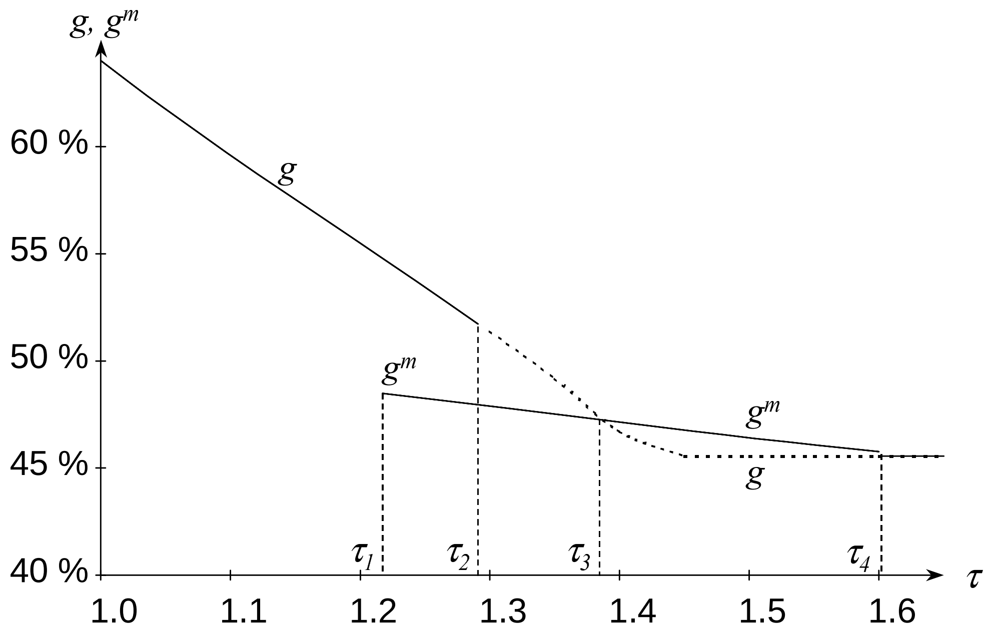

Figure 4: *Growth and international transaction costs.*

Figure 4 shows that the possibility to imitate has the following consequences:

Proposition 4: *Suppose that*

(i) $\tau_3 < \tau < \tau_4$. *In this case we have a unique equilibrium where the East imitates. The global growth rate in real consumption is higher than if imitation were not possible.*

(ii) $\tau_2 < \tau < \tau_3$. *In this case we have a unique equilibrium where the East imitates. The global growth rate in real consumption is lower than if imitation were not possible.*

(iii) $\tau_1 < \tau < \tau_2$. *In this case there exist multiple equilibria. The global growth rate in real consumption is highest in the innovation equilibrium.*

(iv) $\tau < \tau_1$. *In this case we have a unique equilibrium where both regions innovate.*

Part (i) of Proposition 4 is not surprising, given the discussion in Section 3: imitation reduces the disadvantage of a small home market and therefore has a positive growth effect for some intermediate levels of transaction costs. Neither is Part (iv) surprising; for low levels of transaction costs the profit margins are too small to make imitation profitable. Trade is inexpensive, and we have a unique equilibrium where both regions innovate. The new insight comes from Part (ii) and (iii) of Proposition 4, i.e., when transaction costs are only moderately high and imitation may affect growth negatively.[15]

There are two major reasons why growth is highest in the equilibrium where both regions innovate when $\tau < \tau_3$. First, imitation does by its very nature involve some duplication of research effort which tends to reduce the feasible growth rate. Second, the more imitators there are in the East the shorter is the expected monopoly period for the original innovator in the West (c.f., equation (21)); in this sense an increase in the number of imitators has a negative effect on innovation incentives. Because lower transaction costs reduce the importance of the centripetal forces and thus increase the share of world-wide research that takes place in the East, these negative effects do not dominate before the transaction costs are only moderately high.

5.2 Multiple equilibria and international wage gaps

The relatively low input requirements for imitations ($\kappa < 1$) reduce the disadvantage of a small home market in the East. This cost saving is particularly important when trade is expensive, because the price of imported inputs is strictly increasing in τ. Therefore imitation increases labour demand in the East, and reduces the international wage gap. However, this changes if τ becomes sufficiently low. The reason is that imitation restricts the sustainable equilibrium wages in the East, because of the high degree of (latent) price competition from the original innovators. In that sense imitation puts a downward pressure on wages in the East, and Figure 5 shows that the wage level in the East is lower under imitation $\left(w_E^m\right)$ than under innovation $\left(w_E\right)$ if $\tau_1 < \tau < \tau_2$.

[15] Equations (15) and (16) define $\tau = \tau_4$, i.e., the point where it becomes profitable for entrepreneurs in the East to imitate goods from the West (and where we no longer have an equilibrium where the East is completely specialized in agriculture production). We can use a similar method as the one that led us to these equations to find analytical expressions for τ_1 and τ_2.

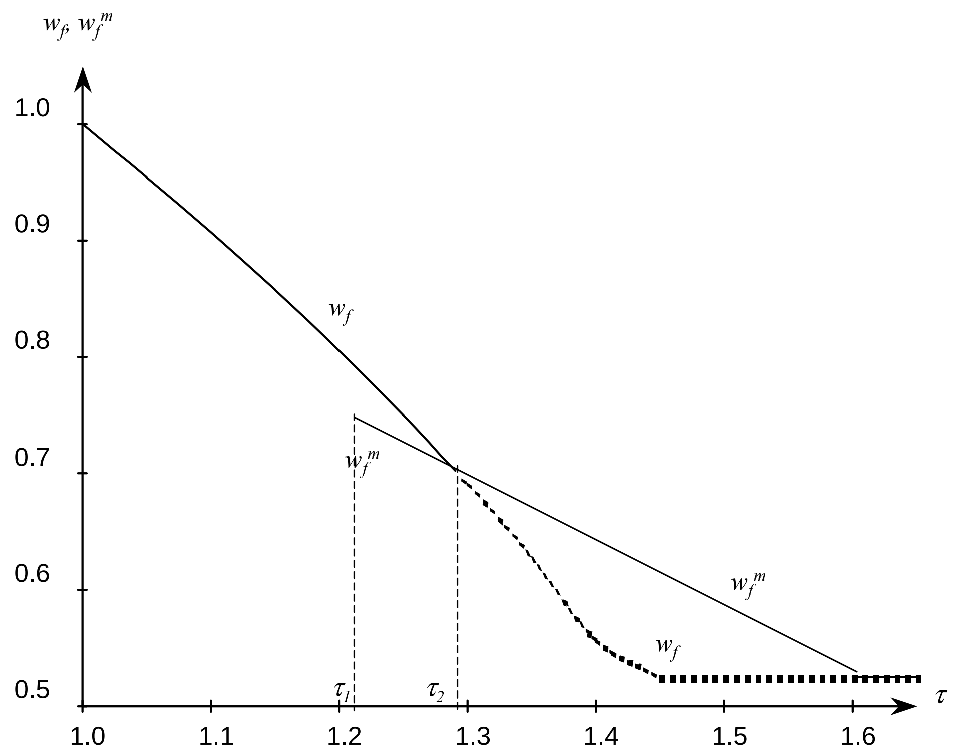

Figure 5: *International wage gaps with and without imitation.*

We thus have:

Proposition 5: *Suppose that $\tau_1 < \tau < \tau_2$, i.e., the case with multiple equilibria. Then the international wage gap is smaller in the innovation equilibrium than in the imitation equilibrium.*

Figure 6 may be useful to see why we have multiple equilibria, and why the imitation equilibrium generates a relatively large international wage gap. The horizontal axis measures transaction costs and the vertical axis measures the value of producing an intermediate good in the East. The upward-sloping solid line shows the ratio v_E^m/Q_E in an outcome where all entrepreneurs in the East innovate and break even ($v_E = P_E$). However, this cannot represent any equilibrium outcome if $v_E^m/Q_E > 1.0$: the present value of an imitation, v_E^m, is then greater than the imitation costs Q_E. Thus imitation offers pure profits, and deviation is profitable. The downward sloping dotted line likewise shows the ratio v_E/P_E in an outcome where all entrepreneurs in the East imitate and break even $\left(v_E^m = Q_E\right)$; deviation from imitation to innovation is profitable whenever $v_E/P_E > 1.0$.

Suppose we are in an outcome where the entrepreneurs in the East innovate ($v_E = P_E$), and consider a point like $\tau = 1.30$. The figure shows that for this level of transaction costs we have $v_E^m/Q_E \approx 1.08 > 1.0$, so deviation from innovation would be profitable. Therefore the economy ends up in an equilibrium where all entrepreneurs in the East imitate, but then it is no longer possible to cover the region's relatively high innovation costs ($v_E/P_E \approx 0.96 < 1.0$ at the curve $v_E^m = Q_E$ when $\tau = 1.30$). The figure further shows that if the East is in an outcome with imitation, for example for historical reasons, it is not profitable to innovate unless the level of transaction costs is lower than $\tau = \tau_1$. In the same way we find that deviation from an outcome with innovation is unprofitable if $\tau < \tau_2$. We thus have multiple equilibria for $\tau \in (\tau_1, \tau_2)$.

The existence of multiple equilibria is caused by imperfect competition and pecuniary externalities. To see this, assume that $\tau \in (\tau_1, \tau_2)$ and that all entrepreneurs in the East imitate. It is individually unprofitable to deviate from this outcome because a potential innovator would face too strong price competition from domestic producers of (imperfect) substitutes to be able to cover the relatively high innovation costs. However, by reducing the competitive pressure, innovation does become profitable if a sufficiently large number of entrepreneurs in the East choose to innovate rather than to imitate. This in turn allows higher equilibrium wages in the region (as was shown in Figure 5). But then, because of the higher wage level, imitation is no longer profitable; the latent price competition from the original innovator in the West implies that an imitator's profit margins - equal to $(\tau w_W - w_E)$ domestically and $(w_W/\tau - w_E)$ abroad - are too low to cover imitation costs.

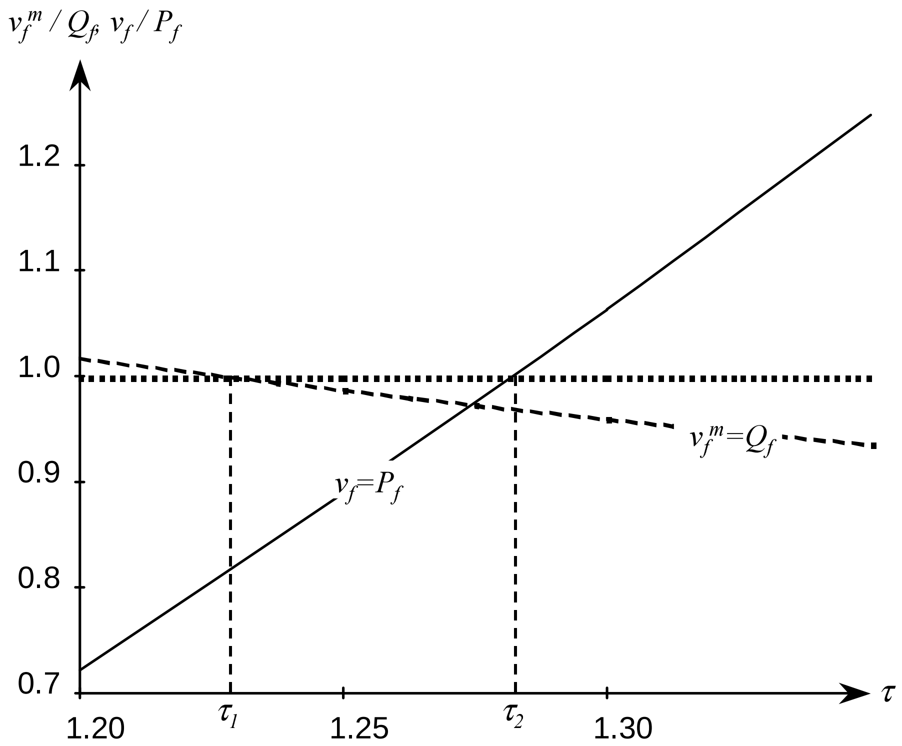

Figure 6: *Multiple equilibria.*

5.3 Summing up the consequences of imitation

Figure 7 sums up the discussion. Both regions are specialized when $\tau > \tau_4$, the West in the modern sector and the East in the agriculture sector, while imitation is both profitable and beneficial ($g^m > g$ and $w_E^m > w_E$) if $\tau \in (\tau_3, \tau_4)$. We have an equally clear result when $\tau \in (1.0, \tau_1)$; the regions are then so closely integrated that entrepreneurs in both regions unambiguously prefer to innovate. Between these extremes the picture is more complex; depending on the level of transaction costs, imitation may affect both the global growth rate and the wage level in the East negatively.

The most interesting region is perhaps for $\tau \in (\tau_1, \tau_2)$. Here we have multiple equilibria, and the international wage gap is largest and the global growth rate lowest in the equilibrium with imitation. Though we are not considering welfare effects and possible policy implications in this paper, it is worth stressing that the model clearly indicates the existence of an 'imitation trap'. In the long run, at least, it is obvious that consumers in both regions would be better off in the innovation equilibrium when $\tau \in (\tau_1, \tau_2)$, but coordination failures may prevent an escape from a possibly inferior equilibrium.

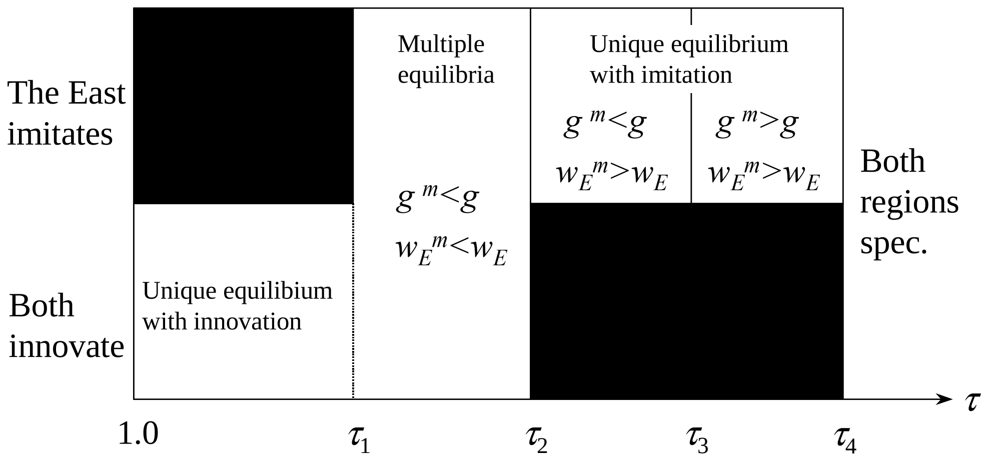

Figure 7: *Transaction costs and consequences of imitation.*

6 Conclusion

In this paper we have asked how trade liberalization affects imitation incentives in poor countries and, in turn, how imitation by poor countries affects international income inequalities and innovation incentives in industrialized countries. We have shown that imitation may not be profitable for developing countries unless trade is sufficiently liberalized. The reason is that imitation requires cheap access both to the input and output markets in the industrialized world. Other things being equal, we should thus expect a positive relationship between trade liberalization and imitation.

The questions of how imitation affects innovation incentives and international income inequalities are less straightforward to answer, since it is not obvious what one should compare with. The existing literature typically assumes that developing countries are unable to innovate, thus making it most relevant to compare an equilibrium where developing countries imitate to an equilibrium where developing countries specialize in the agriculture sector. In this case the theory seems to lend most support to the view that imitation tends to reduce the international wage gap and increase innovation incentives in the more advanced countries. We found a similar result. However, in the present paper the choice between imitation and innovation is endogenously determined. Thus, it may be most relevant to compare an equilibrium where developing countries imitate to an equilibrium where they innovate. When this is the basis for comparison, we find that imitation may in fact increase the international wage gap and reduce innovation incentives in developed countries.

The existence of an inferior imitation equilibrium indicates that stricter enforcement of patent laws, which makes it more expensive to imitate, could be to the advantage both for the most advanced imitating countries and for those countries that are being imitated. However, making it more costly to imitate is likely to be a disadvantage for those countries that are unable to innovate. An interesting path for future research would therefore be to analyze which policy instruments could be used to prevent socially unprofitable imitation without harming the less advanced countries.

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Appendix

A1 Parameter values

In all the simulations $L_W = L_E = 1$, $\kappa = 0.5$, $\eta = 0.7$, $\sigma = 1.8$, and $\rho = 0.1$.

There will always be international wage equalization if η is so small that the agricultural good must be produced in both regions. The mere existence of an asymmetric equilibrium suggests that this outcome is somewhat artificial, and with diminishing returns to labour in the agriculture sector we would in general have $w_E \neq w_W$. Since a model extension along these lines would make the algebra substantially more complex, we have instead assumed that η is so large that one region is able to supply world-wide demand for the $z-$good. In this way we allow international wages to differ in a simple model set-up.

The second essential parameter in this model is σ. It is easy to show that this is an inverse measure both of the heterogeneity of intermediate goods and of the degree of scale economies. In Kind (1998) it is shown that the symmetric equilibrium is always unstable if $\sigma < 2$. The pattern becomes somewhat more complex if $\sigma > 2$. We may still have the innovation and imitation stages mentioned above, but both regions would innovate also when transaction costs are 'very high' (because the symmetric equilibrium is then stable). It is in order to avoid this stage, which is hardly particularly relevant empirically, that we have chosen $\sigma < 2$. Thereby the analysis is simplified, probably without losing any insight.

A2 Proof of Proposition 1

The growth rate in real consumption in region j is equal to $\mu_j = \left(p_{mj}\dot{m}_j + p_z\dot{z}_j\right)/E_j = \eta\dot{m}_j/m_j$, where the last equality is due to the fact that there is no technological progress in the agriculture sector ($\dot{z}_j = 0$) and that a share η of the income is spent on goods from the modern sector. It can further be shown that $\dot{m}_j/m_j = g/(\sigma - 1)$, and consequently $\mu_E = \mu_W \equiv \mu = \eta g/(\sigma - 1)$.

The ownership of the firms producing intermediate goods is evenly spread among domestic consumers as share holders. From equations (7) and (8) we find $\dot{v}_j/v_j = -g$ in the steady state, and that aggregate share value - which equals consumer wealth - is constant and given by

$$\Omega_j = n_j v_j = n_j P_j. \tag{24}$$

Consumer expenditure equals wage income plus profit flows from existing firms minus new investments (savings); $\mathcal{E}_j = w_j L_j + n_j \pi_j - \dot{n}_j P_j$. This can be simplified to

$$\mathcal{E}_j = w_j L_j + \rho \Omega_j \tag{25}$$

in the steady state because financial wealth is then constant (c.f. equation (24)).

Recalling that consumers use a share η of their income on the modern good, we can use Shepard's lemma on (6) and (7) that

$$p_W x_W = \eta(\mathcal{E}_E + \mathcal{E}_W)/n_W + P_W g \tag{26}$$

when only the West produces intermediate goods. With this specialization pattern balanced trade requires

$$\eta \mathcal{E}_E = (1 - \eta)\mathcal{E}_W. \tag{27}$$

Inserting equations (24)-(27) into labour market equation (11) we find equation (14) in Proposition 1.[16]

A3 Proof of Proposition 2

At each moment of time $\dot{n}$ goods are developed in the West while $\dot{n}_E$ goods are copied in the East, and it is easy to verify that $\dot{n}/n = \dot{n}_E/n_E = \dot{n}_W/n_W$ in the steady state. Due to the CES-formulation we know that firms in region j have an aggregate market share equal to $s_{jk} = n_k q_k^{1-\sigma}/\left(n_j q_j^{1-\sigma} + n_i q_i^{1-\sigma}\right)$ in market $k = i, j$ (where the q's are *c.i.f.* prices). It takes $\left(s_{WW}\eta\mathcal{E}_W + s_{WE}\eta\mathcal{E}_E\right)/p_W$ units of labour in

[16] From equations (24), (25) and (27) we can further find an explicit expression for w_E.

the West to meet consumer demand for modern goods, while $s_{WE}\dot{n}_E Q_E/p_W$ workers are needed to satisfy demand from imitators in the East. This leaves

$$s_{WW}\dot{n}P_W/p_W = L_W - \left(s_{WW}\eta\mathcal{E}_W + s_{WE}\eta\mathcal{E}_E\right)/p_W - s_{WE}\dot{n}_E Q_E/p_W \tag{28}$$

workers to the research sector in the West. We further note that balanced trade requires

$$s_{WE}\eta\mathcal{E}_E + s_{WE}\dot{n}_E Q_E = (1-\eta)\mathcal{E}_W + s_{EW}\eta\mathcal{E}_W + s_{EW}\dot{n}P_W. \tag{29}$$

Using $\dot{n}/n = \dot{n}_E/n_E = g^m$ (superscript m for imitation) and $\mathcal{E}_j = w_j L_j + \rho\Omega_j$ together with equations (28) and (27) we have $nP_W g^m/p_W = L_W - w_W L_W/p_W - \Omega_W\rho/p_W$. By simplifying this expression we find equation (19) in Proposition 2. That $p_W/\left(nP_W\right) > 1$ is obvious from P_j in equation (17), since $w_W < p_W$.

A4 Innovation incentives in the presence of imitation

In order to illustrate how imitation affects the incentives to innovate, we shall look at the case where an imitator is obliged to use limit pricing both domestically and abroad. From equation (18) we know that the price indexes in both regions then are independent of the wage level in the East, and that $Q_E = \tau\kappa P_W$. Moreover, domestic and foreign market shares are equal, so we may define $s \equiv s_{WW} = s_{WE} = n_W p_W^{1-\sigma}/\left(n_W p_W^{1-\sigma} + n_E w_W^{1-\sigma}\right)$.

The instantaneous profit flow from an innovation is

$$\pi_W = \left[s\left(\eta\mathcal{E}_W + \eta\mathcal{E}_E\right) + s\left(\dot{n}P_W + \dot{n}_E Q_E\right)\right]/\left(n_W\sigma\right),$$

while development costs are P_W, and the required rate of return equals $(\rho + g + m)$. Let $q(m) \equiv \frac{\pi_W(m)}{P_W(\rho+g+m)}$. Imitation now tends to increase (decrease) the growth rate if $q'(m) > 0$ ($q'(m) < 0$).[17] Steady state consumer expenditure equals $\mathcal{E}_j = w_j L_j + \rho\Omega_j$. Since $Q_E = \tau\kappa P_W$ we have $\Omega_E = \tau\kappa\Omega_W n_E/n_W$ and $\left(\dot{n}P_W + \dot{n}_E Q_E\right) = g\left(n/n_W + \tau\kappa n_{E/}n_W\right)n_W P_W$. Using this in the expression for π_W, we can write

$$q(m) = \frac{S\eta\left(w_W L_W + w_E L_E\right) + s\eta\rho\left(1 + \frac{n_E}{n_W}\tau\kappa\right) + sg\left(\frac{n}{n_W} + \frac{n_E}{n_W}\tau\kappa\right)}{\sigma\left(\rho + g + m\right)}, \tag{30}$$

[17] This may be regarded as a Tobin's-q approach, where $q = 1$ along a balanced growth path. The methodology was introduced in endogenous growth models by Baldwin and Forslid (1996), who note that while q determines the steady state capital-labour ratio in exogenous growth models, it determines the level of real investments in endogenous growth models.

where $S \equiv s/(n_W P_W)$; the lower the S, the higher the innovation costs behind each unit market share per firm. Note that the numerator of (30) can be interpreted as the value of demand measured in units of innovation costs P_W; the first and second terms show revenue from consumer demand (financed from wage and interest income, respectively), and the third term shows revenue from sales to innovators and imitators.

The aggregate market share for innovators is decreasing in m, and from the expression for s we find

$$\frac{ds}{s}\frac{m}{dm} = -(1-s). \tag{31}$$

Though innovators as a group lose market share when m increases, the same need not be true for each individual surviving firm. The low price on imitated goods moreover implies that there is an inverse relationship between m and P_W (for any given n), and differentiation shows that

$$\frac{d(n_W P_W)}{(n_W P_W)}\frac{m}{dm} = -\frac{n_E}{n_W + n_E}\left\{1 + \frac{1}{\sigma-1}\left[\left(\frac{w_W}{p_W}\right)^{1-\sigma} - 1\right]s\right\}. \tag{32}$$

Equation (32) is always negative, and tends to increase the incentives to innovate. A low σ means that innovators use a high markup, and the cost reducing effect of imitation is therefore higher the lower the σ. It can be shown that $s(w_W/p_W)^{1-\sigma} = (1-s)g/m$, and using this together with equations (31), (32) we find $\frac{dS}{S}\frac{m}{dm} = \left(\frac{1}{g+m}\right)\left(\frac{\sigma-2}{1-\sigma}\right)[g(1-s) - ms]$, or

$$\frac{dS}{S}\frac{m}{dm} = \frac{n_E}{n_W + n_E}\left(\frac{\sigma-2}{1-\sigma}\right)\left[\left(\frac{w_W}{p_W}\right)^{1-\sigma} - 1\right]s. \tag{33}$$

Equation (33) shows that the effect of smaller market shares and reduced innovation costs cancel each other exactly if $\sigma = 2$. Other things being equal, imitation therefore does not affect the profitability of innovation if $\sigma = 2$. But other things are, of course, not equal; a higher imitation share m may in fact increase the first term in the numerator of (30) even if $\sigma > 2$, if it leads to a higher wage level in the East. Similarly, a higher m tends to increase financial wealth in the East, and the positive effect of this is reflected by the expression $\tau\kappa n_E/n_W = \tau\kappa m/g$ in the second term of the numerator of (30). The resulting higher demand for modern goods has a positive incentive effect on innovators in the West.[18] The third term in the numerator, where $(n/n_W + \tau\kappa n_E/n_W) = (m+g)/g + \tau\kappa m/g$, reflects the positive demand effect, domestically and abroad, of a higher imitation rate. This positive effect must, however, also be weighted against the loss of market share s, so it is ambiguous whether the total effect is positive or negative.

The last effect, which is unambiguously negative, is that higher imitation increases the probability that a given brand in the West will be copied. Therefore the required rate of return increases: $\frac{d(\rho+g+m)}{(\rho+g+m)}\frac{m}{dm} = \frac{m}{(\rho+g+m)}$.

A5 *Derivation of the value of an innovation*

With other parameter values than those used in this paper we may find that it is unprofitable for an imitator to export because $\tau w_E^m > w_W$. What is the expected value v_W of making an innovation?

Let v_W^m denote the value of an innovation that has been imitated by a firm in the East. If $\tau w_E > w_W$ the optimal price strategy for the original innovator is to charge τw_E (given that $p_W > \tau w_E$) and continue to sell the good domestically. In this case $v_W^m > 0$. Otherwise, if $\tau w_E \leq w_W$, we have $v_W^m = 0$. The easiest way to find v_W in this more general case, is to extend the arbitrage arguments developed by Grossman and Helpman (1991): Consider a firm in the West that manufactures a product which has not yet been imitated. During a short time interval dt, this firm receives a profit flow $\pi_W dt$. During the same interval, $\dot{n}_E dt$ variants in the West are imitated, and the probability that any given brand is imitated equals $mdt = \left(\dot{n}_E/n_W\right) dt$. The share holders observe a capital loss equal to $\left[v_W - (v_W^m + \dot{v}_W^m dt)\right]$ if this occurs, otherwise the share value increases by $\dot{v}_W dt$ (with probability $(1 - mdt)$). Equating the return from holding a share in a firm whose product has not been copied, to the return on a bank deposit gives us

$$\pi_W dt - mdt\left[v_W - (v_W^m + \dot{v}_W^m dt)\right] + (1 - mdt)\,\dot{v}_W dt = \rho(v_W dt).$$

Dividing by dt and then taking the limit as dt goes towards zero, this can be written

[18] Recall that the numerator in (30) measures revenue in terms of innovation costs, therefore terms with $n_W P_W$ in both the numerator and denumerator do not show up.

as

$$\pi_W/v_W - m(v_W - v_W^m)/v_W + \dot{v}_W/v_W = \rho. \tag{34}$$

The instantaneous profits for a monopolist equal $\pi_W = p_W(x_{WW} + x_{WE})/\sigma$, so equation (34) implies that

$$v_W = \frac{p_W(x_{WW} + x_{WE}) + \sigma m v_W^m}{\sigma(\rho + g + m)}, \tag{35}$$

where x_{WW} and x_{WE} denote aggregate sales domestically and abroad, respectively, for an innovating firm in the West. From this it is easy to verify that we have $v_W^m = \max\{0, (w_E\tau - w_W)\, x_{WW}/\,(\rho + g)\}$. Equation (13) is the special case of (35) where $\tau w_E \leq w_W$ so that $v_W^m = 0$.