Quality and Interrelated Growth

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Abstract

This paper develops a model in which a rapid expansion of the quality frontier by rich countries pushes poorer countries down the quality ladder and thereby leads to a widening dispersion of quality around the world as well as sluggish growth in poorer countries. This paper documents these features in the data, such as a recent rise in the dispersion of quality exported around the world between rich countries on the one hand and either poor countries or countries stuck in a middle-income trap on the other hand, as well as a widening dispersion of per-capita income among these groups.

1 Introduction

This paper develops a model of interrelated growth in which an evolving quality frontier makes it increasingly difficult for countries away from the frontier to catch up, and indeed makes them prone to falling incomes as their existing skill set and associated technology becomes less valuable over time. In this model, sustaining growth requires a continual progression through producing goods of higher and higher quality, and the engine propelling a country through producing goods of increasing quality is the skill set of labor that firms can draw on for producing these goods. The failure of a country to sustain this progression is thus intimately linked to a failure of its labor force to acquire new and better skills. However, goods produced at lower levels of the quality ladder compete with the introduction of new goods by countries at the quality frontier, thus making it difficult to sustain growth when the quality frontier is expanding. This model is shown to match key aspects of countries in different phases of development. Indeed, the emergence of the middle-income trap within the past half century can perhaps be partially attributed to the evolution of countries at the frontier of quality, as a rapid expansion of the frontier may have made it difficult for relatively poor countries to progress up the quality ladder and thereby sustain growth.

The quality of a good is inferred from its price as measured by its unit value computed from the United Nation's COMTRADE database. This paper documents that the spread of quality or unit values for all products exported in the world increased dramatically from 1980 to 2000, which is also the time during which per-capita GDP in the richest countries rose significantly relative to the rest of the world. During that time fewer countries exited low-income status and fewer countries entered high-income status relative to prior or subsequent times. There was also a dramatic slowing of per-capita GDP of many middle-income countries during that time, which is now referred to as the Middle-Income Trap. This paper also corroborates an inverse relationship between the quality of exports and per-capita GDP, and shows that countries in a middle-income trap are likely to have fallen in the quality of goods exported relative to countries that had progressed smoothly through their middle-income phase. These results support key predictions of the model developed in this paper.

2 Literature Review

Heterogeneity of goods along a quality dimension in a theory of growth was initially developed by Stokey (1988), Grossman and Helpman (1991), and Aghion and Howitt (1992). A common theme in these models is the association of growth with a progression of producing higher quality goods along with Schumpeter's (1942) idea that new goods or production techniques make old ones obsolete. Trade and development dimensions of this quality progression were also developed during this time by Segerstrom, et. al. (1990), who presented a model of North-South trade such that new, high quality goods are introduced and produced first in the North, but the production of these goods moves to the South as even newer goods are introduced in the North.[1] Endogenizing aspects of such a pattern of production and trade as it relates to quality goods, as well as providing a mechanism by which poor, developing countries could be encouraged or discouraged from climbing the quality ladder, is a chief focus of the current paper. A related literature has also developed to more closely study the incentives for research and development in a non-competitive framework, such as Grossman and Helpman (1989), Jones (1995), Kortum (1997), Segerstrom (1998), Young (1998), and Howitt (1999). This connection is surely foundational to understanding the engine for growth as it relates to quality goods, but this paper will approach this issue from a very tractable perspective of human capital accumulation in a perfectly competitive environment.

Computing unit values from trade data to infer quality was done by Schott (2004, 2008), Hummels and Klenow (2005), Hallak (2006), Khandelwal (2010), Hallak and Schott (2011), Feenstra and Romalis (2014), and Martin and Méjean (2014). Each of these papers provides evidence that unit values are related to variables such as per-capita income as one would expect in models in which price differences reflect quality differences. Some of these papers are concerned, though, that unit values may also reflect sources of price differences other than quality differences and hence try to disentangle these effects. Of particular note, though, is Feenstra and Romalis' (2013) finding that much of the variation in export-based unit values seems to be due to differences in quality. For this reason, the current paper will attribute all the variation in unit values to variation in quality. Amongst the papers just mentioned, Martin and Méjean (2014) is closely related to the current paper as they present evidence that competition from low-quality goods in poor, developing countries led rich, industrialized countries to move up the quality ladder. An important idea in the current paper is in some sense the reverse: a movement up the quality ladder by rich, industrialized countries tends to push poor, developing countries down the quality ladder.

[1] Dinopoulos and Segerstrom (1999) also develop a model with two identical countries that divide the production of quality goods between them, which they use to examine issues of trade, skill accumulation, and the skill premium.

3 The Model

3.1 Preferences

There are $J \geq 1$ countries indexed by $1 \leq j \leq J$ and each country is populated by $N_j > 0$ dynastic households living in a perfect-foresight, discrete-time setting in which time is indexed by $t \geq 0$. Each dynasty has an infinite horizon, but a member of a dynasty only lives for one period, so that each period the prior member of the dynasty exits (dies) and the new member enters (is born).[2]

People/dynasties in country j have preferences over a sequence of consumption goods $\{c_{jt}^b, c_{jt}^q\}_{t=0}^{\infty}$, given by

$$\Sigma_{t=0}^{\infty} \beta^t \left(\left(c_{jt}^b\right)^{\frac{\sigma-1}{\sigma}} + \theta \left(c_{jt}^q\right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $0 < \beta < 1$, $\theta > 0$ and $\sigma > 1$ (or Cobb-Douglas if $\sigma = 1$). For a basket of goods $c_{jt}(s)$, $s \geq 0$, good c_{jt}^q is a composite good constructed as

$$c_{jt}^q = \int_0^\infty e^{\alpha s} c_{jt}(s) ds,$$

where $\alpha > 0$. Good c_{jt}^b, which will be referred to as good b, represents "basic" goods which do not not vary by quality. Good c_{jt}^q, which will be referred to as good q, represents "quality" goods comprised of a basket of goods $c_{jt}(s), s \geq 0$, that vary by quality. Good $c_{jt}(s), s \geq 0$, which will be referred to as good s, represents a specific "quality" good in which a higher s means higher quality.

3.2 Technology

A person in country j chooses a skill level based on their dynasty's type. A person's dynasty is identified as being of type i with $0 \leq i < 1$. For any country j, there are fraction $\zeta(i)$ dynasties of type i, so

$$1 = \int_0^1 \zeta(i) di.$$

For a person in dynasty of type i from country j at time t, it takes fraction

$$\xi_{jt} \kappa(i)(s + \varphi), \tag{2}$$

[2] Extending this setup to include overlapping generations would certainly add more dynamics and be more realistic, but the infinte-horizon dynasty with one-period-lived generations will allow us to sharply focus on the relationship of goods quality and skill acquisition between countries.

$\varphi > 0$, of time in a period to acquire skills at the level of $s \geq 0$ (just as for good s). Assume that $\xi_{jt} > 0$ and that $\kappa(i) > 0$ for any $0 \leq i < 1$, κ is a continuous, strictly-increasing function of i, and that κ is unbounded (i.e., becomes arbitrarily large as i approaches 1). Time spent acquiring skills is not available for work, hence a person that chooses skill level s will supply $1 - \xi_{jt}\kappa(i)(s + \varphi)$ fraction of time to the market. A person is born as unskilled, hence it takes no time to remain unskilled

Firms in country j at time t are able to produce good b with technology

$$y^b_{jt} = A^b_{jt} n^b_{jt}, \tag{3}$$

$A^b_{jt} > 0$, where n^b_{jt} can be labor of any skill level, including unskilled. Firms are able to produce good s with technology

$$y_{jt}(s) = A^q_{jt} n_{jt}(s),$$

$A^q_{jt} > 0$, where $n_{jt}(s)$ can be workers of skill level s or greater.

An unskilled person can only work as an unskilled worker producing good b. A person with skill level s can choose an occupation, which is to become employed as an unskilled worker producing good b or a skilled worker requiring skills $s' \leq s$. Note that it takes time to achieve the skill level $s = 0$ and such a person can choose to work as an unskilled worker or a skilled worker with skill level $s = 0$, as these are different jobs potentially paying different wage rates.

Country j is thus entirely summarized by the sequence $\{A^b_{jt}, A^q_{jt}, \xi_{jt}\}^\infty_{t=0}$, along with parameters β, θ, σ, α, φ, distribution ζ, and function κ that are common across all countries.

3.3 Equilibrium

People cannot move between countries. Firms can freely enter to produce any good in country j at time t, subject to the constraints on the availability of labor of various skill levels. There is no cost of shipping goods between countries.

Let good b be the numeraire and denote the world price of good s relative to good b, with delivery of both goods in time t, as $p_t(s)$. For goods s' and s to both be purchased, clearly it must be that

$$\frac{p_t(s')}{p_t(s)} = e^{\alpha(s'-s)},$$

so it must be that

$$p_t(s) = \gamma_t e^{\alpha s}$$

for some $\gamma_t > 0$.

With free entry, the competitive wage for firms producing good b must equal A^b_{jt} and the competitive wage for firms producing good s must equal $\gamma_t e^{\alpha s} A^q_{jt}$. During a period a worker of skill level s that works for a firm producing good $s' \leq s$ will earn

$$\gamma_t e^{\alpha s'} A^q_{jt}(1 - \xi_{jt}\kappa(i)(s + \varphi)),$$

but working as an unskilled worker will earn

$$A^b_{jt}(1 - \xi_{jt}\kappa(i)(s + \varphi)).$$

An unskilled person working as an unskilled worker will earn A^b_{jt}.

Each period, people choose their skill level and occupation to maximize their earnings. If a person chooses to work as an unskilled worker, then clearly the person will not choose to acquire any skills and will earn A^b_{jt}. If a person chooses work as a skilled worker, then clearly the person will choose $s' = s$ and will choose s to maximize earnings for a skilled worker of level s. The relation between skill level and earnings for a skilled worker of type i from country j at time t is graphed in Fig. 1. Denote the value of s that maximizes earnings of a skilled worker by $s^*_{jt}(i)$, which is given by

$$s^*_{jt}(i) = \max\left\{0, \frac{1}{\xi_{jt}\kappa(i)} - \frac{1}{\alpha} - \varphi\right\}.$$

That is, if a person of type i from country j at time t chooses to acquire skills, then it will be optimal for that person to choose skill level $s^*_{jt}(i)$. A person of type i from country j at time t will choose to acquire skills $s^*_{jt}(i)$ and work as a skilled worker if

$$\gamma_t e^{\alpha s^*_{jt}(i)} A^q_{jt}(1 - \xi_{jt}\kappa(i)(s^*_{jt}(i) + \varphi)) \geq A^b_{jt}, \tag{4}$$

else the person will spend no time acuiring skills and will work as an unskilled worker.

To simplify some notation, define the function Ω as

$$\Omega(z) = \min\{1 - z\varphi, z/\alpha\} e^{\max\{1, \alpha/z - \alpha\varphi\} - 1}$$

for $z > 0$. Note that $\Omega(z)$ is a strictly-decreasing function of z, $\Omega(z)$ becomes arbitrarily large as z approaches zero, and $\Omega(1/\varphi) = 0$.

When $s^*_{jt}(i)$ is written in terms of $\kappa(i)$, inequality (4) can be written as

$$\gamma_t A^q_{jt} \Omega(\xi_{jt}\kappa(i)) \geq A^b_{jt}. \tag{5}$$

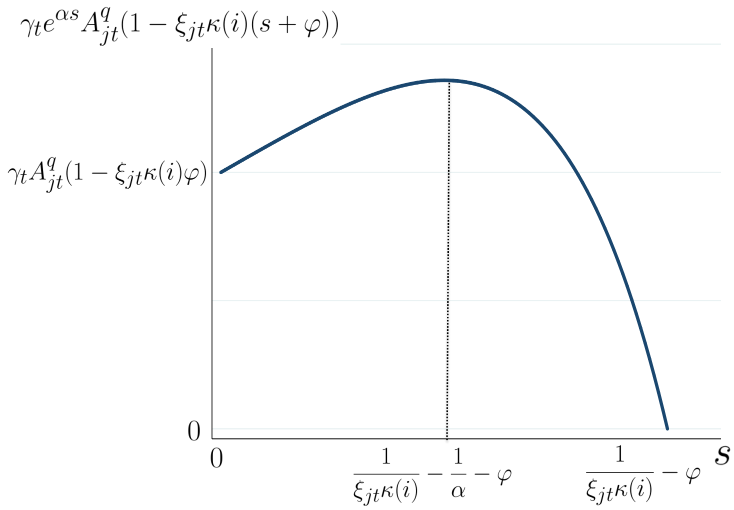

Figure 1: The Return to Skill

Note that the left side of eq. (5) is a decreasing function of i so there should exist some cutoff value, say $\hat{i}_{jt}$, such that types below this value worked in the skilled sector whereas those above do not. Given properties of κ and Ω already discussed, if

$$\gamma_t A^q_{jt}\Omega(\xi_{jt}\kappa(0)) \leq A^b_{jt},$$

then $\hat{i}_{jt} = 0$, else $\hat{i}_{jt}$ is such that

$$\gamma_t A^q_{jt}\Omega(\xi_{jt}\kappa(\hat{i}_{jt})) = A^b_{jt}. \tag{6}$$

People of type $i \leq \hat{i}_{jt}$ will choose to aquire skills at the level of $s^*_{jt}(i)$ and work as skilled workers, whereas those of type $i > \hat{i}_{jt}$ will work as unskilled workers. Note that $\hat{i}_{jt}$ rises as γ_t rises, $\hat{i}_{jt} = 0$ for sufficiently low γ_t, and $\hat{i}_{jt}$ approaches $I_{jt} < 1$ defined such that $\xi_{jt}\kappa(I_{jt}) = 1/\varphi$ as γ_t becomes arbitrarily large.

Denote by W_{jt} the income available to country j at time t from the skill and occupation decisions of people living within the country. W_{jt} can be written as

$$W_{jt} = A^b_{jt}N_j\int_{\hat{i}_{jt}}^{1}\zeta(i)di + \gamma_t A^q_{jt}N_j\int_0^{\hat{i}_{jt}}\Omega(\xi_{jt}\kappa(i))\zeta(i)di. \tag{7}$$

Assume that trade must be balanced each period, so for a given sequence of country incomes W_{jt} in units of good b in each time period t, the country-level sequence of budget constraints for all people in country j is given by

$$c^b_{jt} + \gamma_t\int_0^\infty e^{\alpha s}c_{jt}(s)ds = W_{jt}.$$

People maximize utility subject to their sequence of budget constraints, which leads in aggregate to

$$c_{jt}^{b} = \frac{1}{1 + \theta^{\sigma}\gamma_t^{1-\sigma}} W_{jt}, \tag{8}$$

and

$$\gamma_t \int_0^{\infty} e^{\alpha s} c_{jt}(s) ds = \frac{\theta^{\sigma}\gamma_t^{1-\sigma}}{1 + \theta^{\sigma}\gamma_t^{1-\sigma}} W_{jt}. \tag{9}$$

Given the perfect substitutability of quality goods, the composition of good q is entirely supply determined. Individual consumption is proportional to aggregate consumption, with factor of proportionality determined by individual income relative to aggregate income.

An equilibrium requires that, for each time t,

$$\Sigma_{j=1}^{J} c_{jt}^{b} = \Sigma_{j=1}^{J} y_{jt}^{b}. \tag{10}$$

If this equation holds, then by Walras' Law the market for good g will clear in equilibrium too. Using eqs. (3), (7) and (8), the equilibrium condition (10) can be written as

$$\frac{\Sigma_{j=1}^{J}\left(A_{jt}^{b} N_j \int_{\hat{i}_{jt}}^{1} \zeta(i)di + \gamma_t A_{jt}^{q} N_j \int_0^{\hat{i}_{jt}} \Omega(\xi_{jt}\kappa(i))\zeta(i)di\right)}{1 + \theta^{\sigma}\gamma_t^{1-\sigma}} = \Sigma_{j=1}^{J} A_{jt}^{b} N_j \int_{\hat{i}_{jt}}^{1} \zeta(i)di,$$

which can be rearranged to yield

$$\left(\frac{\gamma_t}{\theta}\right)^{\sigma} \Sigma_{j=1}^{J} A_{jt}^{q} N_j \int_0^{\hat{i}_{jt}} \Omega(\xi_{jt}\kappa(i))\zeta(i)di = \Sigma_{j=1}^{J} A_{jt}^{b} N_j \int_{\hat{i}_{jt}}^{1} \zeta(i)di. \tag{11}$$

Finding an equilibrium is thus reduced to finding a sequence $\{\gamma_t\}_{t=0}^{\infty}$ such that eq. (11) holds for each t. Eq. (11) for different values of t are independent of each other. The left side of eq. (11) equals zero when $\gamma_t = 0$, is a strictly-increasing function of γ_t once the term is strictly positive, and becomes arbitrarily large as γ_t becomes arbitrarily large. The right side of eq. (11) is strictly positive, equals $\Sigma_{j=1}^{J} A_{jt}^{b} N_j$ as γ_t approaches 0, and is a decreasing function of γ_t. There thus always exists an equilibrium and this equilibrium is unique.

3.4 Some Examples

This section works through some examples that highlight how the equilibrium responds to assumptions regarding productivty growth and skill accumulation.

Example 1: All Countries Experience Similar Productivity Growth

Suppose all countries experience similar, constant productivity growth. Specifically, for fixed initial productivity $A^b_{j0} > 0$ and $A^q_{j0} > 0$ for each country j, assume

$$A^b_{j,t+1} = (1 + \nu^b)A^b_{jt}$$

and

$$A^q_{j,t+1} = (1 + \nu^q)A^q_{jt},$$

where $\nu^b \geq 0$ and $\nu^q \geq 0$. The results depend on the value of ν^b relative to ν^q.

From eqs. (6) and (11) we see that if $\nu^b = \nu^q$ then γ_t will remain constant over time and the allocation of labor across countries will not change. Each country's income as measured by W_{jt} will rise in proportion to the rise in productivity. The flow of utility from each time period will rise over time.

If $\nu^b > \nu^q$ so that productivity growth in the basic-goods sector is higher than that in the skilled-goods sector, from eq. (11) we see that for a constant γ_t the right side would rise faster than the left side, hence γ_t must rise over time. Consequently, via eq. (6), each country's skill cutoff $\hat{i}_{jt}$ would rise, thereby leading to larger fraction of workers entering the skilled-labor market in each country. The converse would be true if $\nu^b < \nu^q$.

Example 2: One Country Experiences Symmetric Productivity Growth

Suppose only one country experiences symmetric productivity growth, so that $\nu^b = \nu^q > 0$ for country j, but there is no productivity growth for all other countries. The effect of productivity growth on the allocation of resources is determined by eq. (6). For a given vaue of γ_t, a symmetric rise in all productivity will have no effect on the skill threshold.

The general equilibrium effects on γ_t depend on whether or not this country is a net consumer or producer of basic goods (whether $c^b_{jt} > y^b_{jt}$ or not), as reflected in the sign of

$$\left(\frac{\gamma_t}{\theta}\right)^\sigma A^q_{jt} \int_0^{\hat{i}_{jt}} \Omega(\xi_{jt}\kappa(i))\zeta(i)di - A^b_{jt} \int_{\hat{i}_{jt}}^1 \zeta(i)di.$$

From eq. (11) we see that if it is a net consumer, then a symmetric rise in productivity will tend to lower γ_t, and consequently will lead to a rise in the skill threshold for all countries. In this sense, productivity growth in rich, industrialized countries would lead to a rise in the threshold to be employed in the skilled sector in poor, developing countries. Growth in rich, industrialized countries leads to a rise in the quantity of quality goods and thereby a fall in the price of quality goods, thus reducing the incentive for poor, developing countries to acquire skills to produce quality goods.

Example 3: One Country Experiences Skill Accumulation

Suppose one country experiences a fall in the cost of acquiring skills. For a given value of γ_t, per eq. (6) the country would experience a rise in $\hat{i}_{jt}$ and consequently a rise in the fraction of skilled workers. Regarding the general equilibrium effects, for a fixed γ_t the rise in $\hat{i}_{jt}$ would lead to a rise in the left side of eq. (11) and a fall in the right side, hence γ_t must fall over time. The fall in γ_t will tend to shift more workers to the unskilled sector in all other countries. Hence, a rise in skills in rich, industrialized countries would lead to a rise in the threshold to be employed in the skilled sector in poor, developing countries.

This result can be summarized and expanded upon with Fig. 2. In this figure, a country's engine for growth is a fall in the cost of acquiring skills which leads to a rise in the fraction of skilled workers along with a shift to producing higher quality goods. However, if the countries experiencing this type of growth are sufficiently large, then the price of quality goods as reflected in γ_t will tend to fall over time. Countries that do not experience a fall in the cost of acquiring skills will experience a loss in skills and falling incomes. Sustaining growth requires a sufficiently rapid fall in the cost of acquiring skills relative to the fall in the price of quality goods, as depicted by the curve labeled "falling ξ_{jt}" in Fig. 2. As shown for the curve labeled "constant ξ_{jt}", failure to sustain any fall in the cost of acquiring skills leads not only to stagnant income, but actually a fall in skill accumulation and a consequent fall in income. As shown in the intermediate case (the straight line between the two curves just mentioned), in this environment maintaining a constant level of income will require some progress in reducing the cost of acquiring skills. In this sense, a rapidly expanding frontier for producing quality goods makes it difficult for countries lower on the quality ladder that are not experiencing a rapid accumulation of skills to sustain growth.

4 The Data

This paper uses the United Nations' COMTRADE database to infer a good's quality. Amongst other variables, COMTRADE records total export value and quantity from all countries for various classifications of goods. New classification systems are introduced in some years, but the longest time period is associated with SITC Rev 1, which has data from 1962 (currently up to 2014). Within SITC Rev 1, this paper identifies commodities at the 4 digit level. Each commodity is associated with at least one of thirteen different quantity measurements (e.g., number of items, weight in kilograms, volume in liters, etc.),

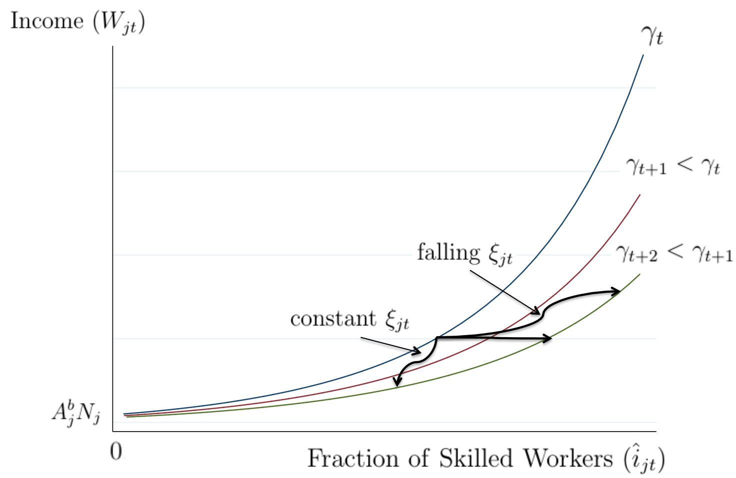

Figure 2: Income, Skills and the Price of Quality Goods

and some commodities are associated with more than one quantity type. For this paper, each commodity/quantity type combination for which data exists is considered a different commodity. Unit value defined as total export value divided by total export quantity is a measure of a good's quality as reflected in its price per unit.

The primary use of COMTRADE data will be to construct unit values and thereby compute an overall measure of the quality of a country's exports. The following steps were used to construct this measure for each year: (1) for each country, compute the unit value of each commodity that is exported,[3] (2) for each commodity, compute the export value-weighted average unit value around the world and thereby compute a scaled unit value for each country's exports of a commodity which is the unit value divided by this weighted average,[4] (3) compute a country's overall scaled unit value as the export value-weighted average of the scaled unit value for all exports by that country, which will be referred to as the country's (relative) export quality.

We are interested in the distribution of country export quality over time, as this is an overall measure of the difference across countries in the quality of goods they produce

[3]As in Feenstra and Romalis (2014), to reduce the influence of outliers, only unit values for exports in excess of $10,000,000 are used. Additionally, only exports with quantities more than 100 units are used.

[4]To further reduce the influence of outliers, only scaled until values less than 20 are used. For example, the country unit values for the Bahamas are 1.03, .97, 29.53, .98, .88, and .95 for 1974, 1975, 1976, 1980, 1981, and 1982 respectively (the intervening years are missing) without this restriction, but the 1976 value of 29.53 falls to 1.27 with this restriction, with all other values remaining unchanged. The vast majority of observations are not affected by this restriction.

and export. Fig. 3 reports the inter-quartile range for the distribution of country export quality over time. The key feature of this graph is a dramatic increase in the dispersion of country export quality from 1980 to 2000 relative to the trend before or after that time period. Indeed, after 2000 there seems to be a fall in the dispersion of country export quality.

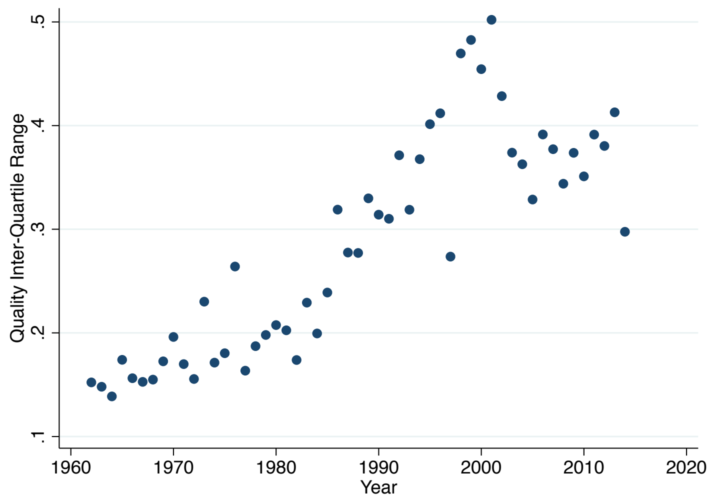

Figure 3: Quality Inter-Quartile Range: 1962 - 2014

One question studied will be the length of time a country is in a middle-income phase, for which it will be useful to study data as far back as possible so as to include the middle-income phase of current wealthy countries. Long-term GDP data is obtained from Maddison-Project (2013), which calculates real per-capita GDP for most countries around the world, starting in some countries in year 1, but consistently since 1950 for most countries. Currently the data ends in 2010, although for many developing countries data ends in 2008, so GDP comparisons will only be made up to 2008.

The average real per-capita GDP and median country export quality of the richest countries relative to the average real per-capita GDP and median country export quality of the rest is presented in Fig. 4. The richest countries are defined as the 20 countries with the highest real per-capita GDP in 2010, referred to here as the top 20 countries. This figure reveals an acceleration of the relative GDP of the top 20 countries during the period 1980 to 2000. Also shown on this graph is the median country export quality for the top 20 countries relative to the median of rest. The pattern over time in the median quality ratio is similar to the pattern over time in average GDP. The GDP pattern also closely matches the pattern of country export quality dispersion as captured by Fig. 3, as both exhibit an acceleration from

1980 to 2000 and both exhibit a turning point around 2000. As a measure of this relation, a regression of the median quality ratio on the gdp ratio yields a coefficient of .1161 ($t = 8.69$) and a regression of the quality inter-quartile range on the gdp ratio yields a coefficient of .1209 ($t = 15.08$). These graphs support the hypothesis that an acceleration of growth in the richest countries led to a widening distribution of qualities of goods produced and exported around the world.

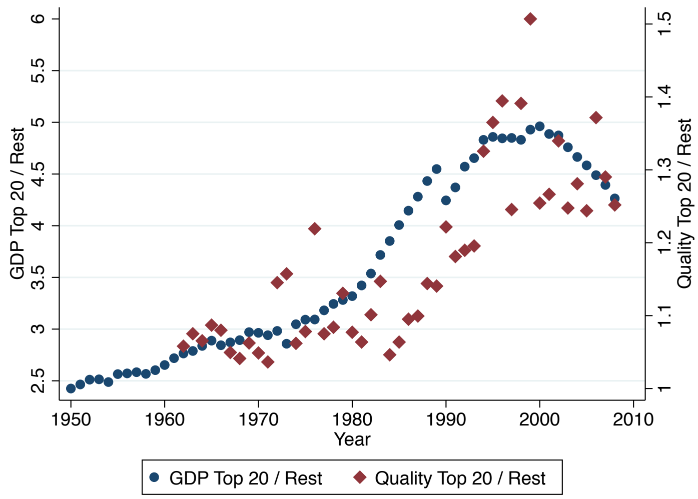

Figure 4: Relative GDP and Quality of Top 20 Countries

Over time, countries transition among low income, middle income, and high income categories, defined here as below \$4,000 real per-capita GDP (1990 dollars), from \$4,000 to below \$12,000, and above \$12,000, respectively). One premise of this paper is that perhaps the acceleration of growth for high-income countries made it increasingly difficult for other countries to sustain growth and transition to the next higher category. Fig. 5 documents the fraction of countries in each category over time. In 1950 almost all countries, by today's standards, are categorized as low income, with just over 15% of countries categorized as middle income. From 1950 to 1980 there was a steady decline in the fraction of low-income countries and a steady rise in the fraction of middle-income and high-income countries. From 1980 to 2000, however, the fraction of countries in each category remained roughly constant. The decline in the fraction of low-income countries and rise in fraction of high-income countries resumed following 2000. Here again, these trends line up very closely to the trend in dispersion of country export quality.

Fix. 6 examines more closely the transition through the middle-income phase and

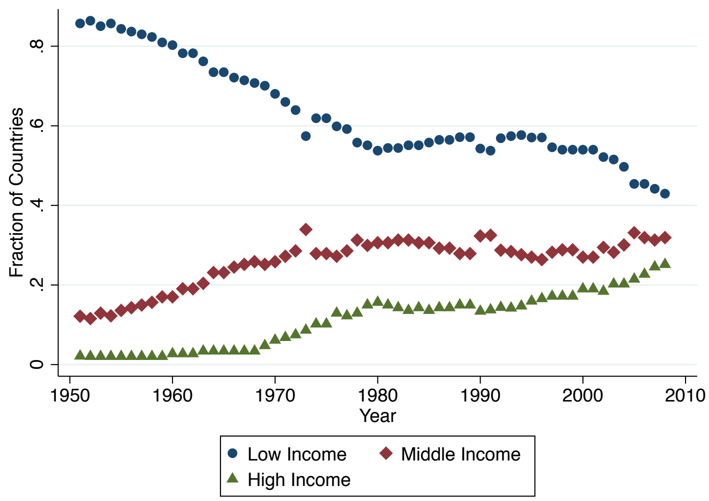

Figure 5: Fraction of Low, Middle, and High Income Countries: 1950 - 2008

documents the recent emergence of a middle-income trap. On the horizontal axis is the date that a country first crossed from low-income to middle-income status.[5] On the vertical axis is either the length of time the country took to enter the high-income category or, if the county has not yet entered the high-income category, an estimate of the length of time it would take to enter the high-income category. This estimate is based on the last observation of real per-capita GDP, extended forward based on the average growth rate since entering the middle-income category. The estimate of the duration in the middle-income phase is capped somewhat arbitrarily at 400 years, which will be binding if the average growth rate is sufficiently small or negative. There was a steady decline in the duration of being in the middle-income phase over time for those countries that entered the middle-income phase prior to the 1960s. What's clear from this figure is that many countries that entered the middle-income category after the early 1960s fell into a middle-income trap, in that the estimated duration in the middle-income phase became unusually long relative to the historical downward trend of this duration. Note that the middle-income phase of a country that entered this phase in the 1960s also coincides with the time period during which there was a dramatic rise in the dispersion of country export quality as exhibited in Fig. 3.

In a sense, one could use Fig. 6 to separate out those countries that fell into a middle-

[5] To ensure at least 15 years of data, only countries that entered middle-income status prior to 1996 are graphed.

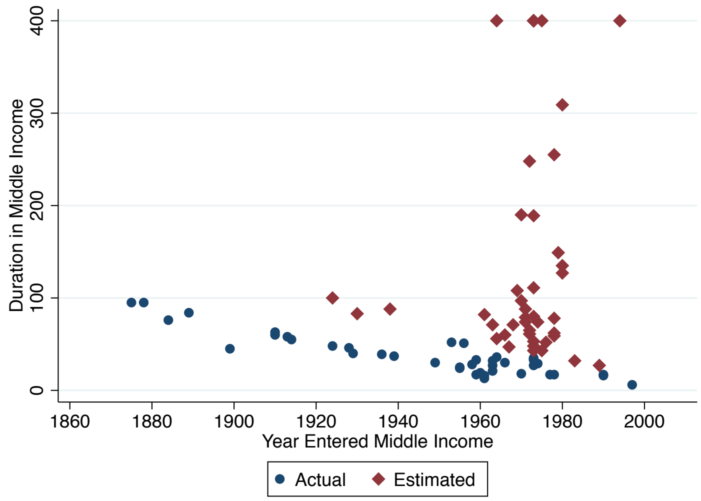

Figure 6: Duration in Middle-Income Phase

income trap vs. those that did not. The countries within a narrow downward-sloping band progressed as expected over time, whereas those above the band can be thought of as those countries that fell into a middle-income trap. Based on Fig. 6, a reasonable separation seems to coincide with the following: those countries that escaped the middle-income trap are all the countries that exited the middle-income phase (labeled "Actual") as well as those that did not exit by the end of the sample (labeled "Estimated") but have an estimated duration of 50 years or less. Using this separation, Fig. 7 displays the median country export quality of those that did not fall into the trap vs. those that did. Here as well the trend is remarkably close to the overall trend in the dispersion of country export quality and relative per-capita GDP of the richest countries, suggesting that those countries that fell into the middle-income trap are also those that fell in relative quality ranking. For comparison purposes, a regression of relative median export quality in Fig. 7 on the relative gdp ratio in Fig. 4 yields a coefficient of .0668 ($t = 7.28$).

5 Summary

Post-war growth led to a gradual fall in the fraction of low-income countries, so that by 1980 the fraction of countries classified as low-income dropped to around 55 percent and correspondingly the fraction of countries classified as middle-income rose to about 30 percent

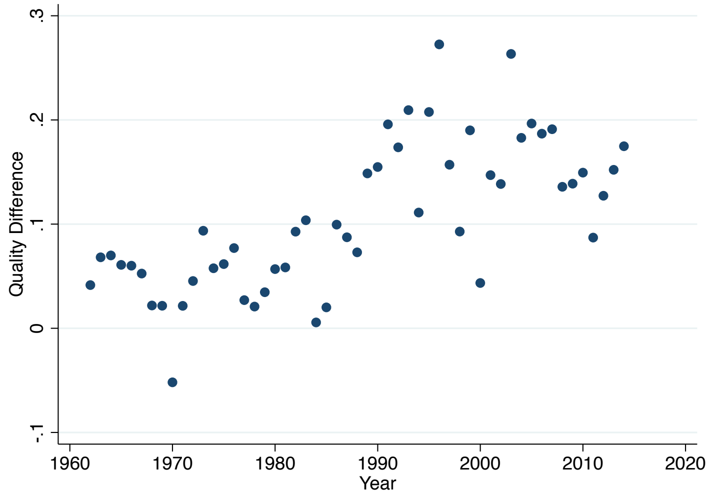

Figure 7: Quality in Middle-Income Escaped vs. Trapped Countries

and high-income to about 15 percent. These trends stopped from 1980 to 2000 and indeed during this time many countries fell into a lengthy middle-income trap. This is puzzling especially in light of the dramatic rise in per-capita incomes of the richest countries relative to the rest of the world during that time, hence clearly there is no sense in which the engine for growth in the world stopped during that time. This paper provided evidence that the range of quality of goods exported around the world rose dramatically from 1980 to 2000 and has shown that there was a related rise in quality of goods exported by the richest countries relative to the rest of the world, and also specifically relative to countries caught in a middle-income trap. In the model developed in this paper, these two trends are linked: the engine of growth in rich, industrialized countries led them to move up the quality ladder and these goods competed with lower quality goods produced by poor, developing countries, thereby making it difficult for them to continue to progress up the quality ladder as a means to sustain growth.

The interrelated nature of growth does not necessarily mean that growth of one country comes at the expense of another. Productivity growth of all countries, or an accumulation of skills in all countries, would make all countries better off. Indeed, the post-war trend up to 1980 seems to have reasserted itself since 2000. The nature of technological change at the frontier, though, suggests that the forces described in this paper will reappear.

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