The Evolution of Modern Educational Systems

Technical vs. General Education, Distributional Conflict, and Growth[*]

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ABSTRACT

We study the evolution of an educational system founded on a hierarchical differentiation between vocational and general education, with vocational playing an inferior role in the society. The dynamics are best summarized by the ratio of the fraction of the population in vocational to that in general education, which we interpret as a measure of the degree of stratification of the society. We show that this ratio first rises and then declines with the level of development, displaying an inverted U-shape which reflects the complex interaction between economic and political forces, including aggregate income growth, wealth inequality and political participation.

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Key Words: Vocational education, General education, Income distribution, Politics, Growth.

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1   Introduction

The new literature on growth has established the crucial role of human capital and educational attainment in the process of development. However, the role of the specific structure of the educational system is still largely unexplored. In particular, while the distinction between privately and publicly provided education and that between local and state educational systems have attracted considerable attention, the available models - and empirical measures - of educational attainment fail to distinguish between different kinds of curricula.

The aim of this paper is to focus on the distinction between vocational and general education at the secondary school level, and to study the relationship between the mix of these two alternative kinds of schooling and the evolution of societies, both from an economic and a socio-political perspective. Without denying the relevance of technological progress for the issue at hand, we develop a deeper explanation for the link between education mix and economic development that stresses the role of distributional conflict and political change in the shaping of the educational system.

The main idea stems from the observation that, historically, unequal societies have tended to produce a hierarchical differentiation of educational institutions which was founded precisely on the distinction between technical and general training. Acting as a countervailing force, in the face of the expansion of educational opportunities that technological progress inevitably calls for, curricula differentiation has served the purpose of perpetuating the pre-existing social order through a process of exclusion of the emerging middle classes from the more prestigious, academically-oriented institutions. Accordingly, in an early stage of economic development, vocational curricula have tended to expand, while the subsequent rise of the economic and political power of the middle class have provoked an enlargement of general education at a later stage.

In our model, society is initially divided between an affluent "elite" and a lower class. Every individual is assumed to have the elementary skills which are taught in primary school. We therefore aim at describing the phase, in the process of development, during which an economy is already past initial industrialization and about to jump into its high industrial era. Accordingly, our focus is on the evolution of secondary education, under the assumption that the goal of universal basic literacy has already been met. Secondary education, in its general form, is initially only available to the elite, and is associated with political power as well as a prestigious social

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status. Preferences include a term which reflects children's social status. The initial, static equilibrium is disrupted by the introduction of a new, modern technology, which requires a combination of general and specific skills. This justifies the introduction of vocational schools.

Conflict in this society is mediated by the electoral process. The main issue for educational policies is the size of the general sector. Decisions are made through majority voting, which is however restricted by a minimum wealth requirement that is initially met only by the elite. Given the preference specification, the voting process is such that the median voter will want his children to enter general high school, while excluding the children of everyone poorer than himself. We show that in a first stage of development the size of the vocational sector relative to the general sector increases. At a later stage, once the pool of individuals with basic education is exhausted, the vocational sector reaches a ceiling. As lower class wealth levels cross the voting threshold the political equilibrium generates a general sector that expands relative to the vocational one. The resulting evolution of the educational system is best summarized by the ratio of vocational to general education (V/G), which we interpret as a measure of the stratification of the educational system and society. We show that this ratio initially increases with income and then decreases, reflecting the complex interaction between economic and political forces in the society.

Note that technological progress alone will not produce the inverse U-shape relationship. Without voting over the expansion of general education, together with limits on political participation and an incentive for the elite to restrict access, V/G would immediately converge to its efficient level. With all these elements, as the political process opens up, the mix does get closer to the efficient one but only gradually, and without ever reaching it, not even asymptotically.

While our model is designed to capture the specific dynamics of the education mix, it also offers consistent and useful predictions for the evolution of aggregate income, wealth distribution, relative wages and political participation. Aggregate income grows throughout the process, but at varying rates that depend not only on exogenous technological progress, but also on the endogenous evolution of the educational system. Under realistic parameter values, there is a wage premium for general education, which is more pronounced in the initial phase of the process. In the first phase the faster rise in the relative wage of general labor increases inequality while eventually inequality declines, although it never disappears. Political participation gradually expands, but there is a tendency for the lower class not to be able

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to affect the political equilibrium immediately.

Our work is related to a growing literature on the political economy of education, which has its sources in the early contributions on the relationship between human capital and growth.[1] Stiglitz (1974), Glomm and Ravikumar (1992), Fernandez and Rogerson (1995), Saint-Paul and Verdier (1993), Boldrin (1993), Gradstein and Justman (1997) and Kaganovich and Zilcha (1999) focus on public vs. private provision. Benabou (1996) and Fernandez and Rogerson (1997) distinguish between local and state funding for education. Kim and Kim (2000) and Zeira (1997) consider, as we do, different types of curricula, but stress their technological functions rather than their social role, as reflected by our specification of preferences. Other papers that consider the role of a self-interested elite group in shaping educational development include Grossman and Kim (1999), Bourguignon and Verdier (2000) and Galor and Moav (2000). The first paper argues that an elite might want to open education to poorer agents in order to reduce predation by the poor against the elite. The second two papers emphasize that short-term economic benefits for an elite in educational expansion might be offset in the long-run by the political empowerment of the poor that comes with education. Our model shares some of this aspect since vocational education increases elite wages while leading its recipients across the voting threshold. However, our elite could not choose to stop the process even if it wished to. None of these models consider the mix of vocational and general education that is central to our work. Finally, another important source of inspiration for the present paper is the stream of recent work on the connection between the sociological analysis of factors such as social status and norms and their economic implications (Cole, Mailath and Postlewaite (1992), Fershtman, Murphy and Weiss (1996) and Corneo and Jeanne (1999)).

In contrast to the economics literature, the sociology literature has a long tradition of studying curriculum differentiation in secondary education. There are two main theories aimed at explaining the evolution of modern educational systems. The "functionalist" perspective emphasizes the role of technology in driving curriculum differentiation: in this view, the initial rise of vocational education would reflect nothing more than rising labor market demand for related skills and viceversa in a subsequent phase. However, a large empirical literature, surveyed in Collins (1971), fails to establish a correspondence between the dynamics in the demand for specific skills (as reflected by a number of skill measures) and the supply of such skills

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[1]See Lucas (1988) and Azariadis and Drazen (1990).

(as reflected in the educational attainment of the population). This casts serious doubt on any explanation for the evolution of educational systems that relies primarily on the technological requirements of jobs. In contrast, the "conflict" perspective sees curriculum differentiation more in terms of an elite group preserving its position by channeling a substantial portion of educational expansion into second-tier varieties that will not allow their recipients entry into elite circles. In this view curricula differentiation reflects an attempt by the elite to protect its exclusiveness (Weber (1921), Neelsen (1975)). Our approach integrates aspects of both the functionalist and the conflict approach while being closer in spirit to the latter than the former.

The rest of the paper is organized as follows. In section 2 we present empirical and historical evidence in support of our modelling assumptions. In section 3 we present the model. In section 4 we derive our results. Section 5 draws some conclusions and derives policy implications of our results.

2   Empirical and historical evidence

For the sake of clarity we should be precise here about definitions. By "vocational" education, we mean a course of secondary schooling directly related to a specific occupation, where a large part of the curriculum is devoted to learning practical skills to be used immediately upon graduation. Standard usage refers to vocational education also as "technical", "practical", "applied", sometimes "modern" education. "General" education, on the other hand, is defined by a curriculum that has no immediate connection with any occupational application, but prepares the student in basic knowledge that can be used to learn many different occupations. "Academic", "classical", or "liberal" studies therefore also fit the definition of general education which includes such elite institutions as the German Gymnasium, the French Lycee and the English Public Schools. At the primary level, all education tends to be general in nature, while for higher education "specialized" curricula necessarily prevail. Indeed, general education has traditionally been a prerequisite to gain access to higher education. Therefore, we focus our investigation on the secondary level of education, for which the distinction we stress is a meaningful one. Note that we do not deny that recipients of vocational education benefit from their training. We merely point out that historically general secondary education has been a much better avenue into elite circles than has vocational education.

Our analysis is motivated by the stylized fact that for a wide variety

of countries the ratio of the fraction of the population in vocational secondary education to that in general secondary education (V/G) is low at an early stage of development, high at a medium stage and low again at a high stage. Available evidence suggests that this relationship tends to hold in both time series and cross section. Bertocchi and Spagat (1997) show that for Italy V/G goes from 1.05 in 1861 to a peak of 3.06 in 1921 and back down to 0.71 in 1990 (see Figure 1). Flora (1983) studies several European countries, and finds that whenever complete time series are available for a prolonged time span, once again there is evidence of an initial rise and a subsequent decline of V/G (as in Austria, 1881-1975, and Switzerland, 1888-1936); consistently, when data are instead available only for an earlier period, V/G grows steadily, as in Sweden, 1886-1910; while it declines monotonically over the post-war period in France and England. Finally, according to Mueller (1977), the V/G ratio in Prussia starts in 1854 at 0.39, with a steady increase to 2.4 in 1936. Bennett (1967) analyzed a cross-section data set with 70 countries and found an inverse-U relationship with the rich and poor countries tending to have low secondary school V/G ratios and middle income countries having high ratios. We assembled a much more comprehensive data set using UNESCO (various years) covering a panel of 149 countries for 1950-1991 and also found evidence for an inverted U-shape relationship between secondary V/G and per capita GDP (in constant 1980 US$). Our estimated relationship is

$$\frac{V}{G} = \left(7.67 \times 10^{-5}\right) GDP - \left(5.21 \times 10^{-9}\right) GDP^2 \qquad (2.1)$$

with t values of 10.1 and -9.4 for the first and the second coefficient, respectively.[2] This equation suggests that V/G is maximized at a per capita GDP level of $7,310. Figure 2 shows the average value of V/G for all the countries in each of 19 income classes (where each class is $1,000 wide, i.e., class 1 includes observations ranging from $0 to $1,000, while class 19 includes observations ranging from $18,001 to $19,000).

Mueller, Ringer, and Simon (1977) provide a socio-historical and comparative account of that decisive period, in the history of European education, that goes from 1870 to WWI. Through a country by country investigation, these authors show that in England, France and Germany, during the late 19th century, educational institutions were transformed into a system which

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[2]Our data set includes almost all countries in the world aside from Eastern Europe, the Soviet Union and oil countries.

has been since modified, but never replaced. Before this time, the dominant form of secondary education was centered upon the classical languages and literature. The transformation that intervened was centered around the introduction of less prestigious institutions which were supposed to provide so-called modern, or technical, training. One motive that determined this transformation was to bring schools into closer interaction with the occupational system of the high industrial era. However, it is clear that specific social roles and ranks were associated with different institutions, with technical curricula being ranked very low. Therefore, while it is true that access to secondary education was widely enlarged, this did not imply a real democratization of educational opportunities, because this process was matched by a growing complexity of educational institutions. Segmentation produced parallel, non-communicating tracks, with marked differences both in their curricula and the social origin of the students enrolled. The system that emerged was meant to perpetuate the hierarchical structure of these societies and, at least as the structure of the educational system is concerned, did achieve this goal at least until WWI. The expansion of enrollments in secondary school was therefore accompanied by a process of exclusion. The data reported indeed show that during this period we observe a quantitative stability in the traditional education sector, along with an expansion in the new, and less accredited, schools. This pattern was followed by all European countries. Shavit and Blossfeld (1993) report additional supporting evidence for an investigation covering thirteen countries. For a larger set of countries, in 1967 the OECD (1967) still finds evidence of a marked institutional differentiation. Note also that the European model was exported, as a by-product of colonization, to a large portion of the less developed world. The metropolitan countries in fact generalized to their colonies the principles underlying the organization and articulation of the metropolitan educational institutions, interfering with the local process of elite formation. Moreover, the colonial educational policies are believed to have significantly affected human capital formation in these countries even after independence (Foster (1966), Clignet (1968)). Trow (1967) describes the evolution of the education system in the United States. Many similarities with Europe do emerge. Before 1870, the American secondary school system offered a mass, largely terminal secondary school system was developed, with the purpose of providing increasingly vocational education to the emerging middle class. In a later phase, after WWII, the system underwent a second transformation, moving it in the direction of a mass preparatory, rather than a terminal, system (see also Goldin (1994)). However, a very important difference with

the European dual system is the early introduction in the US of the comprehensive school. This was done under the influence of thinkers such as John Dewey (1916), with the declared goal of strengthening more general aspects of high school curricula and at the same time avoiding premature career choices and facilitating greater social cohesion. However, the OECD (1967) report suggests that the objectives of the comprehensive school have remained unfulfilled, having not been able to satisfy the claim for equality by the lower classes. Differentiated, vocational curricula do in fact still appear in the US, in a lagged fashion, at the college level, while at the same time the diffusion of tracking within the comprehensive school system can be viewed as fulfilling the same stratifying role of European vocational schools.

To conclude, on the basis of a broad evidence, the first stage described in our model, which predicts an expansion of the ratio between vocational and general education, for the developed countries can be dated as the period that goes from the 1870s up until WWI, with a peak being reached during the interwar period. A phase of relative stability of the ratio is then followed by a final decline after WWII. Therefore, our model does capture the crucial features of the evolution of modern educational systems in advanced countries, starting from the end of last century. And it can also support the conclusions of cross-section investigations based on countries which display different levels of developments.

The predictions of our model on the evolution of wealth distribution are also consistent with the historical evidence. Among economic historians (see, for example, Lindert and Williamson (1985)) there is general agreement that during the third quarter of the last century inequality started to decline. For the developed countries, the downswing phase of the Kuznets curve (see Kuznets (1955)) therefore coincides historically with the period we are referring to.

Historical research also supports our conclusions regarding political participation. Following an early stage during which participation in the political process is restricted to an elite, it progressively expands in a subsequent phase (Bendix (1978), Flora (1983)). In Britain, for example, the franchise was extended first in 1832, and then again in 1867 and 1884, while the school reform process leading to the modern system started with the Education Act in 1870 (followed by additional reforms in 1891, 1893, 1899, and by the 1902 Balfour Act, which introduced the grammar school as the foundation of the British secondary school). Similarly, in all other European countries school reforms and enrollment expansion - along the lines previously described - started only after democratization

3   The model

Technology and wages   Time is counted off in discrete intervals $t = 1, 2, \dots$. At time 1 the economy adopts a new, modern technology given by

$$Q_t = A_t G_t^\alpha V_t^{1-\alpha} \tag{3.1}$$

where Q_t is output, G_t is the input of labor which received a general education and V_t is the input of vocational labor at time t respectively. We assume, except in section 4.3.4, that the parameter $\alpha \geq \frac{1}{2}$, which implies that the income share of general labor is greater than the income share of vocational labor. This assumption reflects the historical evidence which is available for late 19th-century Europe, where a large share of income and wealth was held by a small privileged group. [3] This assumption also implies that the marginal product of general labor will exceed that of vocational labor unless the number of general workers exceeds that of vocational workers, something that, it turns out, cannot occur in this model.

The sequence $\{A_t\}_{t=1}^\infty$ describes an exogenous process of technological progress, that evolves according to

$$A_t = \gamma A_{t-1} \tag{3.2}$$

with $\gamma > 1$. The idea is that, before time 1, the technology was different and in particular did not require vocational labor. Therefore, it is technological progress that triggers the reform of the educational system.

Production continues in a constant-returns-to-scale traditional sector that uses the quantity of minimally educated labor, U_t, to produce output U_t. So total output includes both the modern sector and the traditional sector and is given by $Q_t + U_t$.

All three types of labor are paid their marginal product. Therefore, at each t, simple labor receives a wage of 1, vocational labor gets $w_t^V = (1 - \alpha) A_t G_t^\alpha V_t^{-\alpha}$ and general labor gets $w_t^G = \alpha A_t G_t^{\alpha-1} V_t^{1-\alpha}$.

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[3]In the UK the income share of the top 10% of the population was 53.4% in 1867, and remained above 50% well through the pre-WWI period. Wealth, which is proxied in our model by the bequests, was even more concentrated, with 76.7% being held by the top 10%, and 65.7% by the top 5% in 1875. A similar pattern was followed by the other European countries. See Flora, Kraus and Pfenning (1987), Lindert (1986) and Williamson (1991).

Social structure and wealth distribution There is a stationary population of overlapping generations of individuals who live for two periods.[4] Each individual has one parent and one child. In each generation there is a continuum of individuals of size 1, with the generic agent denoted by $i \in [0, 1]$.

Adult individual i at time t has either basic education only, or secondary education as well. Secondary education comes in two kinds: vocational and general. Accordingly, we divide the total population into three segments at each point in time: individuals $i \in [0, U_t]$ have only basic education, individuals $i \in (U_t, V_t]$ have vocational education and individuals $i \in (V_t, 1]$ have general education.[5] The last group, of size $G_t = 1 - V_t$, which we refer to as the "elite", initially holds a monopoly over general education. We assume that at time 1 the elite is less than half the population. The "non-elite", of size $U_t + V_t = 1 - G_t$ includes both the vocationally educated and those with only basic education.

For the sake of simplicity, we assume that all individuals who belong to the elite start with an identical level of initial wealth, b_{G1}, that exceeds all non-elite wealth levels. The non-elite have various levels of initial wealth, b_{i1}. Without loss of generality we order the individuals so that $b_{it} \geq b_{jt}$ iff $i \geq j$. Let $F_t(\cdot)$ denote the distribution function over wealth at time t. We assume that $F_1(\cdot)'s$ only positive mass point is at b_{G1}.

The educational system Each recipient of vocational education must pay a "tuition" c^V in order to train in the first period of his life. [6] Since such an individual could have worked and received a wage of 1 in both periods of his life, the full opportunity cost of education is $2 + c^V$. Therefore, it is individually rational to choose vocational education over unskilled work in period t iff $w_t^V \geq 2 + c^V$.

Similarly, recipients of general education pay tuition $c^G \leq c^V$. A strict inequality would capture the idea that vocational education requires extra equipment expenditures not incurred for general education. While a strict inequality is not necessary for our analysis, the empirical literature docu-

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[4]On the specific link between population growth and education, see Dahan and Tsiddon (1998).

[5]Later we will show that family dynasties can only move up, from basic education to vocational education and from vocational education to general education so there will be no ambiguity over this classification.

[6]The main results of the model are robust to an alternative specification where all schools are financed by the elite (see Bertocchi and Spagat (1998)).

ments that indeed all practically-oriented training is associated with higher costs. [7] Of course, individuals will choose general education over vocational education iff $w_t^G - c^G \geq w_t^V - c^V$.

We will use the notation y_{it} to denote individual $i's$ "total income", after tuition and inclusive of inheritance, at time t as $y_{it} = b_{it} + 2$ for $i \in U_t$, $y_{it} = b_{it} + w_t^V - c^V$ for $i \in V_t$ and $y_{it} = b_{it} + w_t^G - c^G$ for $i \in G_t$.

Individual lives In the first period of life, individuals either take a job after acquiring basic education, or they go to secondary school. At the end of the period, they receive a bequest from their parent, and in the next period they collect a wage, consume, leave a bequest to their children, and vote over educational issues to be specified below.

Preferences Individuals care not only about the income they leave to their children, [8] but also about their children's social status. In this society, status is derived from access to general education, which is perceived as more prestigious than vocational education. Formally, preferences over activities at time t are given by

$$u_{it} = (1 - \delta) \log c_{it} + \delta \log b_{it+1} + s_{it+1} \tag{3.3}$$

where $0 < \delta < 1$ is a preference parameter, c_{it} is consumption, b_{it+1} is the bequest to the child, and the variable s_{it+1} captures the notion of social status with $s_{it+1} = \frac{1}{G_{t+1}}$ if the child is admitted to the elite and $s_{it+1} = 0$ if the child is excluded from it. Notice that, in the event the child does belong to G_{t+1}, the corresponding utility is decreasing in the size of G_{t+1}.[9] This is consistent with general education being the exclusive and prestigious privilege of a restricted segment of the population.

Since social status, through social arrangements, has certainly played a crucial, stable and persistent role in the evolution of modern educational systems, we believe that it is reasonable to postulate preferences that directly include it as an argument. On the other hand, we stress that we have introduced it only to simplify the voting procedure described below.

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[7] See Psacharopoulos (1994).

[8] The "warm glow" type of preferences is chosen to simplify the analysis. Roberts (1999) is an interesting attempt to generalize such analysis to the case of dynastic preferences.

[9] Nothing depends on the linear specification of the status term in (3.3). Any formulation such that the utility of the elite is increasing in the exclusiveness of general education is sufficient for our purposes.

In particular, it is crucial for our analysis that agents with access to elite education wish to exclude others from this privilege. We can work with any mechanism that accomplishes this goal.

Political participation and the general education sector   At time t, in addition to their consumption and bequest decisions, old-age individuals also vote on the size of the general education sector in the next period, G_{t+1}. They care about this because of the presence of social status in their utility functions. There is an exogenous minimum wealth requirement, $\widetilde{b}$, for participation in the voting process.[10] Consistent with the social function of the elite in this model, we assume that, once a dynasty makes into the elite, he can never be kicked out, i.e., $G_{t+1} \geq G_t$.[11] The people for whom $b_{it} \geq \widetilde{b}$ vote on the expansion of general education, i.e., the amount by which G_{t+1} exceeds G_t. Note that the qualitative predictions of the model would not be affected by the introduction of an endogenous level of $\widetilde{b}$ which could, for instance, be inversely related to the level of income, or else replaced by a minimum schooling requirement.[12] To organize the exposition we assume that, initially, the elite's income is above $\widetilde{b}$, while the income of all the non-elite is below $\widetilde{b}$.

Elite expansion between times t and $t+1$ is decided by majority voting amongst the eligible old generation at time t with the median voter determining the result. Note that at the time of the vote G_t is already determined so that the vote is really over G_{t+1}. Once G_{t+1} is selected children are enrolled into elite education in order of their parents' wealth, i.e., the richest come first. In particular, defining b_t^G by $G_{t+1} = 1 - F_{t+1}\left(b_t^G\right)$, all parents with wealth not less than b_t^G will get their children into general schools and, hence, the elite. Given this mechanism, each voter, i, has a most preferred

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[10]Saint-Paul and Verdier (1993) and Gradstein and Justman (1999) also introduce a franchise requirement. Acemoglu and Robinson (2000) study the link between the progressive extension of the franchise, growth and inequality.

[11]One way to think of this assumption is that the elite has good cohesion and, therefore, takes care of its own member.

[12]Formal wealth and/or education requirements were widespread up until the beginning of the 20th century, both in the Old and in the New World (see Engerman and Sokoloff (2001)). In addition, as argued by Almond and Verba (1963) and Brady, Verba and Schlozman (1995), participation in the political system can be de facto denied to the poorest segments of the population even within fully democratic political systems. Husted and Kenny (1997) discuss several devices, such as poll taxes and literacy tests, that have been employed to restrict the poor from voting. Our simple modelling assumption is meant to capture also this kind of situations.

expansion level $G_{it+1} - G_t \in [0, 1 - G_t]$ and the actual expansion will be $median\{G_{it+1}\}$.[13]

It should be stressed that restricted majority voting is just a device to capture the idea that the elite begins with all the power but gradually loses a lot of it as the economy develops. All we need is that the mechanism determining entry into general education gives increasing power to people lower down the economic ladder as these people get richer.

Finally, the mechanism of admitting individuals into the elite in order of their wealth is rather arbitrary, although not entirely unrealistic. But this is, again, only a simplifying assumption. We could use other mechanisms, such as ability, to determine entry and our results will be essentially the same.

Utility maximization When individuals make their utility maximization decisions the size of the general education sector for their generation has already been determined through voting of the previous generation. At this point, by previous assumption, access to higher education is dictated by parental wealth. Of course, other selection mechanisms, such as selection by test scores, are possible. In practice, wealthy individuals tend to have better entry chances to good schools under any selection mechanism so this assumption relatively innocuous.

For simplicity, we assume the interest rate to be zero. Each non-elite individual, i, below the voting threshold chooses c_{it}, b_{it+1} and whether or not to take a vocational education to maximize utility (3.3) subject to

(i) $c_{it} + b_{it+1} \leq y_{it}$.
(ii) w_t^V given.

Note that the educational choice is relevant for determining y_{it}.

Each non-elite individual , i, above the voting threshold chooses c_{it}, b_{it+1}, the size of the general education sector, G_{it+1}, and whether or not to take a vocational education to maximize utility (3.3) subject to the constraints

(i) $c_{it} + b_{it+1} \leq y_{it}$
(ii) $G_{t+1} = median\{G_{it+1}, \{G_{jt+1} : j \neq i\}\}$
(iii) $G_{it+1} \geq G_t$ is not weakly dominated
(iv) w_t^V, $G_{jt+1} \forall j \neq i$ given.

The third constraint is standard in the voting literature to prevent arbitrary voting when there are a large number of voters and no individual can directly

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[13]The political issue is well-defined, since it is unidimensional and implies single-peaked preferences. If the median is not unique we can select the infimum of the set of media.

affect the outcome through his vote. It is equivalent to a requirement that no voter would be dissatisfied with his vote if he were suddenly made a dictator. Its effect is to ensure sincere voting.

Each elite individual, i, chooses c_{it}, b_{it+1}, G_{it+1} and whether take a general, vocational or no education to maximize utility (3.3) subject to the constraints

(i) $c_{it} + b_{it+1} \leq y_{it}$

(ii) $G_{t+1} = median\{G_{it+1}, \{G_{jt+1} : j \neq i\}\}$

(iii) $G_{it+1} \geq G_t$ is not weakly dominated

(iv) w_t^V, w_t^G, $G_{jt+1} \forall j \neq i$ given.

Note that elite membership allows but does not compel an individual to take a general education.

The solutions to these maximization problems are quite simple. First, educational decisions are chosen to maximize income. To describe these decisions we introduce the notation $e_{it} = U, V, or\ G$ to denote, respectively, a decision to remain unskilled, take vocational education or take general education for individual i at time t. Second, non-voting individuals take their total income, y_{it}, consume a fraction $(1-\delta)$ and bequeath a fraction δ to their offspring. Third, voters also consume $(1-\delta)y_{it}$ and bequeath δy_{it}. In addition, each votes for the minimal size general education sector that will include his own child, i.e., each i sets $G_{it+1} = 1 - F_t(b_{it})$.

Political equilibrium

Definition. A political equilibrium starting from initial conditions A_1, b_{i1} for $i \in [0,1]$ and G_1 consists of a sequence $\left\{c_{it}, b_{it+1}, e_{it}, G_{it+1}, U_t, V_t, G_t, w_t^V, w_t^G\right\}_{t=1}^{\infty}$ such that the following hold: (i) $\{c_{it}, b_{it+1}, e_{it}, G_{it+1}\}$ are determined for all $i \in [0,1]$ and t by maximizing utility subject to the appropriate constraints; (ii) for all t the triple $\{U_t, V_t, G_t\}$ giving aggregate numbers in each type of education is consistent with individual decisions; (iii) w_t^V and w_t^G are market determined for all $t = 1, 2, ...$; (iv) G_t for $t = 2, 3, ...$ is a voting equilibrium.

4   Analysis of the model

4.1   The size of the vocational education sector

The new technology that is introduced at time 1 creates a demand for both general and specific skills. We will distinguish between two stages of economic development. In Stage 1 only some of the non-elite receive vocational

education, while in Stage 2 secondary education is universal, either in the vocational or general form. In the following discussion, we analyze the determination of the size of the vocational education sector stage by stage.

Stage 1 All agents in the model can choose to remain unskilled or to train for vocational labor (the elite has the additional choice of general labor). Therefore, until the time τ at which $U_\tau = 0$, there must be income equalization across the two types of labor, i.e., it must be the case that $w_t^V - c^V = 2$.[14] This implies that the V_t satisfies

$$V_t = (\frac{(1-\alpha)A_t}{2+c^V})^{\frac{1}{\alpha}} G_t \tag{4.1}$$

Equation (4.1) has reasonable properties. By complementarity, V_t increases with G_t. Moreover, V_t is increasing in A_t, the level of technology. Finally, the cost of vocational education, c^V, is negatively related to V_t. If all elite individuals choose general education then wages for general labor are

$$w_t^G = \alpha A_t^{\frac{1}{\alpha}} (\frac{1-\alpha}{2+c^V})^{\frac{1-\alpha}{\alpha}} \tag{4.2}$$

which shows that only the wage rate for general labor follows the evolution of technological progress, while the vocational wage rate, $2+c^V$, at this stage does not benefit from it. This is because improvements in technology lead to increases in the quantity of vocational workers, eliminating the pressure for wages to increase. The wage ratio for educated labor is

$$\frac{w_t^G}{w_t^V} = \alpha A^{\frac{1}{\alpha}} (1-\alpha)^{\frac{1-\alpha}{\alpha}} \left(2+c^V\right)^{-\frac{1}{\alpha}} \tag{4.3}$$

which implies that there is a positive wage premium for general education when

$$A_t > \alpha^{-\alpha} (1-\alpha)^{\alpha-1} \left(2+c^V\right) \tag{4.4}$$

meaning that technology has to be sufficiently advanced while costs have to be relatively moderate. It can be shown that $\alpha \geq \frac{1}{2}$ implies that $\alpha^{-\alpha} (1-\alpha)^{\alpha-1} \leq$

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[14]This equality is a simplification device. There are various assumptions we could make that would drive a wedge between the two wages but they would add nothing but complication to the analysis. Note also that we have assumed that individuals are admitted into vocational schools in order of their wealth, with the richest getting in first. Nothing that follows depends on this assumption.

2. So $A_t \geq 4 + 2c^V$ is a sufficient, although far from a necessary, condition for elite wages to always exceed vocational wages throughout Stage 1. Of course, if this is the case then general labor will be preferred by the elite to vocational labor even after tuition since we have assumed that $c^V \geq c^G$. Thus, the provisional assumption that all elite individuals choose general education would be validated.

We summarize the behavior in Stage 1 with the following proposition.

Proposition 1. In Stage 1: a) V_t and $\frac{V_t}{G_t}$ are increasing; b) vocational incomes equal incomes for basic education after tuition payments are accounted for.

Stage 2   From time τ on, i.e., after the pool of individuals with only basic education has been exhausted and $U_t = 0$. Again making the provisional assumption that all elite member choose general education, the size of the vocational sector of the educational system will be determined residually as $V_t = 1 - G_t$. The size of the vocational sector cannot increase further during this stage and may decrease as people move up into the general sector.

Substituting into (3.1) and calculating marginal products, we can find the corresponding wage rates, which are given by

$$w_t^V = (1 - \alpha)A_t(\frac{G_t}{V_t})^\alpha \tag{4.5}$$

$$w_t^G = \alpha A_t(\frac{V_t}{G_t})^{1-\alpha} \tag{4.6}$$

Both increase with technological progress and depend on the ratio $\frac{V_t}{G_t}$, positively for w_t^G and negatively for w_t^V. The wage ratio is

$$\frac{w_t^G}{w_t^V} = \frac{\alpha (1 - G_t)}{(1 - \alpha) G_t} \tag{4.7}$$

This will never be less than 1, because $\alpha \geq \frac{1}{2}$ and the voting equilibrium always gives $G_t \leq \frac{1}{2}$. Including tuition payments only increases the general education premium. Therefore, elite individuals would indeed choose general education.

Again we summarize with a proposition.

Proposition 2. In Stage 2: a) V_t and $\frac{V_t}{G_t}$ are not increasing and may be decreasing in t; b) general incomes are greater than vocational incomes; c) the traditional sector disappears.

4.2   Note on the Role of Social Status

As mentioned above, we have included social status in the utility function merely as an analytical convenience so that voters wish to restrict access to general education once their own children are admitted. An alternative would be to have individuals' preferences respond positively to the income of their children. This would deliver identical results in Stage 2 where elite wages are decreasing in G_t. However, in Stage 1 this is not the case, because more general workers draw more vocational workers, preserving the wages of the former. In practice, such a mechanism would probably not work perfectly smoothly so that parents would retain a motive for keeping their children's skills scarce. Such an imperfection could do the same work in our model as social status does in Stage 1. However, we choose social status because it strikes us as a simple and persuasive reduced form.[15]

4.3   Dynamics

We are now ready to examine in detail the dynamic implications of the introduction of the vocational education sector. We get interesting dynamics for the size of the vocational and the general education sectors, for the level of income and its growth rate, for the degree of inequality and for the rate of political participation. We will study the evolutions of all these variables by proceeding, once again, stage by stage. The next subsection, 4.3.1, will be devoted to the first stage, while 4.3.2 will explore Stage 2.

4.3.1   The expansion of the vocational education sector

First of all, notice that since we have assumed that the non-elite are all below the voting threshold in period 1, the size of the general education sector will be the same in period 2 as it is in period 1. After period 2 it is possible for lower class incomes to rise above the voting threshold. If enough of them do to change the class of the median voter, then the general education sector will expand. If the general sector does not expand during Stage 1 then, by

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[15]See Cole, Mailath and Postlewaite (1992) and Fershtman, Murphy and Weiss (1996) for papers primarily interested in the nature of status.

equation (4.1), the dynamics of the vocational sector will be governed by the equation

$$V_{t+1} = \gamma^{\frac{1}{\alpha}} V_t \tag{4.8}$$

which predicts that there will be a continuous expansion of V_t at the rate of $\gamma^{\frac{1}{\alpha}} - 1$, driven by technological progress. If, on the other hand, the voting equilibrium does change during Stage 1, forcing expansion of the general sector, then the vocational sector will grow faster than $\gamma^{\frac{1}{\alpha}} - 1$. Social and technological factors therefore contribute to the shaping of the educational system. Again using (4.1) we have that the ratio $\frac{V_t}{G_t}$ will be increasing over time according to

$$\frac{V_{t+1}}{G_{t+1}} = \gamma^{\frac{1}{\alpha}} \frac{V_t}{G_t} \tag{4.9}$$

which holds regardless of whether or not the voting equilibrium is changing during Stage 1. Finally, it is clear that the secondary school enrollment ratio, which is given by $V_t + G_t$, will also be increasing during this stage.

The growth implications for this phase are as follows. Aggregate income dynamics can be tracked by computing the rate of growth for the output of the modern sector of the economy, i.e., the one that employs vocational and general labor. Until the voting equilibrium changes we have, using (3.1), (3.2) and (4.9) that the rate of growth of the modern sector is given by $g^M \equiv \frac{Q_{t+1}}{Q_t} - 1 = \gamma^2 - 1$. This growth rate is positive and greater than $\gamma - 1$, the rate that would be sustainable purely due to technological progress. Note that this growth rate does not depend on t. If the voting equilibrium does change during Stage 1 then $g^M > \gamma^2 - 1$.

Traditional sector growth is given by $g_t^T \equiv \frac{U_{t+1}}{U_t} - 1$, which is negative and equal to $\dfrac{V_t \left(1 - \gamma^{\frac{1}{\alpha}}\right)}{U_t}$ when the voting equilibrium is not changing and even more negative when it is changing. Despite the shrinkage of the traditional sector, total output must be increasing because wages are higher in the modern sector than in the traditional sector and every individual is paid his marginal product. Since income grows monotonically with time, it is therefore legitimate to establish a positive relationship between the ratio $\frac{V_t}{G_t}$ and the level of income $Q_t + U_t$. In fact, when productivity in the modern sector is high then the traditional sector will be very small relative to the modern sector and the growth rate for the whole economy will be approximately equal to the growth rate of the modern sector. Therefore, as long as the voting equilibrium is not changing at this stage, the two variables grow at approximately the same speed. We summarize with the following.

Proposition 3. In Stage 1: a) $\frac{V_t}{G_t}$ grows at the rate of $\gamma^{\frac{1}{\alpha}} - 1$; b) when the elite is not expanding Q_t also grows at the rate $\gamma^{\frac{1}{\alpha}} - 1$, while it grows faster otherwise.

Let us analyze now the evolution of income distribution in the society. Utility maximization leads to the bequest function

$$b_{it+1} = \delta y_{it} \tag{4.10}$$

for $i \in V, G, U$. For sufficiently high wages the sequence of bequests for a dynasty will be increasing. This is a very reasonable condition for the modern sector because if this condition were not satisfied then the new technology would be inferior to the previous one, which had endowed the initial generations with bequests b_{i1}. We will therefore proceed under the assumption that this condition is indeed satisfied for workers in the modern sector. Before completing the analysis of the evolution of wealth distribution we will assume that (3.5) holds, i.e., that throughout Stage 1 after-tuition elite income exceeds after-tuition vocational income even when all elite members choose general education.

Under the above assumptions, the evolution of bequests will be given by

$$b_{it+1} = \delta \left[b_{it} + \alpha A_t^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{2+c^V} \right)^{\frac{1-\alpha}{\alpha}} - c^G \right] \tag{4.11}$$

for the elite, and by

$$b_{it+1} = \delta(b_{it} + 2) \tag{4.12}$$

for vocational workers. Notice again that the income of the elite increases with technological progress while the income of individuals with vocational education does not. Since elite wages and wealth are already larger than their vocational counterparts in period 1, this lopsided wage growth exacerbates inequality.

Finally, we can examine the evolution of political participation in the society. If wealth levels start surpassing $\tilde{b}$ then the voting pool expands. This event, by itself, is not sufficient to alter the voting outcome, since until a mass at least equal to G_1 get the franchise the median voter will still be an offspring from the original elite.

4.3.2 The contraction of the vocational education sector

Stage 2 is reached at the time τ that all individuals are enrolled in secondary school, i.e., it is defined by the condition $U_\tau = 0$ which implies that the secondary school enrollment ratio is 1. Equations (3.2) and (4.1) together imply that Stage 2 must eventually be reached. From that point on V_t will be determined as a corner solution rather than through (4.1).

Define ζ to be the first period reflecting a change in the voting equilibrium, i.e., ζ is the smallest number such that $G_\zeta > G_1$. Note that this must happen for some finite ζ because, by (3.2) and (4.6), vocational wages grow without bound in Stage 2 and so eventually everyone must get the franchise in this stage if they did not already get it in Stage 1. Suppose for the moment that $\zeta > \tau$ and consider the dynamics during this substage. From τ to ζ both G_t and V_t are constant, and so is their ratio. The growth rate of output in the modern sector, which is the only one left, equals $\gamma - 1$ so it is slower than in Stage 1.

The evolution of bequests is given by the equations

$$b_{it+1} = \delta(b_{it} + \alpha A_t(\frac{V_t}{G_t})^{1-\alpha} - c^G) \tag{4.13}$$

for elite individuals and

$$b_{it+1} = \delta(b_{it} + (1-\alpha)A_t(\frac{G_t}{V_t})^{\alpha} - c^V) \tag{4.14}$$

for non-elite individuals, with the elite continuing to bequeath more than the non-elite throughout Stage 2.

Now consider together the case where $\zeta \leq \tau$ and the case where $\zeta > \tau$ and $t \geq \zeta$. The median voter now is not a member of the original elite, and is able to vote his child into the general education sector, thus expanding the size of G_t. The sequence of events is as follows: since G_t can only expand at the expense of V_t, the expansion of G_t comes with a reduction in V_t. The ratio $\frac{V_t}{G_t}$ therefore falls, at a speed that depends on the initial wealth distribution, and will be faster the smaller the dispersion in the initial wealth levels of the lower class b_{i1}. Moreover, as G_t grows, w_t^V rises, pushing towards income equalization and accelerating expansion of political participation. The identity of the median voter will change accordingly, and more and more people will be able to vote their children into general education.

We can now derive the growth implications for this stage of the economy. Aggregate output growth will be given by

$$g_t = \gamma \left(\frac{G_{t+1}}{G_t}\right)^\alpha \left(\frac{V_{t+1}}{V_t}\right)^{1-\alpha} - 1 \qquad (4.15)$$

which depends on the dynamics of $\frac{V_t}{G_t}$ and will be greater than 0 as long as $G_t < \alpha$. This condition will always by satisfied because no more than half the population can ever be voted into general education.[16]

In the long run, the economy and society reach a steady state with full political participation. At that time the ratio $\frac{V_t}{G_t}$ stabilizes at 1 and aggregate output growth equals $\gamma - 1$. Individual incomes tend toward equalization. However, since the outcome of the voting process implies that G_t will never rise above $\frac{1}{2}$, in the long run the elite will earn more than the non-elite as long as $\alpha > \frac{1}{2}$. On the other hand, the children of the original elite will progressively lose their monopoly over general education, the voting process and much of the economic privilege attached to this social status. Another implication is that the income share of the enlarged pool of individuals with general education will remain greater than $\frac{1}{2}$. The following proposition summarizes these results.

Proposition 4. In Stage 2: a) Output grows; b) $\frac{V_t}{G_t}$ may remain constant initially; c) eventually $\frac{V_t}{G_t}$ will decrease monotonically to 1.

Combining Propositions 3 and 4 leads to the main result of the paper, which is that the relationship between $\frac{V_t}{G_t}$ and income follows an inverse U-shape.

Proposition 5. In Stage 1 $\frac{V_t}{G_t}$ increases with the level of income; in Stage 2 $\frac{V_t}{G_t}$ initially decreases with the level of income, and then becomes a constant.

4.3.3   Summary

For expositional clarity, we will now summarize the evolution of each variable of interest, stage by stage. For simplicity consider the case in which $\zeta > \tau$. Figure 3 describes the evolution of the educational system. In Stage 1 the vocational sector grows at the rate $\gamma^{\frac{1}{\alpha}} - 1$. In Stage 2, it is constant from time τ to time ζ, and then it decreases until some time ξ after which it

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[16]In fact, g_t is going to be higher than $\gamma - 1$ but higher or lower than $\gamma^{\frac{1}{\alpha}} - 1$ depending on income distribution.

equals $\frac{1}{2}$. The general sector is constant through Stage 1 and continues so until time ζ of Stage 2. After that it increases until ξ and stabilizes at $\frac{1}{2}$. The ratio $\frac{V_t}{G_t}$ rises from 1 to τ, is constant between τ and ζ and decreases between ζ and ξ at which point it stabilizes at 1. The secondary school enrollment ratio grows steadily over time and reaches 100% by Stage 2. Figure 4 describes the evolution of aggregate income, which always rises in this model, but at varying rates, reflecting endogenously the evolution of the educational system. Initially, as the economy exploits more and more intensively the new technology by employing vocational labor, the rate is highest at $\gamma^{\frac{1}{\alpha}} - 1$. By Stage 2, the traditional sector has disappeared and growth is slower because the opportunities to shift labor into the modern sector have disappeared: the growth rate is $\gamma - 1$ from τ to ζ and from ξ on, and higher between ζ and ξ. Inequality increases in Stage 1, since elite wages increase while non-elite wages remain constant. By the time ζ at which $\frac{V_t}{G_t}$ starts to decline, vocational wages pick up thanks to the relative scarcity of vocational labor, but only under the condition $\alpha = \frac{1}{2}$ will they reach the level of general wages. When this condition is not satisfied, inequality will persist in the long run. Political participation tends to increases with income, but enfranchisement of the non-elite does not immediately affect the voting outcome, because initially the median voter is still a member of the original elite. At time ζ the median voter does not come from the elite and is able to vote his child into general education. Political participation is full in the long run

4.3.4 The case of $\alpha < \frac{1}{2}$

While the above analysis has been conducted under the assumption of a higher income share for the generally educated, it is instructive to analyze also the opposite case. For $\alpha < \frac{1}{2}$ we have wage equalization for general and vocational labor at every point in time. When the size of the elite reaches α it stops growing to prevent vocational wages from surpassing general wages (recall that elite membership allows but does not compel an individual to take a general education).Therefore, the economy converges to a steady state with general and vocational sectors of size α and $1 - \alpha$ respectively.

5 Conclusion

To conclude, we would like to indicate a few possible implications of our model for educational policies in developing countries. Policy-oriented research on the economics of education has developed along two lines. The first is a micro-oriented approach, which has focused primarily on the compilation of rate-of-returns estimates to investment in education. These studies, as surveyed in Psacharopoulos (1994), have reached the conclusion that the academic secondary school curriculum provides higher returns than the technical/vocational track Our model is consistent with such an empirical result, and with the implied policy prescription .[17]

The second stream of literature, closer to our approach, is directly linked to growth theory and its macroeconomic implications. In this work the role of vocational vs. general education for development has been addressed only very superficially. The conventional wisdom, in accordance with a functionalist view, used to be that vocational education should have higher priority in developing economies than in developed countries, and this conclusion permeated the orientation of international organizations and less-developed countries' governments in the early post-war period. [18] However, we have demonstrated how socio-political factors play a crucial role in the shaping of educational systems, and that the expansion of the vocational sector in an early development stage may actually be the goal of a policy of exclusion perpetrated by an elite group. Local policymakers who negotiate with international organizations are invariably members of the same elite group. The main lesson from this paper is that international policymakers involved in human capital development planning must develop a keener awareness of the socio-political considerations that interfere with strictly economic ones and act accordingly.

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[17]Bertocchi and Spagat (1998) carry out a policy analysis that compares the mixes of vocational and general education that occur in the model with the unique output-maximizing mix and show that the vocational sector grows too large and the general sector remains too small relative to the efficient solution. This implies that developing countries will tend to overinvest in vocational education at the expense of general.

[18]This view was challenged, among others, by Foster (1968), who stressed the role of socio-political considerations for a growth-stimulating educational policy.

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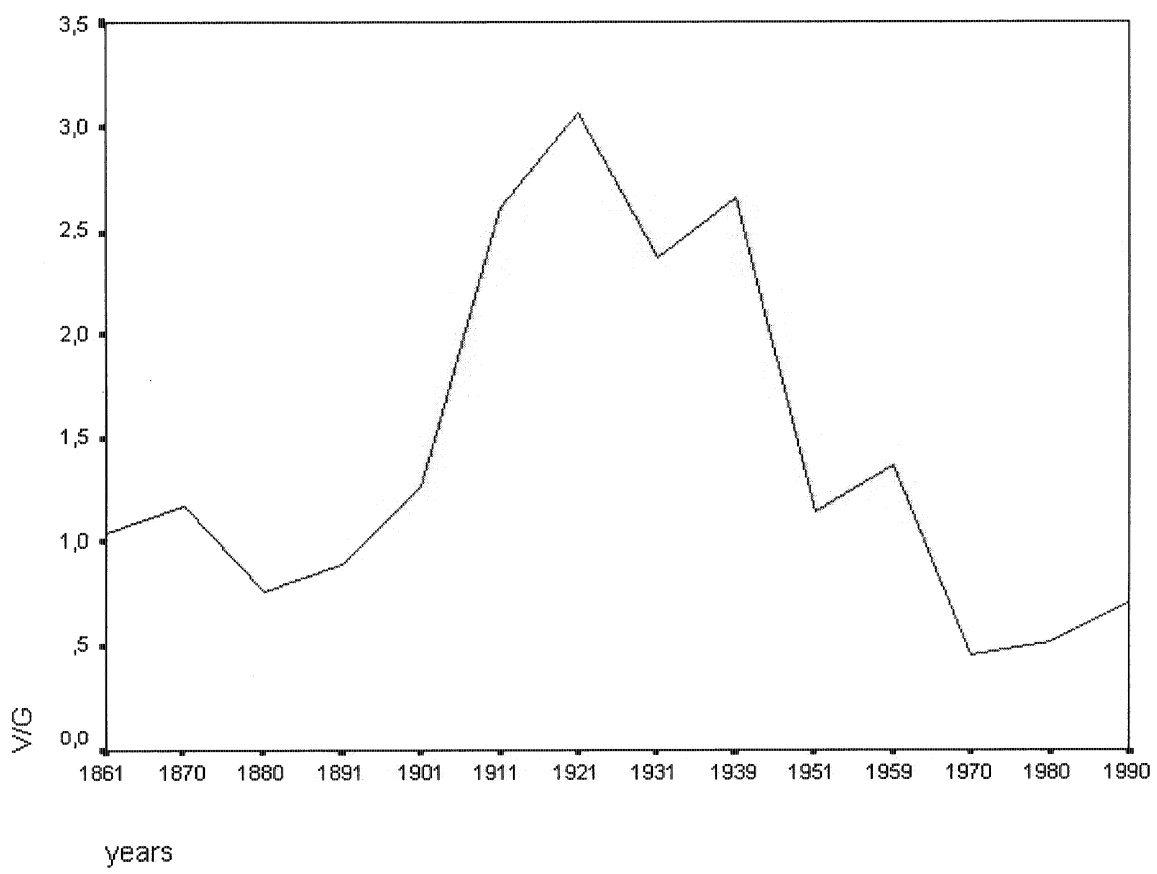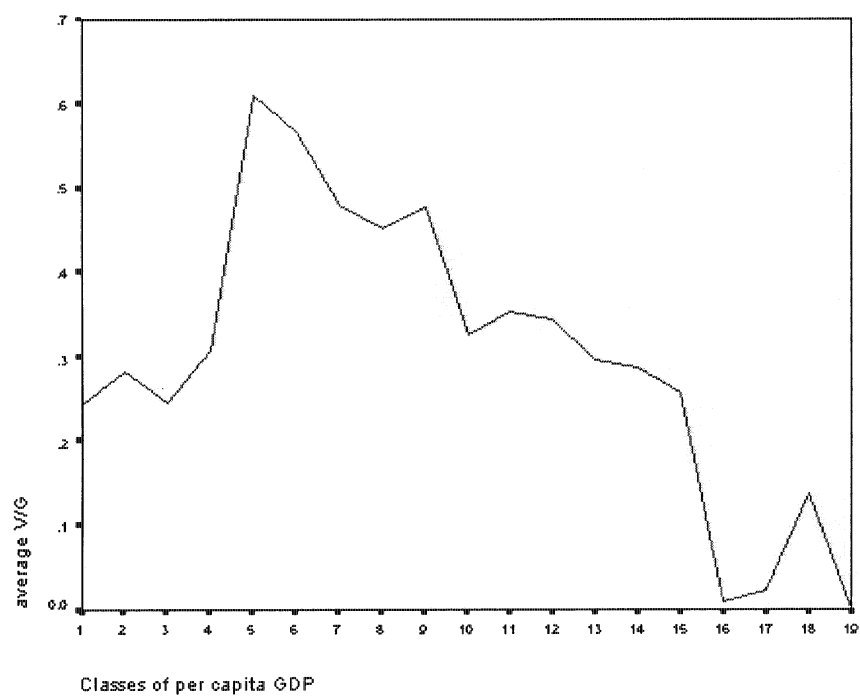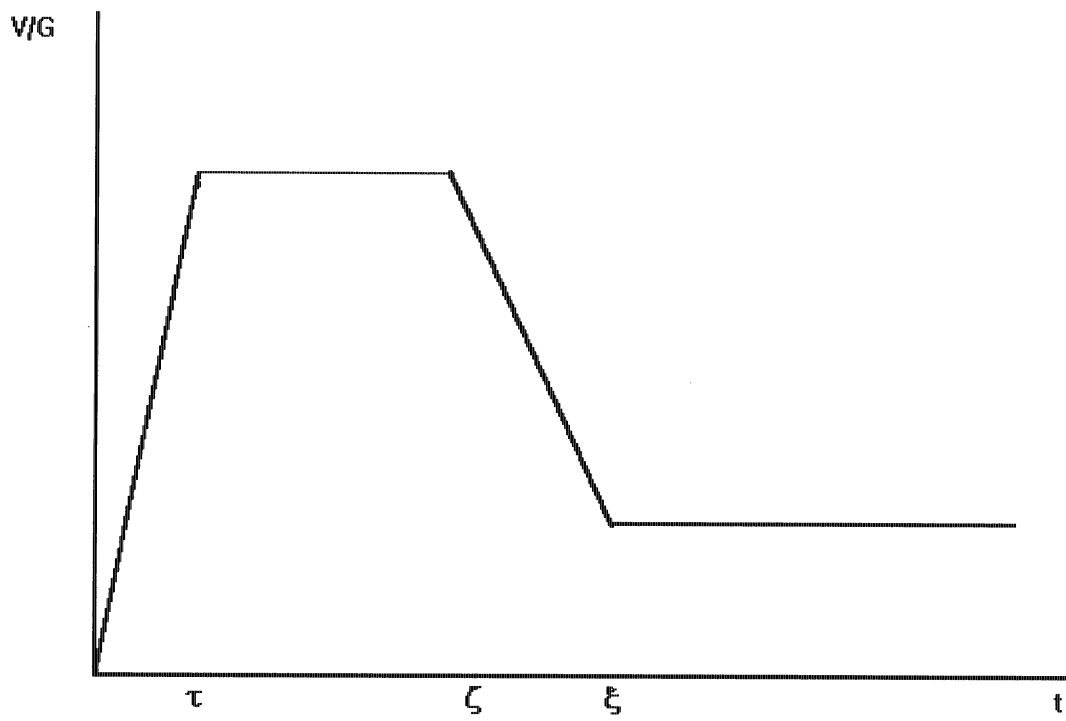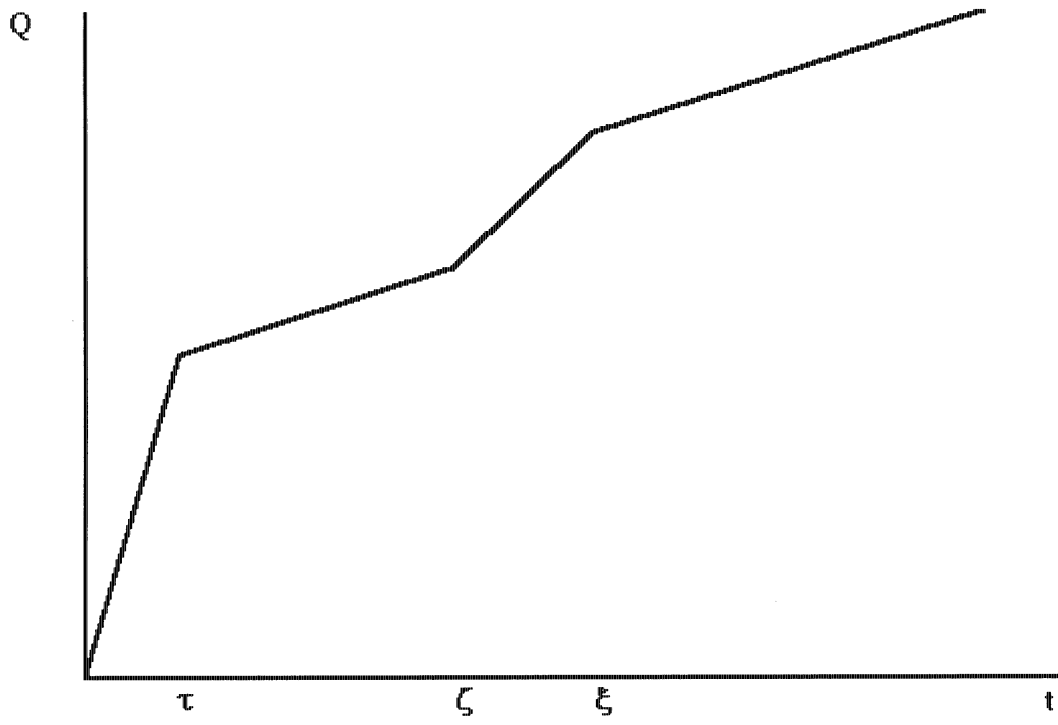Zeira, J., 1997, Technical Progress, Employment, and Output, mimeo, Hebrew University.

years

Figure 1

Classes of per capita GDP

Figure 3

Figure 4