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Abstract

This paper argues that recent trends in the global economy have led to a shift in developed countries' comparative advantage from mature industrial to early stage entrepreneurial production. We develop a three stage product life cycle model in which we distinguish between life cycle stages characterized by new, mature and off-shored production. In that model we analyze the impact of a level shock in the supply of unskilled labor in the South, a decrease in the level of political risk associated with outward foreign direct investment (off-shoring), and the widespread diffusion of a general purpose technology such as ICT. Due to endogenous responses in the allocation of entrepreneurial activity, the above shocks all result in a shift in the comparative advantage of developed countries towards new varieties, which corresponds to activities in the early stages of the product life cycle. Moreover, because entrepreneurs also serve as the agents that move varieties between life cycle stages, their value added increases due to globalization and technical change. By contrast, the factors of production employed in the mature stage of the life cycle, e.g. low skilled northern labor, become less valuable. Thus, the model predicts the emergence of an entrepreneurial economy in the North as the South opens up to trade and industrializes.

Keywords: Product Cycles, International Trade, Entrepreneurship, Globalization

JEL classification: F01, J31, O1, P0

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1. Introduction

Audretsch and Thurik (2001) already posited the argument in this paper when they observed: "*A consequence of globalization is that the comparative advantage of high-wage countries is no longer compatible with routinized economic activity, which can easily be transferred to lower-cost regions outside Western Europe*" (Audretsch and Thurik (2001), p 271.) . In this paper we seek to provide the formal rigor of a fully specified model of international specialization to the intuitions underlying this claim.

Our starting point in this exercise is the product life cycle hypothesis. Vernon's (1966) product life cycle hypothesis has proven very useful in the analysis of international patterns of trade and technological change. An elegant and tractable life cycle model of international trade was formalized by Krugman (1979) using the Dixit-Stiglitz (1977) framework of monopolistic competition and love-of-variety preferences. In his model, however, innovation and imitation, and therefore technological change, were kept exogenous. The issue regained momentum when Grossman and Helpman (1991a) linked Romer's (1986, 1990) ideas about endogenous innovation to the Krugman (1979) model of international trade.

The product life cycle ideas have since informed studies in industrial dynamics (e.g. Klepper (1996), Agarwal (1998), Werker (2003)) and technology driven structural change in labor markets (e.g. Sanders (2005) and Zhu (2004, 2005)). In more recent work it has also been applied in the analysis of foreign direct investments (e.g. Lu (2007)) and off-shoring/outsourcing (e.g. Gao (2007)). In short, it has proven a very versatile frame of reference that allows one to theorize about the important linkages between technological change, international trade and the implications for factor demands in the context of globalization and rapid technological developments.

In this paper we build on this tradition and present a three stage endogenous life cycle model to analyze the impact of three exogenous shocks on trade patterns, the location of production activities and the relative demand for three types of labor in North and South. In the model a new good is invented and first produced in the North using high skilled labor only. In the second stage, which is termed the mature stage, low skilled labor in the North can be brought in. But to get to this stage process innovations are required. These innovations embody routines in specialized machines and tools as well as in organizational practices that allow for specialization between low and high skilled labor. In our stylized model we assume a single process innovation is required and allows for the production of a good to switch from high to low skilled labor entirely. We then introduce a third stage exhibiting off-shoring in a global economy. As Vernon (1966) and Antrás (2005) argue, only northern mature products are generally being off-shored. In addition we assume that this too requires additional investment in (organizational) innovation. Finally we assume that all innovative activity, initially introducing new products, developing process innovations or the off-shoring of mature production processes, requires the investment of what we label "entrepreneurial resources".

The comparative advantage of a country is then determined by its relative supply of high and low skilled labor and entrepreneurial resources. Countries that are rich in high skilled labor (the North) will specialize in products in early stages of the life cycle. Countries that are rich in low skilled labor (the South) specialize in mature, (off-shored) production. Countries that are rich in entrepreneurial resources will innovate, introducing new products, developing maturing process innovations and making the innovations that allow for off-shoring.

This dynamic model of comparative advantage has clear benefits over the more static traditional models of trade. The standard Heckscher-Ohlin framework, for example, predicts that a high skilled labor abundant North will specialize in bio-tech industries because the production process is skill-intensive. By contrast, the model introduced in this paper predicts that such comparative advantages are only temporary. The skill-abundant North specializes in bio-tech products because they are new. Their production will be located in the North only as long as it takes (northern) entrepreneurs to develop the process innovations and off-shore (the routine parts of) the production process to the South. A product life cycle approach takes the evolution of technology into account and links factor endowments, production location and structural change such that a more dynamic interpretation of "comparative advantage" emerges.

Using this model we show that a combination of three shocks can be held responsible for some major trends in the global economy, the rise of an entrepreneurial economy in advanced northern economies and the industrialization of the South(-East). The paper is organized as follows: The empirical trends in North and South that motivated this paper are presented in section 2, the model is then presented in section 3 and section 4 analyzes the comparative static results that we are interested in. Section 5 then summarizes and concludes.

2. The Empirical Trends

The "North" and "South" in product life cycle models of trade refer to the advanced economies that specialize in early stage production and innovation and those less advanced countries that import these goods and specialize in mature products, respectively. When taking the predictions of our model to the data we therefore discuss broad trends in the OECD countries and South-East Asia. We do not want to imply that there are no large differences within these groups. But a model of North-South trade cannot be expected to yield useful insights on these within-group differences. In addition, for the "South" other countries such as the African and Latin American countries are generally less useful as a benchmark as they are still less open to global trade and/or trade mainly in agricultural products and resources, for which the product life cycle hypothesis has little relevance.

Trends in the North (West)

The rising wage inequality and skill upgrading in the North, mainly the United States stands out as an important trend in the 80s and 90s of last century.[2] Relative wages and employment rose for the higher skilled workers, due to skill biased technical change (see Katz and Autor (1999), Sanders and Terweel (2000) and Autor et al. (2005) for surveys of the evidence) that also spread South through trade and FDI (e.g. Feenstra and Hanson (1996, 1997, 1999, 2004), Berman et al. (1998), Hanson and Harrison (1999) and Zhu (2005)).

More recent contributions have offered a more complete picture of the exact underlying shifts in labor demand. One strand of literature depicts the demand for labor as

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[2] This trend is extremely well documented for most OECD countries and has been intensively researched in the 90s and early 2000s. See e.g. Juhn et al. (1993), Berman et al. (1994), Gottschalk and Moffit (1994), Nickell and Bell (1996), Doms et al. (1997), Autor et al. (1998), Machin and Van Reenen (1998), Caroli and van Reenen (2001), Goldin and Katz (2001), Card and Dinardo (2002), Autor et al. (2003), Piva et al. (2005).

polarizing the North (e.g. Goldin and Katz (2007) and Goos and Manning (2007)). Wages and employment for college graduates *and* uneducated service sector workers have risen relative to the middle segment of routine medium skilled jobs in industry and administration. Goose and Manning (2007) attribute this trend to the Autor et al. (2003) "routinization" hypothesis, arguing that technology, and ICT-technology in particular, is very strong in replacing human labor in such routine tasks.

The polarization trend in labor demand also fits well with the observed trend towards de-industrialization (e.g. Boulhol and Fontagne (2006)). All OECD countries have seen a decline in the employment and GDP-share of industry as well as a decline in the OECD share in global trade of manufactures (despite continued growth in output, employment and trade volume levels). Blue and white collar jobs in industrial firms are more likely to be routine jobs or can easily be routinized as services involve interaction with the advanced northern customer (who is less and less inclined to accept routine treatment as his income level increases).

The polarization of labor demand and deindustrialization trend coincided with the reemergence of small and medium sized firms as the main generators of growth, employment and value added. When Birch (1981) first observed this reversal in a long trend of increasing scale and concentration in the developed economies it was not taken seriously right away as the evidence was mixed and the initial methodology could be criticized for several reasons. But the phenomenon turned out to be a lasting one when Acs and Audretsch (1990, 1993) surveyed the evidence for the 1980s. More recent surveys (e.g. Parker (2004), Versloot and van Praag (2007)) clearly establish the importance of entrepreneurship and small firm activity in the modern innovation driven economy.[3]

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[3] Examples of studies in this large and growing body of literature are Storey and Johnson (1987), Brock and Evans (1989), Loveman and Sengeberger (1991) Konings (1995), Davis et al. (1996a, 1996b), Klette and Mathiassen (1996), Broersma and Gaultier (1997), Hohti (2000), Heshmati (2001) and EIM (2002). All studies report, for different countries, sub-periods and methods, that small scale enterprise accounts for an above

The evidence on demand polarization, deindustrialization and the resurgence of small firms as the preferred mode of operation all suggest that the North specializes in non-routine activities. Autor et al. (2003) mainly look at (ICT-)technology to explain this trend. In this paper, following for example Baldwin (2006) and Robert-Nicaud (2008), we add the element of international competition and off-shoring to that hypothesis. A routine job in a northern industry can be replaced with a computerized robot but it may well be cheaper still to have a southern (skilled) worker do the job manually. This off-shoring of production requires an entrepreneur who recognizes the opportunity and is willing to take the risk and organize the off-shoring venture. Typically northern entrepreneurs are better situated to do so (Antrás (2005)). And as entrepreneurial ventures are by their very nature never routine, a specialization in the North on non-routine tasks is consistent with the rise of an entrepreneurial economy. The North is then not only forced to specialize in non-routine entrepreneurial production due to (exogenously) increasing competition from abroad on routine tasks. northern entrepreneurs actually endogenously drive this process of structural change in pursuit of higher profit.

Trends in the South (East)

Because of their sheer size India and China are the most impressive recent examples of newly industrializing economies (NIEs) in South-East Asia. Still, developments in the so called first and second tier NIEs and Japan before them have all shown that education, trade openness and export orientation can cause rapid industrialization and high levels of economic growth

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proportional share of job and wealth creation. Recent surveys by Henrekson and Johanson (2008), Acs and Müller (2008) and Acs et al. (2008) show on top of that that only a small fraction of all small scale enterprise, the so called "Gazelles" actually generate this above average growth.

(e.g. Dowling (1997) and Weiss and Jalilian (2004)).[4] Such rapid industrialization also drives urbanization (Deng et al. (2008), Asian Development Bank (2007)) and wage divergence between unskilled agricultural workers and medium skilled industrial workers. (e.g. Owen and Yu (2008)).[5] The specialized industrial blue and white collar jobs that disappear in the North are rapidly expanding in the South (East). This shift in the composition of occupations does not occur because the tasks performed are not routine and cannot be automated or off-shored, but rather because it is cheaper and more efficient to hire the vast surplus labor from the country side in rapidly growing industrial centers (Owen and Yu (2003, 2008)). In addition, large capital inflows from abroad allow for the rapid build-up of factories and industries (Chow (1993), Zhang (2006), Asian Development Bank (2007)).

In other parts of the world structural change showed less dramatic trends, but with the collapse of communism and the waves of economic liberalization in Latin America, these parts of the world also gradually increased their share in manufacturing exports and global industrial output (Mayer (2003)).

The life cycle hypothesis predicts that, as these countries grow, their comparative advantage will shift towards more advanced early stage production processes. Japanese firms have already made that transition. But in recent years the NIEs have climbed the product ladder (Leu(1998)) and started to compete for global market share in more advanced manufacturing sectors and early stage activities such as R&D, design and product development (Martin (2006), Engardio (2006, 2007)).

[4] First and second tier NIEs are Taiwan, Korea, Singapore and Hong-Kong and Indonesia, Malaysia, the Phillipines and Thailand, respectively.

[5] In China the percentage of the population living in urban area's rose from 26 to 44% between 1989 and 2006 and shows no signs of slowing down. For India this ratio rose more moderately from 25 to 29%. For Indonesia the increase is from about 30 to about 45% (Asian Development Bank, Key Indicators 2007).

3. The Model

Modeling trade flows, the location of production and technological change all have a long tradition in the economics literature. These literatures provide the background for our model. In this section we first present that theoretical background and firmly position our model in these literatures. We then proceed with the formalization of our argument.

Theoretical Background and Modeling Approach

Vernon (1966) linked the location of production activities to the life cycle stage of the product, hypothesizing that new products, because of their higher knowledge intensity, would be produced in the North. The reason is that the North has a relative abundance of skilled labor and therefore a comparative advantage in their production. Krugman (1979) used the Dixit-Stiglitz (1977) model of monopolistic competition to formalize Vernon's idea. In his model he assumed that technology generation and transfer are both exogenous processes. Grossman and Helpman (1991a) used the insights of endogenous growth theory to endogenize the processes of innovation and imitation. In these early models, however, no distinction was made between skilled and unskilled labor in the North. In Zhu (2004) and Sanders (2005), for example, this distinction was introduced but in the former the innovation driven transition from new to mature was lost whereas in the latter the North-South trade dimension was sacrificed to keep the model tractable. Moreover, neither has explicitly addressed the role of northern entrepreneurial agents in initiating the transfer of technology across international borders.

In this tradition we therefore present a new model that distinguishes among three stages of the life cycle of products. The first stage starts with the commercialization of a new product or service. As in most innovation driven endogenous growth models (Romer (1986, 1990), Grossman and Helpman (1991b) and Aghion and Howitt (1992)) an entrepreneur in the North will introduce that new product or service in global markets to capture (temporary) monopoly rents. We assume in addition and in line with earlier life cycle models, that such new products and services are produced with high skilled labor only. The reason is that early stage production requires high flexibility and creativity as well as frequent feedback from the consumer. All this early stage uncertainty gives skilled workers a competitive advantage in production (Schultz (1961)). We refer to this stage as the 'early stage'.

A second stage starts when the product matures. We assume, in the endogenous growth tradition, that someone needs to invest resources in the standardization and routinization of the production processes to move a product into the mature stage.[6] And firms will do so, driven by the desire to cut costs, capture market share and increase profits. Of course "maturity" is not reached at one point in time but a gradual process of introducing many incremental (process) innovations in reality. For mathematical convenience we stylize this process as the endogenous creation of a single process innovation that allows the producer to switch from high to low skilled workers. The cost reduction provides both incumbent and potential entrants with an incentive to invest the required resources.[7] We allow any entrepreneurial agent to enter in that race, such that free entry drives down expected

[6] This does not correspond exactly to the "routinization" that Autor et al. (2003) refer to. The development of routines to substitute specialized capital goods for labour follows the development of routines that allow firms to substitute low skilled for high skilled workers.

[7] In many ways this type of intrapreneurship or corporate entrepreneurship is very much akin to the traditional entrepreneurship and requires the recognition and exploitation of commercial opportunities. To bring an existing new product to the mature stage, however, the opportunities are opportunities to improve the production process and further refine the division of labor. Spin-offs and spinouts from existing incumbent firms' R&D or engineering departments are not an unlikely or uncommon way in which such competition arises. See e.g. Thomson and Klepper (2005).

profits net of sunk investments in innovation down to 0.[8] Finally, we assume that this activity competes for the same entrepreneurial resources in the economy as the commercialization of entirely new products.

Standardization would also allow southern unskilled workers to start producing the product or service.[9] We assume, however, that the act of moving production abroad marks the beginning of a separate third and final stage in the product life cycle. Setting up production facilities in the South is neither costless nor riskless, even when the product and production technology have been developed.[10] We therefore assume that off-shoring requires the commitment of additional entrepreneurial resources..[11] The origin and location of the entrepreneurial resources involved in this process is an empirical issue that has not been addressed in the literature to our knowledge. Given the strong circumstantial evidence on the increasing importance of FDI and northern initiatives to outsource and offshore, we explore the case where taking products to their third 'off-shored' stage in the life cycle requires northern entrepreneurial resources to be committed. We thus assume that it is entrepreneurial FDI, not southern imitative R&D (e.g. Grossman and Helpman (1991a)) or costless spillovers (Krugman (1979)) that will be the medium of knowledge and technology transfer.

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[8] By assuming Bertrand competition and a small fixed start-up cost we can prevent entrants from competing with the incumbent using the same production technology in the early stage.

[9] To the extent that the product is tradable over larger distances of course, which we assume here.

[10] The product and production process may need to be adapted to a new environment, the legal and institutional setting is different and needs to be understood and logistics need to be thought through at the very least. Cultural and language barriers, different infrastructural quality and sovereign/country risks complicate the issue even more.

[11] We might refer to this as extrapreneurship. Seeing and recognizing opportunities for (uncertain) cost reductions outside the firm and country of origin using the same product and production process.

The three stage life cycle is illustrated in Figure 1:

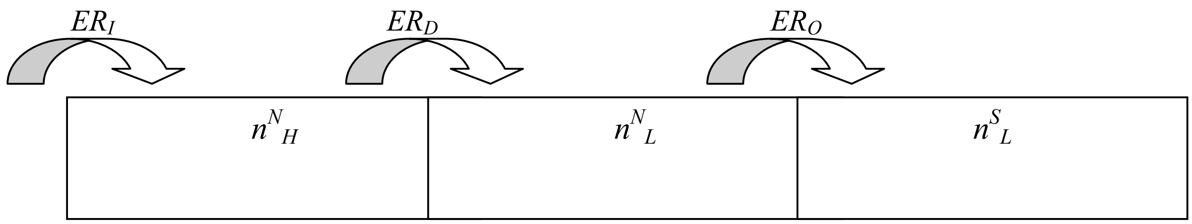

Figure 1: The three life cycle stages.

All product varieties (n) fall in one of the three stages: new ($n^N{}_H$), mature ($n^N{}_L$) and off-shored ($n^S{}_L$). Our model then endogenizes the allocation of entrepreneurial resources (ER) over product innovation (ER_I), process development (ER_D) and outsourcing/off-shoring (ER_O). And it can be shown that a steady state allocation exists for which all ranges grow at the same rate. The relative size of the boxes determines the steady state relative demand and wages for high and low skilled northern and southern workers.

We then parameterize the exogenous shocks we wish to investigate, to explain the dynamics in global specialization patterns. As a result of political risks falling and low skilled labor abundant countries joining the global economy, off-shoring increases. At the other end of the variety range the introduction of a so called General Purpose Technology pulls more entrepreneurial resources into product innovation. Expansion of the boxes on both extremes tends to squeeze the middle range (in relative and absolute terms) and pushes the northern economy further towards what we have labeled “the Entrepreneurial Economy” above; a production structure that relies heavily on skilled labor intensive, early stage production and innovative entrepreneurial activity for creating value added.

Formalization

The model structure follows that of a standard endogenous growth model with variety expansion in final goods (cf. Grossman and Helpman (1991b)). On the consumer side we assume that all consumers have identical preferences and that all goods are tradable. First we assume time-separable preferences and derive consumer demand for consumption over time solving:

$$\max_{C_t} : \int_t^{\infty} e^{-\rho(\tau-t)} \log(C_\tau) d\tau \qquad (1)$$
$$s.t.: Y_t + rA_t = C_t + \dot{A}_t$$

where C_t is an index of consumption defined below, ρ is the discount rate, Y is income, A is the level of assets and a dot over a variable signifies the time-derivative. Below we normalized the expenditure on one unit of the index to 1, such that expenditure on consumption is equal to the index, C. The first order conditions for this problem yield:[12]

$$\dot{C}_t / C_t = r - \rho \qquad (2)$$

This implies that consumers are willing to postpone consumption when the return on assets, r, is sufficiently above their discount rate. This allows entrepreneurs in the model to finance their investments in innovation, development and off-shoring.

[12] See for example Barro and Sala-I-Martin (2004).

Then we assume that at every point in time all consumers maximize a Dixit-Stiglitz (1977) CES instant utility function by choosing the quantities of available varieties to consume. They solve: [13]

$$\max_{c_i} : C_t = \left(\int_0^n c_i^{\alpha} di \right)^{1/\alpha} \qquad \text{where } 0 \leq \alpha \leq 1 \qquad (3)$$
$$s.t.: \int_0^n c_i p_i di \leq C$$

Where i indexes a single variety and n is the total range of varieties consumed. Note that in consumption all varieties are perfectly symmetric but remain imperfect substitutes. c and p are the quantity and price of a single variety, i, in the range, respectively. To derive the instant global demand functions for all varieties in this CES-utility function is straightforward:[14]

$$c^D{}_i = \left(\frac{p_i}{P} \right)^{\frac{1}{\alpha-1}} \frac{C}{P} = p_i^{\frac{1}{\alpha-1}} C \qquad \text{where } P \equiv \left(\int_0^n p_i^{\frac{\alpha}{\alpha-1}} di \right)^{\frac{\alpha-1}{\alpha}} \equiv 1 \qquad (4)$$

Where P is defined as the minimum cost of one unit of the consumption index, C, and is normalized to 1, such that C is equal to total consumption expenditure. This demand equation states that the global demand for a variety is negatively dependent on its price and positively dependent on total consumption expenditure.

Now consider production in our economy. Following the life-cycle literature we assume that products in the early stage can only be produced by skilled workers. For simplicity we assume that an early stage product is produced by only skilled workers and they

[13] All goods are assumed to be tradable and all consumers share the same utility function.
[14] See for example Grossman and Helpman (1991b).

are available only in the North.[15] As is common in innovation driven growth models we assume that different varieties are produced by different firms and there is monopolistic competition between varieties and no competition within them. Where other models can rely on perfect enforcement of intellectual property rights or non-transferable and essential tacit knowledge to eliminate the threat of entry, we have to rely here on the fact that Bertrand competition will drive profits down to 0 rapidly when an entrant has the same marginal cost as the incumbent producer. A small positive start-up cost is then sufficient to allow profitable entry only after a significant cost advantage has been obtained. The early stage firm then sets prices to solve:

$$\begin{aligned} &\max_{p_i} : \pi_i = c_i p_i - w^N{}_H l^N{}_{Hi} \\ &s.t. : c_i = c^D{}_i = l^N{}_{Hi} \end{aligned} \qquad (5)$$

Where $w^N{}_H$ is the high skilled wage in the North, $l^N{}_{Hi}$ is the amount of northern skilled labor employed by firm *i*. Note also that labor is the only factor of production and we define units such that the production volume, *c* is equal to the amount of labor employed.

This yields:

$$p_i = \frac{w^N{}_H}{\alpha} \qquad \forall i \in n^N{}_H \qquad (6)$$

Where $n^N{}_H$ is the range and number of varieties in the early stage. As soon as production has started in the early stage, potential entrants will have an incentive to capture the profits through entry with cost reductions. We allow potential entrants below to invest resources in developing procedures and routines that allow low skilled workers to replace the high skilled

[15] And labor is immobile internationally.

labor force.[16] This will reduce costs and hence increase profits as long as the wage for low skilled workers is less than that of high skilled workers. Once in the mature stage we assume that a producer always has the option to switch back to the old, skilled labor using early stage technology. This implies that in equilibrium high skilled wages must always exceed the low skilled wage and out of equilibrium the profit maximizing price set by the mature firm is equal to:

$$p_i = \min\left[\frac{w^N{}_L}{\alpha}, \frac{w^N{}_H}{\alpha}\right] \qquad \forall i \in n^N{}_L \tag{7}$$

Where $n^N{}_L$ is the range and number of varieties in the mature stage. Again we assume Bertrand competition when entry occurs within a variety and it therefore does not pay for entrants to simply copy a mature firm in the North. However, as was argued above, the mature production process also creates the possibility to outsource/off-shore the product. This only pays for entrepreneurs when the cost reductions are sufficiently large, so this is only profitable as long as low skilled labor in the South is less costly than low skilled labor in the North. By similar logic as above products that have been outsourced will trade in global markets at price:

$$p_i = \min\left[\frac{w^S{}_L}{\alpha}, \frac{w^N{}_L}{\alpha}\right] \qquad \forall i \in n^S{}_L \tag{8}$$

[16] Note that in fact we assume that products only mature as such innovations are actually introduced. It is not an automatic process as for example in Krugman (1979) or Arrow (1962). Nor is it driven by incumbent firm R&D or southern imitative R&D (as in Grossman and Helpman (1991a))

Where $n^S{}_L$ is the range and number of varieties produced abroad.[17] For given n, $n^N{}_H$, $n^N{}_L$ and $n^S{}_L$ the labor markets for northern skilled, unskilled and southern labor can now be assumed to clear, such that the model equilibrates. Given that $w^N{}_H > w^N{}_L > w^S{}_L$ must hold in equilibrium we can compute the demand for each type of labor. Substituting profit maximizing prices, (6), (7) and (8) into the demand function in (4), using the (inverse) production function and summing over all varieties in the three stages of the life cycle yields the labor demand curves for skilled, unskilled and southern labor, respectively:[18]

$$\begin{aligned} L^N{}_H &= \int_{n^N{}_L+n^S{}_L}^{n} \left(\frac{w^N{}_H}{\alpha}\right)^{\frac{1}{\alpha-1}} C di = n^N{}_H \left(\frac{w^N{}_H}{\alpha}\right)^{\frac{1}{\alpha-1}} C \\ L^N{}_L &= \int_{n^S{}_L}^{n-n^H{}_L} \left(\frac{w^N{}_L}{\alpha}\right)^{\frac{1}{\alpha-1}} C di = n^N{}_L \left(\frac{w^N{}_L}{\alpha}\right)^{\frac{1}{\alpha-1}} C \\ L^S{}_L &= \int_{0}^{n^S{}_L} \left(\frac{w^S{}_L}{\alpha}\right)^{\frac{1}{\alpha-1}} C di = n^S{}_L \left(\frac{w^S{}_L}{\alpha}\right)^{\frac{1}{\alpha-1}} C \end{aligned} \qquad (9)$$

Assuming given and inelastic labor supplies in the three markets, wages will equilibrate all markets simultaneously for a given combination of n, $n^N{}_H$, $n^N{}_L$ and $n^S{}_L$ to:

$$\begin{aligned} w^N{}_H &= \alpha\left(\frac{L^N{}_H}{n^N{}_H C}\right)^{\alpha-1} \\ w^N{}_L &= \alpha\left(\frac{L^N{}_L}{n^N{}_L C}\right)^{\alpha-1} \\ w^S{}_L &= \alpha\left(\frac{L^S{}_L}{n^S{}_L C}\right)^{\alpha-1} \end{aligned} \qquad (10)$$

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[17] Contestable markets have been discussed in an earlier working paper version of this paper, Audretsch and Sanders (2007).

[18] The demand for low skilled northern labor will fall to 0 and the demand in the mature sector adds to skilled labor demand in the early stage sector when $w^N{}_H \leq w^N{}_L$. Similarly the demand for low skilled southern labor falls to 0 when $w^N{}_L \leq w^S{}_L$ and the demand in this sector then adds to low skilled northern labor. These asymmetries in substitution possibilities ensure that in equilibrium the wages are falling over the life cycle stages as long as labor is assumed to be immobile, both geographically and between skill groups, such that supplies are given and inelastic.

It is clear from (10) that wages for a given labor type will be increasing in total expenditure, decreasing in supply and increasing in the number of varieties in the appropriate life cycle stage. Also from (10) it follows that in equilibrium $L^N{}_H/n^N{}_H<L^N{}_L/n^S{}_L<L^N{}_L/n^S{}_L$ will hold.[19] As all labor types benefit from general increases in consumption expenditure it is the relative size of life cycle stages that drives the income shares of high skilled, low skilled northern and southern labor. We therefore proceed to endogenize the dynamics in n, $n^N{}_H$, $n^N{}_L$ and $n^S{}_L$.

The assumption of monopolistic competition implies that there are rents. Profits in all life cycle stages are given by:

$$\begin{aligned}
\pi_i &= (1-\alpha)\left(\frac{L^N{}_H}{n^N{}_H}\right)^{\alpha} C^{1-\alpha} && \forall i \in n^N{}_H \\
\pi_i &= (1-\alpha)\left(\frac{L^N{}_L}{n^N{}_L}\right)^{\alpha} C^{1-\alpha} && \forall i \in n^N{}_L \qquad (11) \\
\pi_i &= (1-\alpha)\left(\frac{L^S{}_L}{n^S{}_L}\right)^{\alpha} C^{1-\alpha} && \forall i \in n^S{}_L
\end{aligned}$$

These rents motivate entrepreneurs to enter with new goods and services and develop the process innovations to capture rents in the second and third stage of the life cycle.

The incentive to be(come) an innovating entrepreneur is the expected present value of the profit flow over the first cycle stage. The value of being a northern early stage producer is then given by:

$$v^N{}_H = E\left[\int_t^T e^{-r(\tau-t)}\pi^N{}_H(\tau)d\tau \middle| I(t)\right] \qquad (12)$$

[19] See footnote 18.

which equals the expected discounted profit flow from time *t*, the time of entry, to time *T*, the time at which production with low skilled labor starts and the incumbent is driven off the market, conditional on the information set *I*(*t*) available at time *t.* The flow probability of a product making the transition to the next stage is given by gross rate at which new processes are being developed, $\left(\dot{n}^N{}_L + \dot{n}^S{}_L\right)/\, n^N{}_H$. Assuming that entrepreneurs expect profits to grow at a constant rate, as they will in the steady state, then yields:[20]

$$v^N{}_H = \pi^N{}_H(t)\int_t^{\infty} e^{-(r+(\dot{n}^N{}_L+\dot{n}^S{}_L)/n^N{}_H)(\tau-t)} e^{(\dot{\pi}^N{}_H/\pi^N{}_H)(\tau-t)} d\tau = \frac{\pi^N{}_H(t)}{r+(\dot{n}^N{}_L+\dot{n}^S{}_L)/n^N{}_H) - \dot{\pi}^N{}_H/\pi^N{}_H} \qquad (13)$$

Where the current profits are discounted by the rate of interest, *r*, the rate of profit erosion, $-\dot{\pi}^N{}_H/\pi^N{}_H$ which by Equation (11) equals $-\left((1-\alpha)\dot{C}/C - \alpha\dot{n}^N{}_H/n^N{}_H\right)$, and the hazard rate of losing the profit flow because of routinization, $(\dot{n}^N{}_L + \dot{n}^S{}_L)/n^N{}_L$. An entrepreneur is able to capture this value by founding a new firm and subsequently starting production of a new good or service. Similarly we have for the northern mature stage producers:

$$v^N{}_L = \frac{\pi^N{}_L(t)}{r + (\dot{n}^S{}_L + \alpha\dot{n}^N{}_L)/n^N{}_L - (1-\alpha)\dot{C}/C} \qquad (14)$$

Where we have substituted for the growth rate of profits. Finally the value of owning an outsourced firm that produces in the South is equal to:

$$v^S{}_L = \frac{\pi^S{}_L(t)}{r + \psi - (1-\alpha)\dot{C}/C + \alpha\dot{n}^S{}_L/n^S{}_L} \qquad (15)$$

[20] In fact in steady state profits will decline at a constant rate. See below.

Where ψ is an additional risk premium for producing abroad that reflects the risks of being unable to retrieve profits and reflects the perhaps less than perfect property rights protection in the South.[21]

Let us finally assume that introducing a new good or service, developing a process and outsourcing the production all draw on the same pool of limited resources in the North, which we may label entrepreneurial resources, *ER*.[22] To close the model we must specify how entrepreneurial resources combine with accumulated knowledge to generate the dynamics in the model. Assume:

$$\begin{aligned} \dot{n}^N_H &= \dot{n} - \dot{n}^N_L - \dot{n}^S_L = aER_I^{\gamma} n^A - \dot{n}^N_L - \dot{n}^S_L \\ \dot{n}^N_L &= aER_D^{\gamma} n^N_H - \dot{n}^S_L \qquad \text{where } 0 \leq \gamma \leq 1 \qquad (16) \\ \dot{n}^S_L &= aER_O^{\gamma} n^N_L \end{aligned}$$

Note that a productivity parameter *a* and the amount of entrepreneurial resources allocated are combined with n^A, n^N_H and n^N_L to reflect the knowledge spillovers in the model. Innovation benefits from the (exogenous) stock of knowledge, n^A.[23] Development benefits from the knowledge accumulated in new goods production, n^N_H, and outsourcing benefits from experience in routinized production, n^N_L. Furthermore (16) reflects the assumption that a product must first be invented, can then be routinized and finally outsourced, but only in that order, missing none of the stages in its development.

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[21] This is our parameter for political risk. An anonymous referee has suggested that this parameter might also reflect imperfect capital markets in the South but this is not quite correct. Such market imperfections would raise the interest rate in the South, but in our model the entrepreneurs raise the capital for their ventures in the North and/or in international capital markets. The risk premium then only shows up in their discounting of these profit flows as they are at risk.

[22] Alternatively one could think of R&D labor, engineering talent or organizational and managerial talents. All that is required to justify this assumption is that all innovative activities require the same labor that is a different type of labor than that used in production.

[23] See Sanders (2005) for more details on how this knowledge parameter can be endogenized. In standard endogenous growth models (Jones (2005)) it is frequently assumed to be equal to *n*, accumulated innovation. In this model this would also introduce endogenous growth but that would prevent us from experimenting with shocks to the knowledge stock. We interpret the advent of a new General Purpose Technology as conceptualized by Breshnahan and Trajtenberg (1995), however, as exactly that, a positive shock to n^A.

Entrepreneurial resources now have to be allocated over three alternative uses. In each they must generate the same marginal value product. Assuming this (market clearing) reward to entrepreneurial resources is given by w_E we obtain:

$$w_E = \gamma a E R_I^{\gamma-1} n^A v^N{}_H = \gamma a E R_D^{\gamma-1} n^N{}_H v^N{}_L = \gamma a E R_O^{\gamma-1} n^N{}_L v^S{}_L \tag{17}$$

This arbitrage condition can be rewritten in separate entrepreneurial resources demand equations that are downward-sloping in the reward for entrepreneurial resources.[24] Equating the sum to the total stock of entrepreneurial resources in the North, ER^*, yields the equilibrium reward for entrepreneurial activity:

$$w_E = \frac{\gamma a E R^{*\gamma-1}\, n^A v^N{}_H}{\left(1 + \dfrac{n^A v^N{}_H}{n^N{}_H v^N{}_L} + \dfrac{n^A v^N{}_H}{n^N{}_L v^S{}_L}\right)} \tag{18}$$

which in steady state grows in proportion to n^A times $v^N{}_H$.[25] The latter grows in proportion to profits per variety by (13), which by (11) in turn grow in proportion to $n^N{}_H{}^{-\alpha} C^{1-\alpha}$. It is shown in the Appendix that in the steady state the reward to entrepreneurial resources will grow at the same rate as total consumption expenditure, as will wages in all labor markets, as long as n^A grows at the same rate as $n^N{}_H$. The total range of goods then expands at the common growth rate of knowledge and new, mature and outsourced goods in the global economy. This is formulated in propositions I and II.

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[24] One could consider setting w_E equal to the high skilled wage in the North as it arguably presents the opportunity costs for the entrepreneur. However, this complicates the model considerably without adding much in terms of insight in the mechanisms we are primarily interested in. Sanders (2005) shows the equivalence in qualitative results in a different (two stage life cycle) but closely related model.

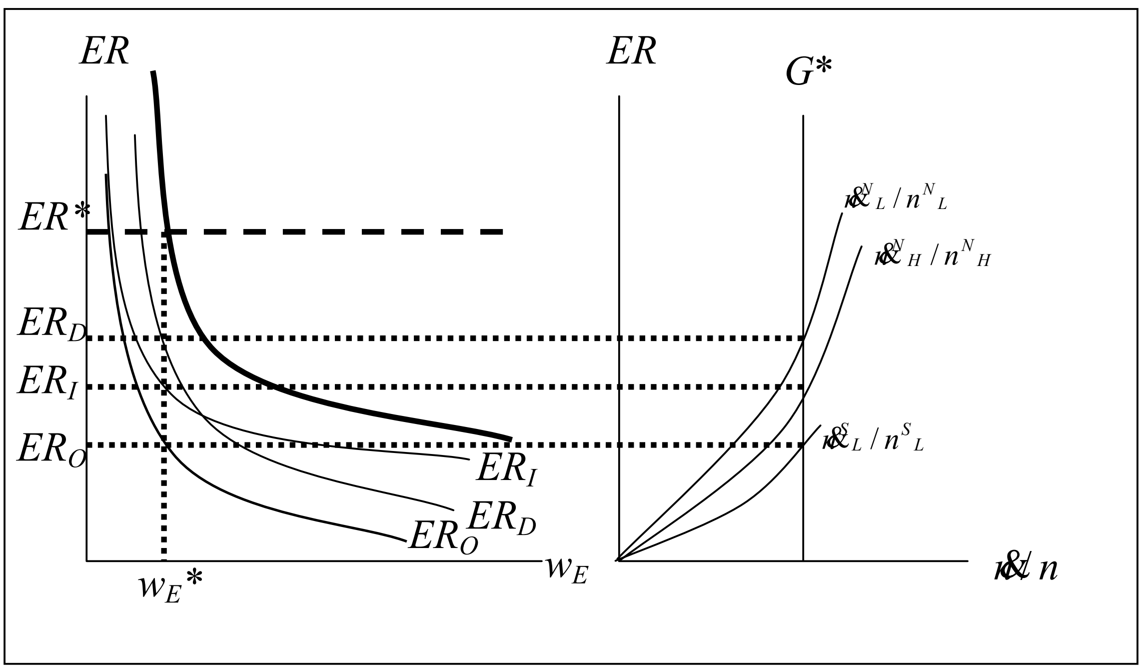
[25] The steady state is characterized by all ranges growing at a common rate, such that the relative labor demands and relative wages remain stable. In that case relative profits and consequently the relative discounted profit flows are also stable.

Proposition I: There exists a steady state equilibrium in which the allocation of all labor types is stable, labor markets clear and income and consumption grow at a common positive rate. This steady state is reached when all ranges of goods grow at a common positive rate that is equal to that exogenous rate of knowledge expansion, G^*.[26]

Proposition II: This steady state is a unique and globally stable equilibrium in the sense that the economy will converge back to this steady state when it is disturbed by shocks.

The proof for both propositions is in the Appendix.

Figure 2:



[26] We have assumed that r-ρ is positive and constant to obtain this result. We would have to specify the consumer problem in much more detail to derive that result in the model endogenously. See Barro and Sala-I-Martin (2004) for the derivation of that assumption in a fully specified model of endogenous savings.

The dynamic equilibrium in the model can be illustrated in Figure 2 by plotting the three demand equations for entrepreneurial activity, implicit in equation (17) and equating the vertical sum of these curves to the exogenous supply of entrepreneurial resources in the North (left panel). In the steady state these levels of activity must generate the same rate of expansion, G^*, to the respective variety ranges. The knowledge spillover structure assumed in equation (16), which implies that all entrepreneurial activity receives a spillover from upstream entrepreneurial activity (which for initial innovation is exogenous knowledge creation $\dot{n}^A / n^A = G^*$), guarantees that in the end all variety ranges will grow at the same rate for a stable allocation of entrepreneurial resources. As was shown under Proposition II and in the Appendix this implies that, in the steady state, the right panel of Figure 2 applies.

4. Comparative Statics

Now consider the comparative statics in the steady state concerning the effects of increases in L^S_L, (globalization/ integration), ψ (property rights/ institutions) and n^A (technology shock/ GPT) and a policy experiment that encourages and stimulates entrepreneurship ER^* (education/ entrepreneurship). To disentangle the effects of these shocks we first consider the shocks in isolation.

An increase in southern (unskilled) labor supply will initially drive down equilibrium wages in the South and push the southern economy out of equilibrium. In equation (11) it can be seen that in that case profits in the South will rise as wages fall. By equation (14) that implies that the value of outsourcing activities increases and entrepreneurs will switch out of innovation and development to outsource more of the existing mature products to the South. As the rate of outsourcing accelerates and the rates of innovation and development fall, there is a change in the relative composition of the global economy. More varieties are produced in the South, variety expansion falls and both n^N_H and n^N_L will fall relative to n^S_L. This, by equation (10) implies that southern wages recover and northern wages will fall, whereas the reward to entrepreneurial resources in the North rises. Of course equilibrium is re-established once diminishing returns in innovation, development and outsourcing (through the gradual reduction of upstream knowledge stocks) make sure that all ranges grow at the same rate again. It should be noted here that the prediction that southern wages fall and recover gradually does not apply for the countries that enter world markets. They enter the market with wages below w^S_L and experience an immediate rise followed by a further increase in their wage levels. The former predictions for southern wage levels apply more to for example countries like Brazil, Mexico and Egypt then India or China[27].

The impact of a drop in political risk ψ enters our model directly in the return to outsourcing equation (14). Decreasing risks implies lower discount rates of given profits, making outsourcing more attractive. The impact on the allocation of entrepreneurial resources and the relative composition of the economy is similar as above. However, there is no steady state reduction in southern wages. Instead the wages rise due to the increased demand. In the North the implications for relative wages and income are similar as before. The entrepreneurs gain and the low skilled northern workers lose out most but also high skilled northern wages fall relative to southern wages.[28]

A rise in the knowledge stock n^A and the rate at which it expands have a temporary and permanent effect on the steady state composition of the economy, respectively. If there is a level shock the benefits will dissipate gradually. The high skilled workers in the North benefit first. Entrepreneurs move into innovation and abandon development and outsourcing. As the available stock of new products expands, however, the entrepreneurs will return to development and ultimately outsourcing. The steady state has not changed so the economy will eventually return to its initial equilibrium.[29] If the growth rate has increased permanently, however, that implies that in the steady state all ranges of goods will grow at a higher rate, but also that the steady state size of the new product range will be larger relative to the others.

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[27] Mayer (2003) also investigates the predicted effects of trade performance and finds that comparative advantage in labor intensive manufactures has indeed shifted from middle-income countries in Latin America towards the labor abundant newly integrating economies in Asia.

[28] Lane and Milesi-Feretti (2003) provide data that show a reduction in the return on US held foreign assets over a period in which the levels of foreign direct investment soared, in particular into formerly communist countries opening up to international trade. This evidence can be interpreted as a drop in required risk premia on foreign investment that is partially due to political risk reduction.

[29] At a higher level of utility, obviously.

Consequently the high skilled workers in the North gain relative to their low skilled counterparts in both the North and South, and again the entrepreneurs benefit.[30]

Finally, a rise in *ER** the stock of entrepreneurial resources/resources in the northern economy, has a peculiar steady state impact in this model. The entrepreneurs will be allocated to expanding the three variety ranges and these ranges and all ranges will therefore expand faster for some time, but as the new and mature goods range are also eroded faster only the range of southern varieties will also grow in relative terms in the steady state. That generates the interesting result that the benefits of entrepreneurship training in general leak to developing countries in the steady state. As entrepreneurs pass the buck, the buck moves faster to where it stops. However, it should be emphasized that in passing the buck the entrepreneur appropriates at least part of the surplus with every pass. Entrepreneurial output thus increases and even though their wages fall, their incomes rise to the extent that northern income increases relative to southern income if demand elasticities are sufficiently low.

It should also be emphasized that the North is composed of many countries and any one northern entrepreneur may take a mature good and outsource it. Having more entrepreneurs and fewer workers in a country puts it in a favorable position relative to the other northern countries, not in the least because more entrepreneurs also means a quicker adjustment to external shocks such as the ones described above.

From a global perspective more entrepreneurs is unambiguously beneficial. An increase in the number of entrepreneurs will reduce global wage- if not income inequality and ensures faster adjustment to equilibrium when exogenous shocks hit the economy. And the world may still have to deal with such shocks in the future; the end of oil reserves, nuclear disaster in the Middle East, the recovery of Japan or the introduction of cold hydrogen fusion

[30] These predictions are also consistent with the acceleration hypothesis that was explored in the context of northern wage divergence between skill levels and has been connected to the introduction of a new General Purpose Technology in Breshnahan et al. (2002). See for example Galor and Tsiddon (1997), Greenwood and Yorukoglu (1997), Caselli (1999), Rubinstein and Tsiddon (1999), Galor and Moav (2000), Aghion (2001) and Aghion et al. (2002) for models that introduce the acceleration hypothesis is one way or the other.

reactors. Whatever lays ahead, entrepreneurs can help deal with it and adjust as long as change opens up (commercial) opportunities.

Finally consider the effect of all exogenous shocks described above combined.[31] From the empirical evidence presented in section 2 it can be concluded that the above shocks give a rough account of what has happened over the past 25 years. The model predicts significant wage divergence in the North between the skilled and unskilled and certainly between the entrepreneurs and workers in general, increasing FDI and outsourcing to the South, and a widening of the North-South wage gap. The latter has not been observed in the data as China and India have always been considered part of the South but taking them out of the sample one sees significant divergence between OECD and non-OECD countries in both wage and income levels. China and India, on the other hand, are seen to quickly close the wage and income gap with the North and not surprisingly they receive the bulk of FDI outflow from the North as well. Lower political risk implies that the downward wage pressure in the (rest of) the South is somewhat ameliorated.

5. Conclusions

In this paper we have proposed a model that endogenously explains the shifting patterns of comparative advantage in international trade. In addition the model also explains relative wage developments in the North and highlights the increasing importance of entrepreneurial resources in advanced economies.

As in traditional trade models, comparative advantages follow from cost advantages and relative resource abundance. But in our model we link resource requirements to the life cycle stage of a product. And the life cycle is linked to rational, profit driven innovative

[31] Not including the increase in ER*, which we consider a policy variable below.

activity by entrepreneurial agents. This implies that the comparative advantage in producing that product shifts from one country or region to the next as innovation causes products to mature. When it becomes profitable to shift production geographically, entrepreneurs will bring the matured products from the North to the South as was already envisioned by Vernon (1966).

Observed wage diversion and polarization in the North and the shift in comparative advantage towards more advanced early stage products has been linked to a reduction in political risk, the integration of populous low wage countries in the South and the advent of a new general purpose technology that (temporarily?) accelerates technological change and innovation in the North. As the global economy expands, it offers more and more lucrative opportunities for (international) entrepreneurs and more and more advanced countries will be pushed from an managed to an entrepreneurial economy. This hurts the relative and possibly also the absolute position of low and even middle skilled northern workers.

When we consider policy responses, however, we need to realize that the North is a fragmented collection of sovereign nation states among whom it is hard to organize collective action. And in this particular case the game they play is a classic prisoner's dilemma. It would be beneficial for the northern (low skilled) workers if all northern countries would agree to restrict the activity of their international entrepreneurs and shift their talent from outsourcing towards maturing northern innovations. But as individual countries benefit from outsourcing the mature technologies they did not have to invent and develop themselves, there is a strong incentive to defect from any such agreements. For the individual northern country the rational thing to do is to try and maximize the benefits from globalization through more, not less, international entrepreneurship.[32]

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[32] And then, of course, redistribute these benefits appropriately without upsetting the incentive structure. Not a small challenge, indeed.

The inability of the North to organize a collective policy is good news for the South. Our policy experiment of increasing the entrepreneurial capabilities in the North shows that self interested national policies will help close the North-South wage and income gaps. And while the northern economies play a zero sum game, the South unambiguously benefits.[33] Northern countries who fail to keep up, will find their comparative advantages under increasing pressure from the South as entrepreneurs from other northern countries outsource their ideas to cheaper locations. The northern unskilled and low skilled workers will have to find shelter in the shrinking non-tradable (e.g. health and personal services and construction) sectors.[34]

Our model is intended, however, to merely present and propose a coherent and consistent theoretical framework to think about shifting comparative advantages and the joint impact of trade and technological change on the wage and income distribution within and among countries. And although we have tried to embed our analysis in the empirical evidence available in the literature, we lack the detailed data on trade, resource intensity and relative factor prices to test our theoretical model more rigorously. We therefore leave this more rigorous and advanced econometric testing of the predictions in our model as an opportunity for future research.

[33] A similar conclusion to the one reached in Krugman (1979) where the North had to "run to stand still".
[34] This is what the evidence on the Polarization hypothesis (e.g. Goos and Manning (2007)) indeed seems to suggest.

Appendix

Proof of Proposition I:

The proposition reads: *There exists a steady state equilibrium in which the allocation of all labor types is stable, labor markets clear and income and consumption grow at a common positive rate. This steady state is reached when all ranges of goods grow at a common positive rate that is equal to that exogenous rate of knowledge expansion, G*.*

A steady state equilibrium in which all growth rates in the model are constant can only exists when interest rates exceed the rate of time preference, such that the consumption index C grows at a constant and non-negative rate by equation (2). In (5)-(8) it was shown that firms within each life cycle stage will set the same price, implying by the symmetry in utility that all varieties in a given life cycle stage are consumed in equal quantities. The production function implies that these quantities are equal to the average available amount of labor for that life cycle stage. Labor market equilibrium in the three production labor markets thus implies that the consumption index is given by:

$$C=\left(\int_{n^N{}_L+n^S{}_L}^{n}\left(\frac{L^N{}_H}{n^N{}_H}\right)^{\alpha}+\int_{n^S{}_L}^{n^N{}_L+n^S{}_L}\left(\frac{L^N{}_L}{n^N{}_L}\right)^{\alpha}+\int_{0}^{n^S{}_L}\left(\frac{L^S{}_L}{n^S{}_L}\right)^{\alpha}\right)^{\frac{1}{\alpha}}=\left(n^N{}_H{}^{1-\alpha}L^N{}_H{}^{\alpha}+n^N{}_L{}^{1-\alpha}L^N{}_L{}^{\alpha}+n^S{}_L{}^{1-\alpha}L^S{}_L{}^{\alpha}\right)^{\frac{1}{\alpha}}$$

It is clear from this equation that the variety ranges need to expand to generate a positive growth in the consumption index. The growth rate of C will, in the limit, rise asymptotically to $(1-\alpha)/\alpha$ times the highest rate of variety expansion if they are not equal.[35] For a constant positive growth rate of C in the steady state they need to expand at the same rate.

Equation (16) can be used to show that a steady state positive rate of variety expansion implies that all variety ranges to expand at the same rate. From the outsourcing equation in (16) it is clear that outsourcing is positive for a given level of entrepreneurial resources, if and only if $n^N{}_L/n^S{}_L$ is constant. If the rate at which $n^S{}_L$ expands exceeds that of $n^N{}_L$ the rate of outsourcing will fall to 0. If it is lower, then the rate of expansion will rise to infinity. This implies that the ranges of mature and outsourced varieties need to expand at the same rate in steady state if they are to expand at a positive rate.[36] Moving up to the rate of maturation, a similar argument implies that the new products range must expand at the same rate as the range of mature products and finally, the top line in (16) implies that the range of new products must expand at the same rate as the knowledge base n^A that is given by G^*.

Using the result that all variety ranges expand at the same rate, G^*, we can conclude that the consumption index then grows at rate $(1-\alpha)/\alpha\ G^*$ which is only a steady state equilibrium if income grows at that rate as well. Income in the model has not been specified, but it is a standard result that optimizing consumers will save a fixed proportion of their income, such that the stock of assets will grow at the same rate as their income. This means their interest income will grow at that common rate as well (as the interest rate is constant). In financial market equilibrium the asset income equals the flow of total profits in the model, that, by (11) and summing over all varieties, will expand at rate $(1-\alpha)(gC+G^*)$, where gC is the growth rate of C. Substituting for the growth rate of C we obtain that total profits (and hence asset income) will grow at $(1-\alpha)/\alpha\ G^*$.

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[35] To see this one should realize that the growth rate of the respective labor forces is 0 by assumption. The growth rate of C then lies between $(1-\alpha)/\alpha$ times the maximum and minimum rate of variety expansion. The weight of a given rate of expansion is determined by the relative size of that range and so the range with the highest rate of variety expansion will increasingly drive the growth in the consumption index.

[36] As varieties cannot be uninvented, a negative rate of expansion is ruled out by construction.

Production wage incomes, by equation (10) will expand at $(1\text{-}\alpha)(gC+G^*)$ as well, as the stocks of available labor are constant.

Finally, the growth in total entrepreneurial income can be derived from (18), using (13)-(15) and (11) to substitute for $v^N{}_H$, $v^N{}_L$ and $v^S{}_L$. As relative profits and variety ranges are constant the reward for entrepreneurial resources will grow at rate $G^* + g\, v^N{}_H$, which, by equations (13) and (11) equals $G^*+(1\text{-}\alpha)gC\text{-}\alpha G^*=(1\text{-}\alpha)(gC+G^*)$.

In conclusion the model has a steady state for which all labor markets clear and consumption as well as all incomes grow at the common rate $(1\text{-}\alpha)/\alpha\ G^*$ where G^* is the rate at which all variety ranges expand and exogenously given by the rate of expansion in the knowledge base.

Q.E.D.

Proof of Proposition II:

Proposition II reads: *This steady state is a unique and globally stable equilibrium in the sense that the economy will converge back to this steady state when it is disturbed by shocks.*

The proof follows trivially from the observation made above, that all varieties must grow at the same rate in a non-negative growth equilibrium. If in equation (16) one of the ranges is growing faster (slower) than the growth rate of knowledge n^A this implies that knowledge spillovers to that activity will decrease (increase). This implies that the marginal value product in that activity will rise relative to the alternative entrepreneurial activities and entrepreneurial resources are reallocated to re-establish equilibrium. As a result of both the larger knowledge spillover and the increase in entrepreneurial resources the rate of variety expansion will decrease (increase). This mechanism ensures that all varieties will expand at the common rate G^* in any steady state equilibrium and stability is ensured.

The second part of the proposition, uniqueness, follows from the fact that all negative growth scenario's are ruled out by construction as varieties cannot be uninvented, whereas the zero growth scenario is not stable (as long as interest rates exceed the rate of time preference and consumers are willing to save) by the mechanism described above and the fact that n^A expands exogenously. There is only one positive growth scenario, which is the one where all varieties expand at rate G^*. In that equilibrium growth of income and consumption are determined and equal to $(1-\alpha)/\alpha\ G^*$.

Q.E.D.

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