Income Inequality and Technical Change in European Union Neighbouring Developing Countries: A Calibration Exercise

by

Gianluca Grimalda[†]

Abstract

An evolutionary two-sector model is used to study the impact of skilled-biased technological change on the growth and inequality paths of an economy. Different scenarios are presented that result from changes in a country's structural conditions. Convergence to a high-growth steady state occurs when initial shortages in skill supply are not too large. This is more likely to occur for Europe New Member States than for other countries. However, a Kuznets dynamic with initial increasing inequality emerges in this case. Countries that are initially less equipped with skilled labour can fail to break out from the poverty trap. Gradualist strategies of convergence are shown to produce better results than 'big bang' strategies.

JEL classification numbers: **O33, O41**.
Key words: Skill-biased technological change; inequality; Kuznets curve, catching-up.

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[†] Centre for the Study of Globalisation and Regionalisation (CSGR), Warwick University
Correspondence address:
Gianluca Grimalda
Warwick University – Room C1.02
CV4 7AL Coventry (UK)
Tel.: +44 (0)24 7657 4424
Fax: +44 (0)24 7657 2548
Email: g.f.grimalda@warwick.ac.uk

1 Introduction

The debate on the relationship between income inequality and growth has intensified over the last two decades[1]. In all probability, the reason is to be found in the complex pattern of changes that has affected world economies over this period and the markedly diverse performances in different countries. Globalisation of product and capital markets, in addition to sometimes radical political reforms, have presented countries with new opportunities to transform their social and economic structure and catch-up in their development process. At the same time, however, their chances of being hit by situations of financial and political crises have increased.

As Figure 1 shows, over the 90's some economies managed to attain sizable growth rates without substantial changes in inequality (e.g. Indonesia, Malaysia, and Slovenia), unlike others, where inequality increased (e.g. Chile, Poland and Lithuania). In contrast, growth rates in other countries were rather sluggish and the inequality performance ranged from the extremes of a marked decrease (e.g. Venezuela, Ecuador and South Africa) to a dramatic rise (e.g. Ukraine and Russia, which experienced a slump in growth).

In spite of the diversity, and to some extent the unprecedented nature of the underlying causes of countries' performances, the 'old' Kuznets hypothesis of a non-linear relationship between growth and inequality has received renewed attention in recent years[2]. The reasons for this revival are twofold. First, Kuznets's seminal analysis refers to the long-term process of industrialisation and urbanisation that affects countries at their early stages of development. The Kuznets's 'story' is that the shift of labour from the agricultural sector - in which both per-capita income and within-sector inequality are low - towards the industrial/urban sector - which starts small with higher per-capita income and a relatively higher degree of within-sector inequality -, results in an

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[1] Theoretical contributions have emphasized the relevance of various variables as mediating factors between income inequality and growth, such as credit markets constraints (Banerjee and Newman, 1991), macroeconomic volatility (Aghion, Banerjee and Picketty, 1999), fiscal policy (e.g. Persson and Tabellini, 1994), type of political systems (Perotti, 1996), human capital accumulation (e.g. Eicher, 1996).

[2] Updated versions of the original Kuznets's model have been offered, for instance, by Robinson (1976), Fields (1980), Bourguignon (1990) and Greenwood and Jovanovic (1990).

inverted U-shaped curve relating economic growth to income inequality (Kuznets, 1955: Table 1, p.13, see also Kuznets, 1963). In Kuznets's original formulation, such a cycle may last as long as a century[3]. This basic mechanism seems to be at work even in the most recent years in developing countries (DCs) such as China and India which have been characterised by a rapid process of growth, triggered among other factors by economic globalisation. In particular, the rise in inequality that has affected these countries has been interpreted as the initial trait of a Kuznets trajectory. In what follows we shall refer to this account as the original Kuznets account.

'New' growth theorists have argued that a similar type of non-linear dynamic also applies to rich countries as a consequence of the skill-biased technical change (SBTC) that has affected these economies over the last two decades (e.g. Galor and Tsiddon 1997; Galor and Moav, 2000; Aghion et al., 1999). On this account, a Kuznets curve originates as a result of wage evolution and changes in the composition of the labour supply. It is argued that the introduction of an SBTC triggers an increase in skilled labour demand and of the skill premium, thus determining an increase in inequality and originating the first segment of the Kuznets inverted U-curve. Then, widening wage-gaps induce unskilled workers to invest more in human capital through education, learning and training. Hence, as workers upgrade their skill levels, skilled labour supply increases. This reduces both the skill premium and inequality, giving rise to the second part of the Kuznets curve. These theories account for the recent rise of within country income inequality (WCII) in developed countries in terms of the upward part of the Kuznets curve, and predict an inequality-decreasing trend for the years to come. The reason is that a period of 15-20 years from the original SBTC is seemingly sufficient for the inequality-decreasing forces to counteract the initial inequality-enhancing effect (Aghion et al., 1999, p. 1655). The Kuznets reversal is seemingly much shorter on this account than the original one. Given the different unit of analysis – rich

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[3] In fact, Kuznets (1955: 4) offers empirical evidence spanning the 50-75 years prior to the 1950s for a sample of developed countries. He points out that during this period only a decreasing trend of inequality can be observed. His implicit assumption is then that a rising trend of a similar length must have preceded such spell.

countries vis-à-vis DCs – and the different time scale, we shall refer to this version as the modern Kuznets account.

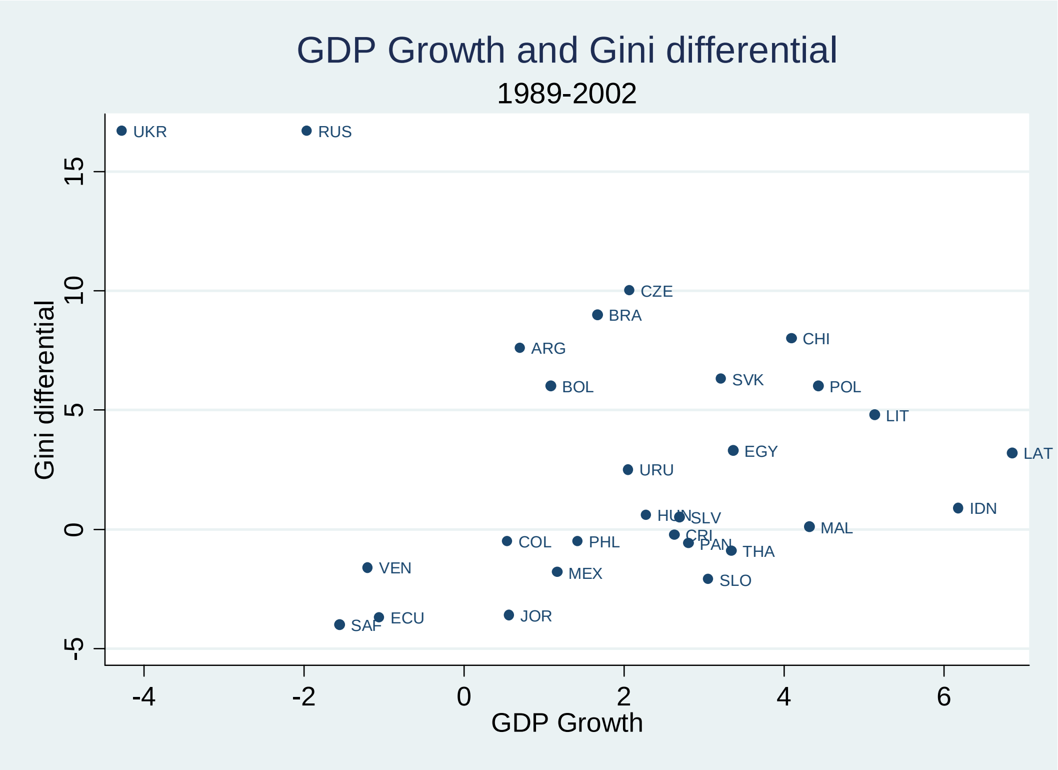

Figure 1

Sources: World Development Indicators (World Bank), September 2005, for data on GDP; World Income Inequality Database (UNU-WIDER), June 2005, for data on the Gini indexes (various sources). Data for each country are computed within the period 1989-2002. The actual length of the spell depends on data availability for the Gini index.

On the empirical side, the Kuznets curve was commonly accepted in the 70s (Ahluwalia, 1976), while more controversial results were found in the following years (Papanek and Kyn, 1986; Anand and Kanbur, 1993; Li, Squire and Zou, 1998). However, more recent studies have given further support to the Kuznets hypothesis. Barro (2000: 23) finds a significant relationship between the Gini coefficient and a quadratic form of the log of GDP in a sample of 100 countries over the period 1965-95. Similarly, Reuveny and Li (2003) find a 5% significant support for the existence of a Kuznets curve using a sample of non-OECD countries over the period 1960-9. In spite of the statistical significance of the relationship, the explanatory power of the hypothesis seems to be limited (Barro, 2000). This suggests the presence of other mechanisms at work in the relationship between growth and inequality.

The purpose of this paper is to increase the understanding of the Kuznets hypothesis and more generally of the causal links between growth and inequality analysing a sample of European Union Neighbouring Developing Countries (EUNDCs). This is done by using a theoretical model that studies the simultaneous evolution of income inequality and growth in response to an SBTC. Focussing attention on SBTCs as major factors of change is justified by the fact that a large set of high-income as well as middle-income countries have been affected by this type of shock over the last decades. Moreover, the increased integration with the EU in recent years have made technological transfers to the EUNDCs more likely. In fact, SBTC has occurred for middle-income countries through importation of machinery from developed countries (Berman and Machin, 2000; 2004), which has led to capital-deepening and (given capital-skill complementarities) to rising relative demand for skilled labour[4]. This evidence seems to confirm the skill- enhancing-trade hypothesis (Robbins, 2003), which argues that trade liberalisation in DCs has induced an SBTC through the capital good importation channel. That this process is relevant for income distribution has been demonstrated by Vivarelli (2004) who shows a significant impact of increasing imports on WCII in a sample of 34 DCs that recently opened to international trade. Hence, the theoretical model will be calibrated on data coming from a sample of middle-income DCs from the EUNDCs area. Given the generality of the model we believe that some of its main insights may be carried over to the other more developed countries which have been affected by SBTC.

The framework for analysis consists of a dynamic two-sector macroeconomic model characterised by different sectoral skill labour intensity and productivity growth rates. Each sector follows a basic Goodwinian dynamic (Goodwin, 1967) with investments and wages being in an inverse relationship along the economy's business cycles. Such a simple sectoral dynamic is altered by two factors. First, agents are able to move across the economic sectors in response to their relative profitability, with cross-sector movements being modelled according to a replicator dynamic (Weibull, 1995; Soete and Turner, 1984). Second, technical progress generally differs in the two sectors, being endogenously determined by the sector-specific share of investments. This determines increasing dynamic returns at the sectoral level, which in turn bring about unbalanced growth and multiple steady states. These are characterised by the specialisation of the economy into one of its sectors. Since the skilled-intensive sector guarantees higher productivity growth rates than convergence to the unskilled-intensive one, the steady state associated with convergence to the skilled-intensive sector is characterised by a higher growth rate than the other steady state. We shall refer to these as the high-growth and the low-growth steady state throughout the analysis.

We present the results of various simulations of the model, which originate from different structural conditions of the economy and characteristics of the shock. In particular, we take the initial level of the skilled labour supply as a basic measure of a country's absorptive capacity in adopting more advanced technologies. This is consistent with the idea put forward in the technology-gap literature (see e.g. Fagerberg, 1994) that countries may have different degrees of capabilities in utilising the same technology. The reason is that country-specific structural conditions may cause 'incongruences' with respect to a certain technology (Abramovitz, 1992). In this literature, the education of the workforce is considered to be one of the most important factors determining a country's capacity to assimilate a more advanced technology (Baumol et al., 1989). Other key parameters in our analysis will be the cross-sector transfer costs which workers have to pay when moving from one sector of the economy to the other and the 'contiguity' of the two technologies in terms of productivity differential.

The analysis of these different scenarios highlights the presence of two causal mechanisms in the relationship between inequality and growth. The first is what we call the incentive effect, that is, the need for wage inequality to be large enough to induce unskilled workers to upgrade their skills and enter the skill-intensive labour market. This effect is the same mechanism as that illustrated in the modern Kuznets account. However, in the present framework we explicitly model the transfer costs which unskilled workers have to sustain in order to move to the skilled-intensive sector, allowing in particular for agents' heterogeneity in the ability to acquire higher levels of skills.

The second mechanism is what we call the productivity effect. Our framework is based on the idea of technical change being localised (Atkinson and Stiglitz, 1969), rather than general purpose (e.g. Helpman, 1998). Accordingly, innovations for each technology are endogenously determined by the amount of learning by doing carried out within each sector rather than in the economy as a whole. As a result, technical knowledge spillovers occur at the sectoral level, rather than at the economy-wide level. This pattern of technical change causes sector-specific productivity growth rates to depend on sectoral investments. A persistently high level of investments in the skilled-intensive sector therefore is necessary for that sector to grow and the economy to converge to the high-growth steady state.

According to this analysis, the basic problem faced by an economy is that these two effects may have opposing implications on the functional distribution of income. The incentive effect may require skilled wages to increase, thus enlarging the labour share and squeezing the capital share. In contrast, the productivity effect will typically call for a greater capital share. The simulations we have conducted show that countries with a high absorptive capacity are better able to manage this trade-off, so are more likely to converge to the high-growth steady state. In spite of this, the results in terms of inequality patterns may differ.

In particular, countries with relatively high absorptive capacity may converge to the high-growth steady state. This is more likely to occur for Europe New Member States than for other countries in the region. However, this is likely to lead to a Kuznets dynamic. On the contrary, countries that are initially less equipped with absorptive capacity can fail to break out from the poverty trap.

Finally, when countries begin with low absorptive capacity the trade-off between the incentive and the productivity effects becomes binding and the economy is more likely to stagnate in a low-growth trap. The reason is that in this case more resources need to be spent on trying to attract workers to the skilled–intensive sector. This leads to a squeeze in profits, with the consequence that the level of investments in the skilled-intensive sector is not sufficient to propel productivity growth and sustain its expansion. This case is generally associated with a pattern of substantial equality. We show that this scenario may indeed emerge in our calibration exercise for some EUNDCs. However, we also show that 'gradualist' strategies – where productivity growth rates are relatively low – can produce better results than 'big bang' strategies – where instead productivity growth rate are immediately fast after the SBTC. The reason is that big bang strategies may 'overheat' the labour market for skilled labour, taking away resources from investment to wages. This may preclude reaching the critical mass of investment in the skilled-intensive sector that is needed to break out from the poverty trap.

Section 2.1 sets out the basic structure of the model, and section 2.2 analyzes its steady states. Section 2.3 describes the nature of the calibration exercise. Section 3 presents the results of the calibration exercise. Section 4 concludes.

2 The Model

2.1 General Features of the Model

This section outlines the main characteristics of the model. The theoretical framework is evolutionary (e.g. Silverberg and Verspagen, 1995). The economy is characterised by a variety of sectors – two in its simplest version – which are associated with technologies with different degrees of skilled labour intensity (section 2.1.A). If we abstract from the between-sector linkages, a simple dynamic *a là* Goodwin (Goodwin, 1967) governs the evolution of the relevant variables in each sector, i.e. unit labour cost (section 2.1.C) and labour demand (section 2.1.D). In particular, these variables follow cycles of fixed duration over time as a consequence of the dynamic of income distribution between capital-owners and workers. A phase of high investments leads to an excess of labour demand which drives up wage rates. This results in a drop in both profit rates and investments, in turn decreasing the level of production and employment. Wages now fall, triggering a new phase of increased investment. This simple dynamic typical of the Goodwinian world is radically modified in our model by the presence of both endogenous technical change (section 2.1.B) and between-sector movements of capital (section 2.1.D) and labour (section 2.1.E).

2.1.A The production function

Each of the two sectors of the economy is associated with a particular technology that differs from the other in its labour skill-intensity. In particular, the 'modern' ('traditional') sector of the economy is associated with a skilled-labour (unskilled-labour) intensive technology. For simplicity, we assume that each technology exclusively requires skilled (unskilled) labour. Moreover, each technology is uniquely associated with a Leontief technique of production with labour and capital being in fixed proportions at each instant in time. The two sectoral production functions take the following form:

$$Q_i(t) = \min\left\{a_i(t)L_i(t), \frac{K_i(t)}{c}\right\} \quad i = 1,2 \tag{1}$$

$Q_i(t), i = 1,2$, is the output produced in the two sectors of the economy at time *t*. $L_1(t)$ and $K_1(t)$ ($L_2(t)$ and $K_2(t)$) represent the employment of skilled (unskilled) labour and capital in the skill-intensive (unskilled-intensive) technology at time *t*. *c* is the fixed coefficient representing the capital content for a unit of output, which is assumed to be equal for the two technologies. $a_i(t), i = 1,2$, is labour productivity. As illustrated in section 2.3, we shall calibrate the two sectors in terms of the high-tech and the low-tech sectors within manufacturing in middle-income DCs. In this way, the model will describe the transition of an economy evolving from a relatively backward sectoral specialisation to a more advanced one.

2.1.B Dynamic of labour productivity

The main hypothesis of the model for what concerns labour productivity is that technical change is localised (Atkinson and Stiglitz, 1969). That is, technical knowledge is assumed to have some sector-specific characteristics which cannot be transferred across the sectors of the economy, so technical change follows different paths in each of the sectors (see e.g. Dosi, 1997). More precisely, we assume technical knowledge is a public good at the sectoral level, but not at the economy-wide level.

In order to model the within-sector dynamic, we draw on the idea of an industry-specific learning curve, which is justified by the assumption of learning-by-doing processes taking place at the level of each sector of the economy (e.g. Krugman, 1987). Learning-by-doing as an engine of technical progress has received extensive support in the literature since the contributions of Arrow (1962), and more recently Romer (1986). Arrow argues that the acquisition of knowledge is related to experience, and suggests using accumulated past investments as its measure. In the present model we want to follow a similar idea, and make capital the main source of technical advances through experience. Nevertheless, this model needs to be adapted to the multi-sector evolutionary framework that we are using. Assuming that technical knowledge depended on the absolute level of capital would lead to the undesirable consequence that sectoral technical knowledge could decrease over time were capital to be disinvested from one sector and reinvested in the other – as may be the case in the present model. For this reason, we propose a different specification, which rests on the idea that technical knowledge growth depends on the accumulated portion of overall capital that is allocated in a sector, rather than on accumulated investments. This is incorporated in equation (2) below, where $\kappa_i(t)$ denotes the portion of capital being invested in sector i – namely, $\kappa_i(t) = K_i(t)/(K_1(t) + K_2(t))$, and g_i, $i = 1,2$ are parameters that characterise the productivity gains in the sectors of the economy:

$$\frac{\dot{a}_i(t)}{a_i(t)} = g_i \kappa_i(t) \qquad (2)$$

This specification maintains the basic idea that technical progress is determined by accumulated experience, as measured by capital, but experience is now seen as stemming from the density of capital that is present in a sector, rather than from investments. This is consistent with the idea that externalities come about because of the average value of the 'encounters' that each firm realises with other firms active in the same sector. In other words, innovations are brought about by the sharing of information, imitation, and learning from each other. In order for the specification of equation (2) to hold, we need to think that it is the average value of such encounters, rather than their total value, that matters for increases in learning. As a result, the higher the concentration of capital in a sector, the higher the frequency of such encounters, the higher the productivity growth rates[5]. Therefore, productivity will only slow down, rather than drop in absolute value, in those sectors that are going through phases of disinvestment.

2.1.C Dynamic of wage rates and prices

Wages for skilled and unskilled workers evolve in accordance with the imbalances between demand and supply in the corresponding sector of the economy. We define $y_i(t), i = 1,2,$ as the unit cost of labour for sector i. That is, $y_i(t) = w_i(t)/a_i(t)$, where $w_i(t)$ is the sectoral wage rate. $y_i(t)$ motion over time is driven by equation (3):

$$\frac{\dot{y}_i(t)}{y_i(t)} = \begin{cases} \gamma\left(x_i(t) - L_i^S(t)\right) + (\eta_i - 1) g_i \kappa_i(t) & if\, 0 \le y_i(t) < 1 \\ \min\left\{0, \gamma\left(x_i(t) - L_i^S(t)\right) + (\eta_i - 1) g_i \kappa_i(t)\right\} & if\, y_i(t) = 1 \end{cases} \qquad (3)$$

The first term in the first line of the equation reflects the changes in wage rates which are due to market imbalances, and depends on the excess of labour demand over supply. Sectoral labour

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[5] Likewise, in other strands of the growth theory literature it has been argued that the type of externalities associated with learning-by-doing may be better captured by the *average* level of capital present in the economy, rather than its absolute value (e.g. Sala-i-Martin, 1990: 20). This approach has been explicitly

demand is defined as $x_i(t) = K_i(t)/(ca_i(t))$, whereas labour supply is denoted by $L_i^S(t)$. The speed at which labour market imbalances affect wage growth is measured by the parameter γ, which can thus be seen as an index of the flexibility of the labour market. γ approaching infinity corresponds to the situation of instantaneous market clearing.

The second term is associated with a sector-specific redistributive mechanism independent of market forces, which assigns a 'bonus' to wages equal to a portion ηi of sectoral productivity gains. Such a component may be seen as an institutional arrangement that accrues a fixed amount of productivity gain to wages as an effect of bargaining over income distribution[6]. In particular, the higher ηi, the stronger workers' bargaining power and the higher their income share. This parameter also determines the steady state level of structural unemployment for the economy (see section 2.3). The second line of equation (3), which holds for $y_i(t) = 1$, is a boundary condition that prevents profits to become negative. That is, firms may stop production rather than producing while making a loss.

As for the prices of output, we assume the country sells its product on the world market. This implies that the demand for its output is perfectly elastic, so any amount of output that is produced can be absorbed by the world market at the given price. Hence, commodity prices will be assumed to be constant and will then be omitted from the analysis.

2.1.D Dynamic of sectoral capital

The second factor that influences the basic Goodwinian dynamic at the level of each sector is given by the possibility for the agents to move across the sectors of the economy in relation to their relative profitability. So, capital-owners may shift their production activities to the sector

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adopted by some economists to model human capital accumulation (Lucas, 1988).

[6] Alternatively, one may see equation 3 as a version of a Philips curve, where the first term captures the effect of unemployment on wage rates, and where the vertical intercept is variable and is given by the term $\eta_i \kappa_i(t) g_i$.

with higher profit rates and workers have the option to move towards the sector offering higher wages. However, agents are boundedly rational (Nelson and Winter, 1982), that is, their choice is subject to cognitive and informational limitations on the environment in which they operate, as well as adjustment costs. As a consequence, at each instant in time only a fraction of agents can adjust to what is currently the optimal action.

Equation (4) below describes the rule of motion for capital invested in sector i of the economy, whereas j denotes the alternative sector:

$$\dot{\kappa}_i(t) = \begin{cases} \kappa_i(t)\left(1-\kappa_i(t)\right)\left[\dfrac{u_i(t)\left(1-y_i(t)\right)\left[1+\alpha\left(1-\nu_i(\kappa_i(t))\right)\right]-u_j(t)\left(1-y_j(t)\right)\left(1+\alpha\right)}{c}\right] & \\ & \text{if } u_i(t)\left(1-y_i(t)\right)\left(1-\nu_i(\kappa_i(t))\right)>u_j(t)\left(1-y_j(t)\right) \\ \kappa_i(t)\left(1-\kappa_i(t)\right)\left[\dfrac{u_i(t)\left(1-y_i(t)\right)-u_j(t)\left(1-y_j(t)\right)}{c}\right] & \text{otherwise} \end{cases} \tag{4}$$

This specification is based on Soete and Turner (1984) and draws on the idea that sectoral capital accumulation depends on both a ‘normal’ accumulation rate that hinges upon a sector’s own rate of investments, and on a ‘redistributive’ component whereby capital is reallocated across sectors. How the ‘normal’ component works can be seen in the last line of equation (4). This is modelled according to the behavioural rules typical of Kaldorian models (Kaldor, 1957). That is, capital-owners reinvest all of their profits in the sector in which they are operating, whereas workers consume all of their income[7]. This component makes sector investment equal to the sector-specific profit rates. As a result, the growth in the share of capital invested in sector i depends on the difference in the sector-specific profit rates, which is equal to the term in square brackets. The possibility of firms being rationed because of labour shortages is also taken into account by

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[7] Nothing substantial would change in the model if workers’ propensity to consume and entrepreneurs’ propensity to invest was constant, but less than one.

means of the variable ui(t), which represents the degree of capacity utilisation of capital in sector i[8].

The first line of equation (4) adds the 'redistributive' component of capital to the 'normal' accumulation rate. Such a 'redistributive' component rests on the idea that capital-owners may decide to switch production sector, whenever they acquire information that the profit earned in the alternative sector is higher than the currently one. However, due to a variety of 'retardation factors' associated with agents' bounded rationality, such an adjustment is not instantaneous and at each instant in time only a fraction of the capital-owners will be able to migrate to what is currently the more profitable sector. Such retardation factors are based on the general idea that information diffuses slowly in the economic system and that agents may make mistakes in 'decoding' such information. More precisely, the model of diffusion of information we adopt hinges upon the idea that information is gained by agents through random 'encounters' with other agents, and through the imitation of the 'most successful' agent by least successful ones (Weibull, 1995)[9]. This leads to a version of the replicator dynamic in the rule of motion for capital. Hence, all factors hindering the possibility of information being diffused in the system, and agents learning from one another, will contribute to slowing down the reallocation of capital across sectors.

Specifically, the parameter α that appears in the first line of (4) is a non-negative parameter that regulates the speed at which information is diffused in the economy in each instant in time. When α is equal to 0, then agents do not acquire information from other agents, and so no cross-

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[8] Formally, $u_i(t)$ is defined as follows:

$$u_i(t) = \begin{cases} \dfrac{ca_i(t)L_i^S(t)}{K_i(t)} & if \quad x_i(t) > L_i^S(t) \\ 1 & if \quad x_i(t) \leq L_i^S(t) \end{cases}$$

[9] Another aspect of the bounded rationality approach is that agents' decision on whether to switch to the alternative sector is not based on expectations on the overall future horizon. Conversely, they only take into account the next instant in time applying adaptive expectations limited to the current period. In other

sector reallocation of capital takes place. In this case, the expression in the first line of (4) boils down to the expression in the second line, which only takes into account the normal accumulation rate. At the limit for α equal to infinity, all agents receive information about sectoral profits, and no agent makes mistakes. Hence, all capital-owners move towards the more profitable sector at a certain instant in time. In other words, adjustments towards the technology that is currently more profitable is instantaneous. When α is positive but finite the presence of some retardation factors in the rate at which the information is diffused, and the possibility of agents making mistakes in decoding such information, imply that only a fraction of capital-owners is able to move their unit of capital from the sector with a lower profit rate towards the sector with a higher profit rate. In general, the higher α, the faster the flow of capital-owners migrating to the currently more profitable sector of the economy.

In (4) we also model explicitly another relevant aspect of cross-sector capital transfers, that is, the presence of adjustment costs in the reallocation of capital, and the heterogeneity of agents in sustaining such costs. Costs are represented in equation (4) by the function $v_i(\kappa_i(t))$, the idea being that if an agent wants to move from sector j to sector i she will have to pay a fraction of her profits given by $v_i(\kappa_i(t))$ in order to switch. Therefore, inter-sectoral transfers of capital towards sector i are conditional on the profit rate in sector i, net of such costs, to exceed the profit in sector j.

We also assume that capital-owners are heterogeneous, in that they have different degrees of specialisation in the use of the two technologies. Specialisation is technology-specific, so that the higher the specialisation in a certain technology, the lower the specialisation in the alternative one. We assume that agents can be ordered on the [0,1] interval, depending on their relative degree of specialisation in technology 1 vis-à-vis technology 2. More precisely, the higher a

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words, if we were in discrete time, agents' behaviour would be based on the simple rule that the expectation on the profit rate for period $t+1$ coincides with the observation of its level at time t.

capital-owner's specialisation in technology 1, and the lower its specialisation in technology 2, the closer it will lie to the left-hand side of the interval, and vice versa. The degree of specialisation is thought of as an immutable characteristic of the agent, acquired prior to the undertaking of economic activities, which solely affects the adjustment costs, but not productivity.

We assume that the higher an agent's degree of specialisation in a technology, the lower her transfer costs to move towards that technology. The functional form that has been used in the calibration exercise is as follows:

$$\nu_i(\kappa_i(t)) = \kappa_i(t)^{\tau_i} \quad , i = 1,2 \qquad (5)$$

τi are positive parameters determining the magnitude of the transfer costs. A diagram for the values $\tau_1 = \tau_2 = 1/2$ is reported in Figure 2. The higher the parameter, the lower the cost for a generic member of the population to transfer to the alternative sector. For agents who are more specialised in technology 1 – namely, those who are closer to the left-hand side of the [0,1] interval – the transfer costs towards technology 1 are relatively low, whereas those to transfer to technology 2 are bigger. The opposite occurs for agents more specialised in technology 2, who lie towards the right-hand side of the [0,1] interval. The agent who is ranked at the leftmost (rightmost) point on the interval sustains zero costs to transfer to technology 1 (2), and an entire yearly profit to transfer to technology 2 (1).

It is worth stressing that such a notion of specialisation is different from the agent's condition as skilled or unskilled. The latter is a condition that may change through time in relation to the sector in which the agent is active at a certain instant in time. The former is a given characteristic of an agent, which is represented by the ordering of the agents on the [0,1] interval. For instance, it is possible that agents who are highly specialized in the skill-intensive technology are nonetheless unskilled. Such would be agents who may move to the skilled-intensive technology at a relatively low cost, but who are currently employing the unskilled-intensive technology.

The results of the model prove to be robust to different possible specifications of the adjustment cost functions. Given the characterisation of the technology in sector 1 as skilled-labour intensive, in the remainder of the paper we shall often refer to the migration from the unskilled-intensive technology to the skilled-intensive one as an upgrade, and to a downgrade for the movement in the opposite direction.

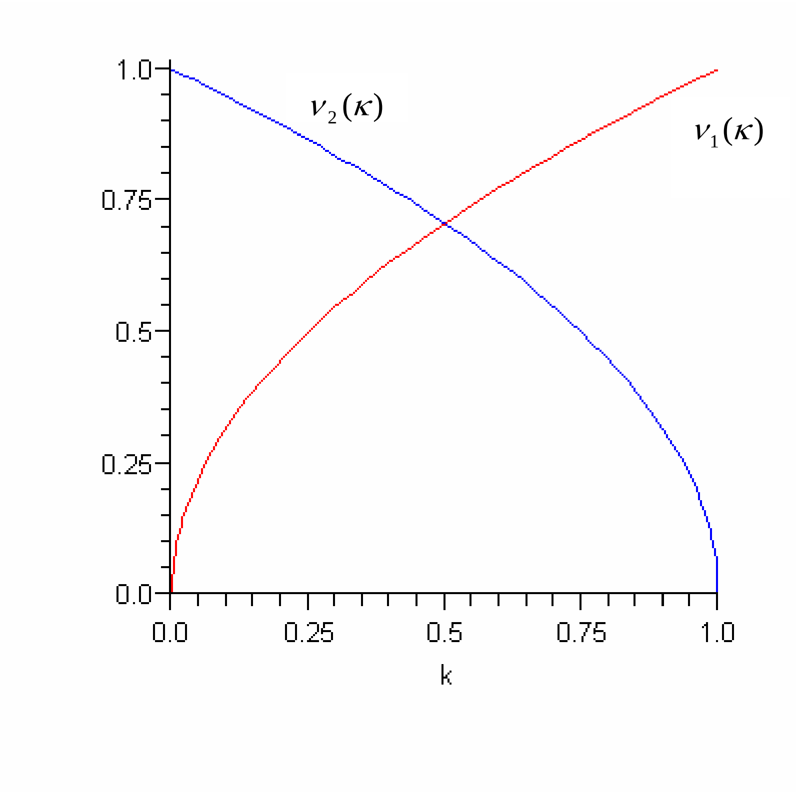

Figure 2

2.1.E Dynamic of labour supply

Equation (5) describes the rule of motion for labour supply in sector *i.*

$$\dot{L}_i^S(t) = \begin{cases} \beta L_i^S(t)\left(1-L_i^S(t)\right)\left[\left(\dfrac{L_i(t)}{L_i^S(t)}\right)w_i(t)\left(1-\mu_i\left(L_i^S(t)\right)\right)-\left(\dfrac{L_j(t)}{1-L_i^S(t)}\right)w_j(t)\right] & \\ \qquad\qquad if \quad \left(\dfrac{L_i(t)}{L_i^S(t)}\right)w_i(t)\left(1-\mu_i\left(L_i^S(t)\right)\right)>\left(\dfrac{L_j(t)}{1-L_i^S(t)}\right)w_j(t) & \\ 0 \qquad\qquad otherwise & \end{cases} \qquad (6)$$

The behaviour of workers is similar to that described in the previous section for capital-owners, in that workers' movements across sectors are triggered by the comparison of the expected wages earned in the two alternative sectors. This happens within the same model of bounded rationality. However, the main difference with the rule of motion of sectoral capital is that there is in this case no 'normal' accumulation rate of workers, as the population of workers is supposed to be fixed. Hence, equation (5) describes the evolution in sectoral labour supply as an effect of the cross-sector movements of workers in search of higher wage rates. β, alike α, measures the information diffusion rate among workers and the speed of cross-sectoral mobility. $\mu_i\left(L_i^S(t)\right)$ represents the adjustment costs that workers have to pay to move from sector *j* towards sector *i*. Even in this case, workers acquire different specialisations in the two technologies which determine such adjustment costs. We take a functional form identical to that used for capital-owners adjustment costs, namely $\mu_i\left(L_i^S(t)\right)=\left(L_i^S(t)\right)^{\lambda_i}$, where λ_i are positive parameters. Even in this case, the higher λ_i, the lower the cost to transfer from sector *j* to sector *i* for a generic worker in the population. We also assume that workers take into account the possibility of remaining unemployed when moving to a different sector, so that wages are weighed by the probability of finding a job in either sector, which is given by the ratio between actual employment $L_i(t)$ and labour supply in sector *i*. In the remainder of the paper, we shall call *s* the labour supply in the skilled-intensive sector – namely, $L_1^S(t)=s(t), L_2^S(t)=1-s(t)$. From now on, for the sake of brevity we will omit the variable t in variables' notation.

2.2 The Steady States of the Model

Given the presence of increasing returns to scale at the sectoral level, the model is characterised by multiple steady states which differ in relation to the sectoral specialisation to which the economy converges. By sectoral specialisation we mean the process that leads asymptotically to the complete allocation of capital and labour to one of the two sectors. A third steady state is given by a balanced growth path in which both sectors of the economy coexist.

The steady states implying sectoral convergence are symmetric and are reported below:

$$\left\{\kappa_1 = 1 \quad y_1 = 1 - cg_1 \quad x_1 = 1 - \frac{(\eta_1 - 1)}{\gamma} g_1 \quad y_2 = \text{undetermined} \quad x_2 = 0 \quad s = 1\right\} \tag{7}$$

$$\left\{\kappa_1 = 0 \quad y_2 = 1 - cg_2 \quad x_2 = 1 - \frac{(\eta_2 - 1)}{\gamma} g_2 \quad y_1 = \text{undetermined} \quad x_1 = 0 \quad s = 0\right\} \tag{8}$$

(7) is characterised by sectoral specialisation into the skilled-intensive sector of the economy, whereas (8) implies convergence to the unskilled-intensive sector. Given that these steady states are characterised by the complete allocation of capital in one sector of the economy, the associated economy's growth rate is entirely determined by the sectoral growth rate, which is given by (2). Hence, the economy's growth rate is equal to either g_1 (in case of convergence to steady state (7)) or g_2 (convergence to steady state (8)). The calibration exercise assigns a higher value to g_1 than g_2 (section 6.2), so that we shall refer to the steady state characterised by convergence to the skilled-intensive sector (unskilled-intensive sector) as the high-growth (low-growth) steady state of the economy.

Both steady states hold under the condition that η_1 and η_2 be greater than 1[10], thus entailing a structural level of unemployment for the workforce equal to $(\eta_i - 1)/\gamma$, $\mathrm{i} = 1{,}2$. One can thus note that a greater speed of adjustment in the labour market, as measured by the coefficient γ (see section 2.1.C), reduces the level of unemployment, which at the limit for γ converging to infinity is equal to zero. Instead α and β do not play a role within this specification. Although the value for y_i, i=1,2, turns out to be undetermined in (7) and (8), the subsequent simulations clearly shows that such a variable converges to the boundary value of 1, i.e. to the situation of zero profits in the sector that remains residual in the economy. The local stability of the first two types of steady state cannot be assessed on purely analytical terms[11]. Still, the extensive simulation analysis that has been conducted shows that these are stable attractors of the system for a feasible constellation of parameters.

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[10] Steady states for the case η_1<1 can also be found, though it is now capital rather than labour to be rationed.

[11] This is due to the presence of some purely imaginary eigenvalues making the system locally non-

The balanced growth path solution depicts a situation in which the two sectors coexist and grow at the same rate:

$$\left\{\begin{array}{lll} \kappa_1 = \dfrac{g_2}{g_1+g_2} & y_1 = \dfrac{g_2 + g_1(1-cg_2)}{g_1+g_2} & x_1 = s - \dfrac{(\eta_1 - 1)}{\gamma} g_1 g_2 \\ y_2 = \dfrac{g_2 + g_1(1-cg_2)}{g_1+g_2} & x_2 = 1 - s - \dfrac{(\eta_2 - 1)}{\gamma} g_1 g_2 & \end{array}\right\} \quad (9)$$

The main characteristic of this growth path is that productivity is the same in the two sectors, and there is rationing of either capital or labour depending on whether the coefficient ηi is less or greater than 1. Since both sectors evolve according to the same growth rate, the economy can be said to follow a balanced growth path. In contrast to the previous steady states, this solution can be ruled out unambiguously as unstable from the analysis of its eigenvalues. The economic reason lies in the property of cumulativeness of sector-specific technology. If this state is perturbed, then sectoral productivities will differ, thus attracting some firms to move to the currently more profitable technology. As a consequence, the sector that ‘by accident’ happens to be more profitable will experience positive sectoral economies of scale that will suffice to break the balance between the two profit rates, triggering a snowball effect of convergence towards one of the steady states illustrated above.

2.3 Modelling the Impact of an SBTC Shock on a Low-growth Steady State

The theoretical exercise that we develop consists in studying the evolution of the system after a low-growth steady state – arguably a realistic representation for a DC lagging behind in the technological ladder - is perturbed as an effect of an SBTC. In other words, we suppose that the economy shifts from the low-growth steady state to a position corresponding to the introduction of an SBTC into the economy. The extent of this shift is derived from real data, so as to reflect

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hyperbolic.

the actual weight of technologically advanced sectors in middle-income countries during the 80s and 90s. The evolution of the system from the new starting position is then analysed.

In order to derive the data used to calibrate the model, we limit to the manufacturing sector, and draw upon the classification offered by the OECD Structural Analysis database that divides the whole manufacturing sector into a group of high-tech and one of low-tech industries (see notes to the Tables 3 and 4 in section 5.2). We then apply such a decomposition of sectors to data derived from the UNIDO database, and we compute the average during the 80s and 90s for a group of middle-high income and one of middle-low income countries for the relevant variables of the model. These countries belong to the area of the European Union Developing Neighbouring Countries (EUNDCs). The data so derived are then applied to the parameters and initial conditions in our model, and used in the simulations. In particular, the means for productivity levels, productivity growth, and wages, for the high-tech (low-tech) sector derived from the data are applied to the relative parameters of the skilled-intensive (unskilled-intensive) sector of our model. Section 6.1 illustrates the theoretical considerations we have followed to calibrate the other parameters.

There exist many different ways of modelling the SBTC shock and the initial conditions of the system. In the method we follow, we try to be consistent with the theoretical background provided by our model, and with the objective of giving a realistic representation of the structure of an economy. In particular, we take the initial value for y2 to correspond to its steady state value given in (8). We then use this value as the 'anchor' from which to compute the initial conditions for y1. This is determined so that its distance from y2 coincides with the actual productivity and wage gaps between hi-tech and low-tech sectors derived from the data (section 6.2: Tables 3 and 4, column 1 and 2).

The initial value for s, rather than being set equal to 0 as in steady state (8), is assigned the value given by the proportion of employment in the hi-tech as opposed to the low-tech sector within the manufacturing sector (Tables 3 and 4: column 3). Moreover, the initial values for labour demand $x_1(0)$ and $x_2(0)$ are 'anchored' on the value chosen for s(0), so as to imply an unemployment rate in the post-shock position of the same magnitude as that derived from the data (Tables 3 and 4: column 6). That is, $x_1(0)=s(0)(1-\hat{U}), x_2(0)=(1-s(0))(1-\hat{U})$, where $\hat{U}$ is the average value for unemployment resulting from the data. Since κ_i directly depends on x_1 and x_2 (see 2.1.B and 2.1.C), the initial value of s determines the weight of the skilled-intensive sector at the beginning of the simulation for both labour supply and capital, and is thereby a measure of the SBTC shock magnitude. Finally, we set $a_2=1$, which is tantamount to fixing a numeraire value for the system.

In spite of the existence of some degrees of arbitrariness in both the way parameters are assigned and in the method used to model the SBTC shock, the robustness analysis demonstrates that the results of the simulations are robust to changes in parameter values as well as in initial conditions (not reported in this paper; available on request).

Relying on this calibration, the evolution of WCII is studied by computing the Gini index for some relevant categories of income. A first measure only considers the distribution of income among workers. Since in our model there are two such categories, that is, skilled and unskilled labour, and a third of unemployed workers, the Gini index is computed on the categories given in Table 1:

Income recipient	**Size**	**Income**
Unemployed	$1-(L_1+L_2)$	*0*
Skilled workers	L_1	w_1
Unskilled workers	L_2	w_2

Table 1: Components of Restricted Gini Index

Unemployed workers' income is set to 0, as there are no unemployment benefits in the model. Skilled (unskilled) workers earn the wage rate w_1 (w_2). We call the resulting inequality measure the restricted Gini index (RGI). An important caveat is that our index only takes into account between-group inequality, whereas it neglects within-group inequality, as all of the agents belonging to each group are assumed to earn the same income. This leads to a substantial underestimation of inequality in absolute terms in our model, although it does not affect the main conclusions of our analysis.

A second index of inequality can be computed by considering capital income as well as labour income. We shall refer to this as the comprehensive Gini index (CGI). The categories of income that are considered are now as follows:

Income recipient	Size	Income
Unemployed	$1+n-[L_1+L_2+n(u_1\kappa_1+u_2\kappa_2)]$	*0*
Skilled workers	L_1	w_1
Unskilled workers	L_2	w_2
Capital-owners active in skilled-intensive sector	$nu_1\kappa_1$	r_1K
Capital-owners active in unskilled-intensive sector	$nu_2\kappa_2$	r_2K

Table 2: Components of Comprehensive Gini Index

n is the ratio between the capital-owners and the workers populations, so that the total population has a size of *1+n*[12]. The first category is now given by the sum of workers and capital-owners who are unemployed; the second and the third categories are occupied skilled and unskilled workers as in RGI. The fourth and fifth categories are capital-owners active in the high-tech and low-tech sectors respectively, whose income is given by the relative profit rates[13]. Since there is an additional factor of dispersion in CGI with respect to RGI, income inequality measured by the former will be higher than the latter.

3 Results of the Calibration Exercise

In this section we present possible scenarios of successful convergence from a low-growth to a high-growth steady state, as well as of stagnation in the low-growth poverty trap. The calibration data are obtained from a sample of EUNDCs.

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[12] Note that a characteristic of the model is that movements between the two populations of workers and capital-owners are not allowed.

[13] Hence, we are considering a measure of inequality based on income, rather than expenditures.

3.1 A Kuznets Dynamic as a result of Successful Convergence to a High-Growth Steady State

The initial values and parameter for the first simulation is taken from the average values for a sample of NMS (See Table 3). Only the key parameters are reported below:

$$\{g_1 = 0.0343; g_2 = 0.0083; a_1(0)/a_2(0) = 1.0182; \mathrm{s}(0) = 0.3458; \mathrm{k}(0) = 0.2308\}$$

g_1 and g_2 are the parameters determining the productivity growth rates in the skilled-intensive and unskilled-intensive sectors, respectively. In the model, their relative value yields the relative ‘potential’ for expansion of the skilled-intensive vis-à-vis the unskilled intensive sector. The values that have been assigned to g_1 and g_2 equal the average productivity growth rates over the last years in the high-tech and the low-tech manufacturing sectors, respectively. The fact that the value of g_1 is about four times higher than g_2 indicates that the skilled-intensive sector has a considerable higher potential for growth.

$a_1(0)/a_2(0)$ represents the ratio in current productivity between the skilled-intensive and the unskilled-intensive sectors *before* the technological shock takes place. The calibration assigns them the actual average value in productivity in high-tech versus low-tech manufacturing sectors in NMS. A ratio greater than 1 means that the skilled-intensive sector has a higher productivity than the unskilled-intensive sector. $s(0)$ and $k(0)$ represent the share of skilled workforce in the population and the share of entrepreneurs active in the skilled-intensive sectors. The former value is taken from the actual average proportion of skilled workers in our sample of NMS. $k(0)$ is instead determined according to other theoretical and empirical considerations. The lower the value of either $s(0)$ or $k(0)$, the higher the shortage of skilled workforce or entrepreneurs, the more difficult for the economy to converge to the high-growth steady state after the technological shock.

shows the evolution over time of the share of entrepreneurs (red line) and workers (green line) active in the skill-intensive sector. It shows the gradual convergence of both entrepreneurs and workers to the skilled-intensive sector. Hence, the structural conditions of the economy are favourable for the economic system to break out from the low-growth steady state into the high-growth one. The second graph plots the evolution of the Gini index over the transition. The Gini index is computed with respect to the five categories of income recipients in the model - namely, skilled and unskilled workers, skilled and unskilled entrepreneurs, and unemployed agents. **Figure 3** shows that a typical Kuznets trajectory accompanies the transition to the high-growth steady state. Income inequality first increases due to an increase in the skilled wage premium – i.e. the wage of skilled workers relative to unskilled ones - and the enlargement of the share of population active in the richest cohorts. This is necessary in order to induce unskilled workers to pay the adjustment costs and migrate into the skilled sector of the economy. As the share of agents active in the skilled sector becomes large enough, the Gini index starts its reversal, until it stabilises on its steady state level (around 18% in the model[14]).

The generality of the model precludes its use in a "predictive" sense. Also the fact that the calibration has been made for the 'average' value of parameters over NMS countries hides important differences at the country level. All the same, the results of this simulation can be used to argue that economies that are in the NMS area have the potential to benefit from imports of skill-biased technologies from countries that are at the technological frontier. The evolution of income inequality shows that higher inequality during the transition may be the 'price to pay' for higher growth in the future. Economic policies fostering the skill upgrade and curbing the geographical relocation costs for both workforce and entrepreneurs may ease this process.

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[14] Note that in the present model the Gini index only takes into account inequality of incomes *between* classes of income recipients, rather than inequality *within* each class. Therefore, the resulting measure underestimates the potential inequality in the economy.

Figure 3: Evolution of share of capital invested and workers employed in the skill-intensive sector

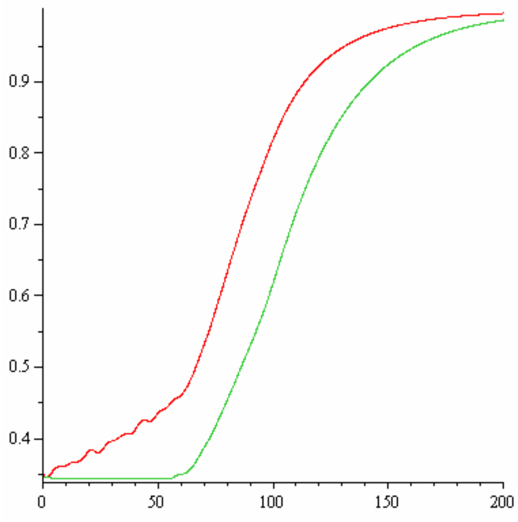
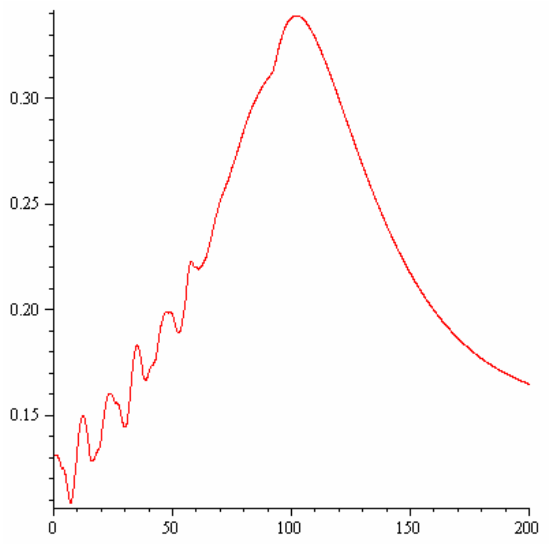


Figure 4: Evolution of Gini index



3.2 Gradualism Vs Big Bang Strategies in technological Upgrading

Rather than showing the results of the simulations for the average of non-NMS states, we focus on two countries in particular, Turkey and Egypt. This will enable us to highlight how differences in the structural conditions can lead to opposing outcomes in the longer run. The main structural parameters and initial values for Turkey are as follows:

$$\{g_1 = 0.0325; g_2 = 0.0213; a_1(0)/a_2(0) = 1.209; \mathrm{s}(0) = 0.2440; \mathrm{k}(0) = 0.2806\}$$

g_1 has very similar magnitude to the NMS average, whereas g_2 is even higher. Hence, the economy sets off with a overall higher potential for sectoral growth. Moreover, the initial relative ratio in productivity favours the skilled-intensive technology even more than for NMS states. The ratio of capital invested in the skilled-intensive sector is higher than in the previous simulation. The main relevant difference is that the skilled workforce is now initially considerably lower than for NMS state, with a difference that nears 10 percentage points.

The parameters and initial conditions for Egypt denote a situation of *lower* initial potential for growth.

$$\{g_1 = 0.0183; g_2 = 0.0036; a_1(0)/a_2(0) = 1.237; \mathrm{s}(0) = 0.2050; \mathrm{k}(0) = 0.2418\}$$

Both g_1 and in particular g_2 are considerably lower in Egypt than in Turkey. g_1 has in Egypt a third of the value it has in Turkey, and g_2 only a sixth. The values for the initial relative ratio in productivity are instead roughly similar in the two countries, that in Turkey being a mere 2% higher than in Egypt. Finally, Egypt suffers from an even more pronounced situation of skill shortage for both workers and entrepreneurs.

The results of the simulations are presented in the diagrams below. In spite of the apparent better potential for growth, the simulation conducted for parameter values drawn for Turkey show a failure to converge to the high-growth steady state. On the contrary, the simulation conducted for parameter values taken from Egypt predicts convergence to the high growth steady state. This apparently paradoxical result can be explained by two sets of considerations. First, the convergence to the high-growth steady state is determined in the model by the *relative* strength of the skilled-intensive sector vis-à-vis the unskilled intensive one. The fact that g_2 is closer to g_1 in Turkey than Egypt means that higher profits will have to be offered to entrepreneurs in the unskilled intensive sector to migrate to the skilled intensive one. Overall, this makes convergence more difficult. The second reason has to do with the *speed* of structural change in the initial phases after the shock. The higher potential for growth in the "big bang" economy has the result to overheat the labour market for skilled labour. This goes at the detriment of profits and thus investments, so that this sector fails to generate self-sustaining growth. In the case of Egypt the transition is smoother, and the economy converges in spite of the fact it was lagging behind Turkey in terms of structural conditions. Egypt experiences a Kuznets trajectory analogous to what observed in the previous scenario. However, the peak in the Kuznets curve is lower than in the first scenario.

On the basis of these simulations, a more 'gradualist' approach seems advisable rather than a 'big bang' one. It seems that growing more cautiously in the initial stages after the shock will cause the economy not to experience bottlenecks and shortages that may prove to be fatal at some later stages. The same word of caution mentioned in the previous section also holds here. These results cannot be used to predict that the Turkish economy *will not* converge to the high-growth steady state, whereas the Egyptian one will. These simulations only have a heuristic values in showing that, under realistic sets of parameters and initial conditions, economies that *a priori* show a higher potential for growth may in fact fail to break out from a poverty trap, unless economies that experience lower growth rates in the shorter run.

Figure 5: Evolution of share of capital invested and workers employed in the skill-intensive sector ("Big bang" strategy)

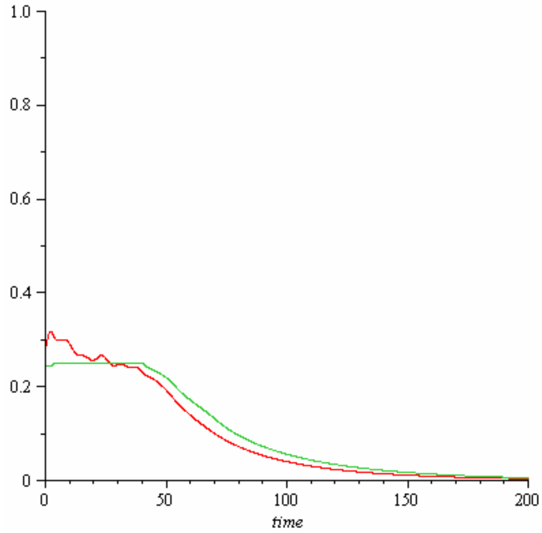


Figure 6: Evolution of share of capital invested and workers employed in the skill-intensive sector ("Gradualist" strategy)

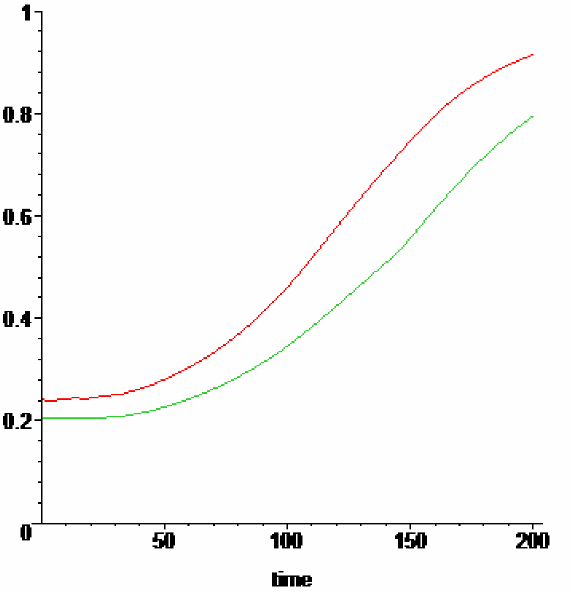


Figure 7 : Evolution of Gini index ("Big bang" strategy)

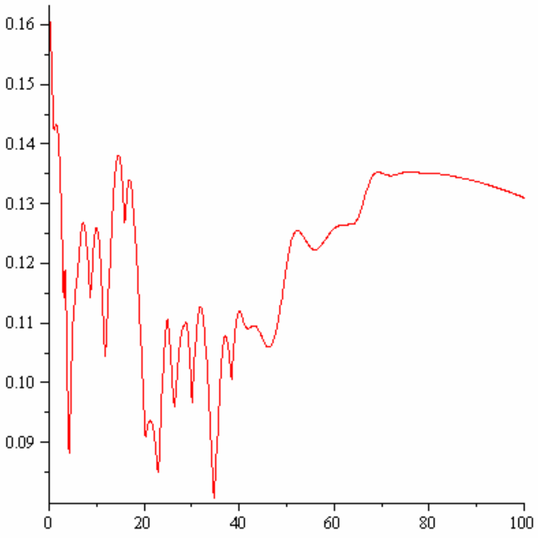
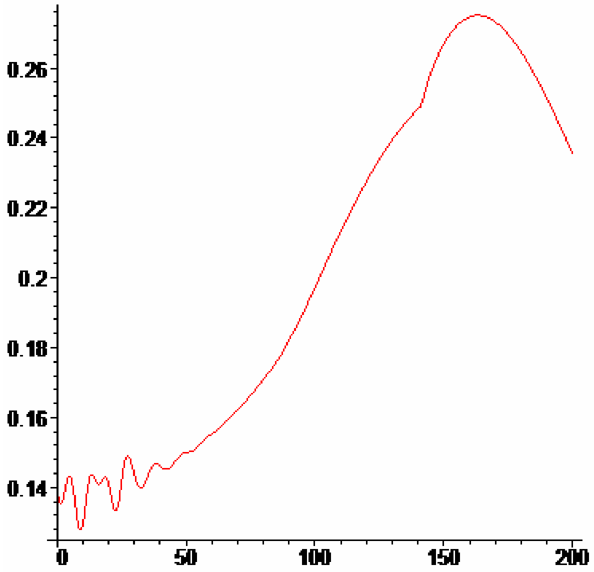


Figure 8: Evolution of Gini index ("Gradualist" strategy)



4 Conclusions

Our analysis shows that the relationship between growth and inequality is complex, and is mediated by the capacity of the economic system to absorb more advanced technologies than those currently in use. The simulations conducted to analyse the impact of an SBTC on income distribution within a DC show that a "Kuznets" dynamics in income distribution is likely to emerge for economies that manage to break out from a poverty trap and converge to a high-growth steady state. This is characterised by a phase of initial increase in income inequality, followed by a phase of reduction in inequality. Hence, inequality may be the 'price to pay' for higher growth in the future. In particular, wage inequality across skilled and unskilled workers acts as an incentive for unskilled workers to upgrade their skills and migrate to the skill-intensive sector. Simulations also show that convergence to the high-growth steady state is not a foregone conclusion. In countries affected by significant skill shortages in both workforce and entrepreneurial abilities, the country may remain stagnating in the low-growth poverty trap even following an SBTC shock. The simulations show that a phase of accelerated growth in the early stages after the innovation may have the consequence of overheating the labour market, reduce the investment in the skill-intensive sector, and preventing the economy from converging to the high-growth steady state in the long run. A more gradualist approach may instead prove to be successful in triggering higher growth in the long run.

The model has focussed on only one factor of structural change - namely, technological change - so some caution is needed when applying these results to the interpretation of reality, where many factors of change will probably coexist. However, we believe that the emphasis of the model on the structural conditions of the economy and on the possibility of the persistency of poverty traps, are general problems associated with the process of catching-up faced by DCs.

5 Appendix

5.1 Theoretical Underpinnings of the Calibration Exercise

In order to assign parameter values for the calibration exercise in (10) and (12), we followed the theoretical considerations reported below. The sectoral productivity growth rates parameters g1 and g2 are assigned the values found for average productivity growth rates in the high-tech and low-tech sector, respectively (see Tables 3, 4: columns 4 and 5). In this way, the steady state productivity growth rate for the economy's leading sector coincides with the value found in the data. Since the convergence to one of the two sectors of the economy is determined by the relative size of productivity growth rates, a different calibration of g1 and g2 would not significantly alter the results of our analysis.

c, i.e. the inverse of capital productivity, is assigned the value consistent with capital income share being equal to a third in the high growth steady state. This is the value generally used in growth accounting exercises to estimate capital income share in developed countries (e.g. Mankiw et al., 1992: 410). This implies a capital income share of roughly 17% for the low-growth steady state, which accords with the idea that DCs have a lower capital income share than developed ones.

γ takes a value of 2.5, which implies that the business cycle has a length of 10 years in the basic single-sector version of the model (section 2). The values of ηi are determined in such a way that the level of average unemployment in either sector is equivalent to that average value emerging from the dataset (Tables 3, 4: column 6). In analogy with Soete and Turner (1984), α and β are both assigned a value of 1. Observations of the relative size of employers vis-à-vis employees for developing countries (e.g. KILM 2001 database, International Labour Office, Geneva) show a value for n as being below 5%, so we set n=4%.

As for the adjustment costs parameters, we have studied the impact of variations in the size of λ in section 3 and Tables 6 through 9. Variations in τ would lead to similar results, so this parameter has been left unchanged throughout the analysis. In the calibration of the parameters, we have assumed that the upgrade costs were ceteris paribus greater than downgrade costs, so that we have chosen values such that $\tau1 \geq \tau2$.and $\lambda1 \geq \lambda2$. We have also assumed that upgrading costs for workers were higher than those for capital-owners. This is consistent with the idea that capital is owned by agents with a higher level of expertise in adapting to new technical paradigms than the workforce. This seems reasonable because firms can typically rely on knowledge acquired from a much longer time-horizon than workers.

5.2 Data Used in Calibration

Table 3: Middle-high income countries in the EUNDCs area: Average compound rate for relevant variables over the period 1980-2000 (or the closest available period)

Country	Productivity ratio HT/LT (1)	Wage ratio HT/LT (2)	Skilled employment (3)	Productivity growth HT (4)	Productivity growth LT (5)	Unemployment (%) (6)
Croatia	1.280	1.163	0.272	NA	NA	9.744
Czech Rep.	NA	NA	0.438	NA	NA	4.790
Hungary	1.311	1.157	0.349	0.471	0.767	8.427
Latvia	0.731	1.069	0.377	5.326	1.070	11.433
Lithuania	NA	1.020	0.246	NA	NA	11.08
Poland	0.962	1.171	0.345	4.371	-0.757	12.436
Slovak Rep.	0.781	0.990	0.399	3.541	2.266	12.840
Slovenia	1.044	1.056	0.340	NA	NA	NA
Average	1.018167	1.089429	0.34575	3.42725	0.8365	10.10714

Table 4: Middle-low-income countries: Average compound rate for relevant variables over the period 1980-2000 (or the closest period when not available)

Country	Productivity ratio HT/LT (1)	Wage ratio HT/LT (2)	Skilled employment (3)	Productivity growth HT (4)	Productivity growth LT (5)	Unemployment (6)
Egypt	1.237	1.322	0.205	1.836	0.356	8.057
Morocco	1.784	1.832	0.144	0.584	1.193	17.4083
Russian Fed.	0.756	0.950	0.385	NA	NA	8.84
Tunisia	1.307	1.268	0.136	NA	NA	NA..
Turkey	1.209	1.402	0.224	3.248	2.132	8.488
Ukraine	NA	0.727	0.342	NA	NA	6.585
Yugoslavia	1.190	1.192	0.278	NA	NA	NA..

Sources: The classification of a country as middle-high or middle-low has been drawn from the UNU/WIDER-UNDP World Income Inequality Database (WIID), Version 1.0, 2000.
All of the other data are drawn from the UNIDO, Industrial Statistics Databases, accessed through ESDS International, University of Manchester
The reference period is 1980-2000, or the closest possible to this.
In the tables, HT denotes High-Tech and LT Low-Tech. This classification follows that suggested by OECD, STAN Database (2001), Annex 3 of the accompanying documentation (available at: http://www.oecd.org/dataoecd/60/28/21576665.pdf). The main idea is that high-tech sectors are those having higher than average R&D expenditure as a measure of either value added or output. For instance, sectors classified as high-tech, in the 3-digit ISIC2 Revision, are the following: 351 (Industrial Chemicals); 352 (Other Chemicals); 382 (Machinery, except electric); 383 (Machinery electric); 384 (Transport Equipment); 385 (Professional & Scientific Equipment). More precisely, the STAN Database proposes a distinction between high-tech, medium high-tech, medium low-tech and low tech. In our analysis, we have grouped together the first two categories, i.e. the high-tech and the medium-hi tech, as this seemed more appropriate for countries at intermediate stages of development.

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