THE PROBABILISTIC PROJECTION OF THE SUPPLY AND DEMAND FOR NEW ENTRANT ENGINEERS TO THE SOUTH AFRICAN LABOUR MARKET 1994-2023

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The development of a non-linear dynamic model to project the demand, supply and the interaction between demand and supply of new entrant engineers to the South African labour market is described. The model was used to generate non-linear probabilistic projections of the supply and demand for the new entrant engineering skills using 1994 as the base year and a time horizon of 29 years. The implications of the probability projection results on the South African economy, demographics, education and labour market are also critically examined. The main findings of this article are that overall, there is a remarkable projected decline in the demand for new entrant engineers to the South African labour market for both the upper and lower 0.3%, 43.3%, 27.2% and 68.3% probability intervals respectively. Conversely, the projection results predict a considerable increase in the supply of new entrant engineers to the South African labour market under the four probability intervals. The findings also suggest that equilibrium between the supply and demand for new entrant engineers will be attained earliest in the year 2000 and latest in 2005.

Background

The issue of human resources supply and demand is intimately interwoven with the well and woe of South Africa’s economy and indirectly, also with its political future. South Africa’s human resources dilemma can be summarized in simple terms as the reality of a vast oversupply of unskilled labour and the simultaneous undersupply of the highly skilled human resources required to operate a modern economy. According to the points of departure presented in the GEAR (Growth, Employment and Redistribution) strategy, sustained growth on a higher plane requires a transformation towards a competitive outward-oriented economy. The strategy attains a growth rate of 6 per cent per annum and a job creation of 400 000 per annum by the year 2000, concentrating capacity building on meeting the demands of international competitiveness (Department of Finance, 1996:2).

The necessity of growth and job creation within the context of globalization and international competitiveness will inevitably lead to intensified pressures for more highly skilled workers. This development has direct consequences for the demand for higher education. The historical trend in skill distribution among the formally employed in South Africa indicates that this demand is growing and will increase as the country takes up the challenges of the globalisation process.

From 1971 to 1994 there was a constant increase in the demand for high-level personpower, the demand for middle-level personpower remained relatively constant and the demand for low level personpower was declining. All economic sectors show at least some degree of shift upwards from the lowest level of skills towards the middle. According to the recent results of the Institute for Employment Research (IER) projections as well, dynamic excess demand characterizes most areas of occupational employment associated with higher level education in the United Kingdom. Supply has been growing rapidly but demand has been growing even faster. The projections highlight the considerable growth anticipated for managers and administrators, professional occupations, associate professional and technical occupations in the United Kingdom. This indicates a continuing intensification of the skill content of the economy. This trend is expected to persist internationally for the foreseeable future (Wilson, 1994:94).

The demand for labour is a derived demand. It is derived from the demand for the products or service provided by the employer. The demand for labour will therefore indirectly be affected by economic conditions such as stimulatory or restrictive fiscal and monetary policy, external and internal competitive conditions. It will also be directly affected by the wage rate being paid to workers and by their productivity. The use of technology and the relative price of labour versus that of capital are further crucial factors influencing the demand for labour. It has thus been argued that a low economic growth rate together with high population growth rates are the most important reasons for the high unemployment levels South Africa is experiencing. In addition to the low economic growth rates, however, is the fact that, even if the same growth rates as in earlier years could have been maintained, fewer employment opportunities would be created now than before. South Africa is
experiencing a less labour intensive growth pattern than before. The production elasticity of employment declined from 0.64 per cent in the 1970s to 0.46 in the 1980s. This implies that 1 percentage annual economic growth was associated with a growth in employment of 0.64 per cent during the period 1970 to 1980. This percentage decreased by more than a quarter to 0.46 per cent during the 1980s. The labour absorption capacity of the economy is declining. In the late 1960s, 74 per cent of new labour force entrants were able to find a job. In the 1990s an average of 400 000 persons enter the labour market every year or 1 500 every working day. This implies an increase in the number of people working and wanting to work of 2.8 per cent per annum. The average increase in employment over the decade 1980-1990 was 0.66 per cent per annum, or only 50 000 workers. Only 14 per cent per annum of the new entrants were able to find a job in the formal economy, a figure that has now dropped to 12.5 per cent (Ligthelm et al., 1990: 633).

During the eighties, if not already since the middle of the seventies, a substitution of capital for labour has occurred among those industries that lend themselves to such substitution. During the same period, the growth in the average product per worker was sluggish and greatly outpaced by the increase in the amount of capital at the disposal of each employed worker. As a result the multi-factor productivity arrived at by combining capital and labour as weighted inputs which produce output has been on the decline. This has been interpreted as a decrease in the marginal product of labour since the inanimate machine cannot be held responsible for the way in which capacity is being utilised. The average product of labour discounted for the increase in the amount of capital at its disposal diminished by 22 per cent between 1974 and 1989. Occurring as it did in the period of increasing demand for higher wages, it could not but reinforce the latter's inhibiting effect on employment. South Africa has been using its abundant lesser skilled or unskilled labour as if it were a scarce factor of production and its scarce capital as if it were the abundant factor. The observed tendencies implied that capital equipment was being employed less and less efficiently or at least to produce diminishing returns. The reverse of the capital output ratio, the ICOR (incremental capital output ratio), has been increasing. Measured from 1964 to 1976, the ICOR amounted to 3.09. Between 1976 and 1990 it had risen to 5.12, which meant that two-thirds more capital was required to produce the same amount of domestic product. The growth and employment creating capacity of the economy is thus declining (Sadie, 1991:159).

The science and engineering work force constitutes a highly skilled economically active population. The role of formal education in the training of such a work force is vital to the achievement of a competitive economy and for future socio-economic stability. At present the system fails to supply the required skills mainly due to the inequalities in the system, although the situation is showing steady improvements in recent years. Not only is South Africa's output in natural sciences, engineering and technology low by international standards, but about 80 per cent of South Africa's resources in these fields are white. These distortions, a direct result of the failure of the education system, led to a severe shortage of graduates in natural sciences, engineering and technology, considered to be the intellectual engine of economic development. Thus the major demographic trends likely to exert an effect on the future interaction between the supply and demand of engineers in the short and medium run will be the dearth of blacks educated in science and technology at all levels and fields. Coupled with this concern is the possibility of an accelerated brain drain through emigration of either experienced or newly trained white scientists, engineers and technologists. Reasons advanced for their disenchancement include the diversion of resources away from projects of long term personal intellectual interest, especially in basic science; political-economic uncertainty, and greater career prospects elsewhere. Concerns about the tendency towards brain drain have already been cited with great frequency by university science and engineering teaching staff and researchers as well as others in the scientific community. But science brain drain is also an expressed concern of the Government of National Unity.

It has been ascertained that the African fertility rate is declining, resulting in a slow-down of the overall South African population growth rate. However, the growth rate of the number of entrants to grade one will rise from 0.73 per cent a year in 1996 to a peak of 1.11 per cent a year in 2006, after which it will decrease again to 0.74 per cent a year by 2011. This means expansion of the whole education system is still in progress. This shows that the effect of increased numbers of school pupils over the next decade or so will be felt in higher education for some time after the year 2005. The greatest short-term expansion will occur among secondary school pupils, whose numbers are expected to rise from 3.5 million to 5.5 million over the next decade. Thereafter the demographic bulge will work its way into the higher education system, inevitably increasing the supply of skilled human resources to the South African labour market. It can be expected that African pupils will account for by far the greatest increase in the number of grade 12 passes over the next decade and hence for the increase in the supply for engineering skills. If the efficiency of schools improves and the pass rate accordingly increases, the number of school leavers qualifying for entrance to higher education institutions will accordingly be higher. It must, however, be emphasized that it is highly doubtful that South Africa will have the resources to guarantee access to higher education programmes to all those who will qualify for consideration (NCHE, 1996).
Discussion of findings

The probabilistic projections are based on the supply and demand for new entrant engineers’ distributions to the South African labour market, defined in terms of high or low values assumed to cover 100 percent of all possible outcomes. The projection utilizes the 68.3%, 27.2%, 4.3% and 0.3% probability intervals of the four respective standard deviations from the mean of a normal distribution. The methodology applied for projection is not discussed here but is fully articulated in Kibuka (1998). The results of the projected supply, demand and the interaction between them are indicated in figures 1, 2 and 3 respectively. Overall, there is a remarkable projected decline in the demand for new entrant engineers to the South African labour market for both the upper and lower 0.3%, 4.3%, 27.2% and 68.3% probability intervals over the projection period. According to figure 1 the low end of the 0.3% probability interval shows almost half of the demand for the 1994 level by the year 2023, a 40% decline in the case of the 4.3% probability interval, a 34% decline in the case of the 27.2% probability interval and 29% decline in the case of the most likely 68.3% probability interval by the year 2023. Considering the projected results of the high end of the probability intervals, though there is a discernible declining trend, a different picture emerges in terms of the individual interval percentages. In the case of the 0.3% probability interval, there is a mere 2% decline in the demand for new entrant engineers on the South African labour market between the 1994 figure and that of the year 2023. For the 4.3% interval the decrease amounts to 7% while it is 15% for the 27.2% interval. However, the high end of the 68.3% probability interval shows an 18% decrease. The upper bounds of the 0.3%, 4.3% and 27.2% confidence intervals also reveal that the demand for new entrant engineering skills will increase for the first 5, 5 and 4 years respectively before eventually declining.

Conversely, the projection results in figure 2 (on page 14) predict a considerable increase in the supply of new entrant engineers to the South African labour market, with the upper most end of the 0.3% probability interval showing an almost doubling of the 1994 supply by the year 2023, a 44% increase in the case of the 4.3 probability interval, a 39% increase in the case of the 27.2% probability interval and a 33% increase in the case of the most likely 68.3% probability interval by the year 2023. The median projection path will, between 1994 and the year 2023, experience a 25% increase in the supply of new entrant engineers to the South African labour market. Discussion of the results of the lower end of the probability intervals also highlights in general terms an increasing supply trend through the projection period, but for only the 27.2% and the 68.3% probability intervals with the 0.3% and 4.3% intervals showing remarkable overall declines. The results in addition declare individual interval percentage differentials in comparison to the corresponding upper interval values discussed above. There is, for example, a 26% decline between 1994 and the year 2023 in the supply of new entrant engineers to the South African labour market for the probability interval 0.3%, an 11% decline in the case of the 4.3% interval, a mere 4% increase in the supply under the 27.2% interval and a 16% increase within the most likely 68.3% probability interval.

Figure 3 (on page 14) highlights in simplified terms the projected results of the interaction between supply and demand. The results are summarised in Table 1. The figure presents the projected number of years it will take for the supply of new entrant engineers to the South African labour market to attain equilibrium with the demand under the upper 0.3%, 4.3%, 27.2% and 68.3% supply and demand probability intervals as well as for the corresponding lower supply and demand probability intervals.

<table>
<thead>
<tr>
<th>Demand &amp; supply probability intervals</th>
<th>Year attaining demand &amp; supply equilibrium (years of interval overlap)</th>
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<tbody>
<tr>
<td>Upper 0.3% intervals</td>
<td>2000 (year 6) to 2003 (year 9)</td>
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<tr>
<td>Upper 4.3% intervals</td>
<td>2000.5 (year 6.5) to 2003.5 (year 9.5)</td>
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<tr>
<td>Upper 27.2% intervals</td>
<td>2001 (year 7) to 2005.6 (year 11.5)</td>
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<tr>
<td>Upper 68.3% intervals</td>
<td>2002 (year 8) to 2007 (year 13.5)</td>
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<td>Median</td>
<td>2005 (year 11)</td>
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<tr>
<td>Lower 0.3% intervals</td>
<td>2011 (year 17) to 2023 (year 29)</td>
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<tr>
<td>Lower 4.3% intervals</td>
<td>2008 (year 14) to 2017 (year 23)</td>
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<tr>
<td>Lower 27.2% intervals</td>
<td>2005.5 (year 11.5) to 2013 (year 19)</td>
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<tr>
<td>Lower 68.3% intervals</td>
<td>2003.5 (year 9.5) to 2011.5 (year 16.5)</td>
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The findings revisited in the table show that there is only a 0.3% probability that the equilibrium between the supply and demand for new entrant engineers will be attained the earliest in year 6. Yet, according to the median projection result, equilibrium will only be attained in year 11. An even more disturbing revelation is that, based on the most likely 68.3% probability interval, the balance between the supply and demand for the new entrant engineers to the South African labour market will not be realised until the earliest in year 8. These will be years which may be regarded as acceptable from the point of view of the individual since the engineer will be assured of a job, but from the point of view of the nation are probably not so desirable.

Conclusion

The projections show that the numbers of technically skilled people required annually go far beyond the existing capacity of South Africa’s higher educational institutions. Economic growth and implementation of development programmes are
Figure 1: Fractiles of the probability distribution of the future demand for new entrant engineers to the South African labour market

Figure 2: Fractiles of the probability distribution of the future supply of new entrant engineers to the South African labour market

Figure 3: Fractiles of the probability distribution of the future interaction between the supply and demand for new entrant engineers to the South African labour market
being retarded by the lack of sufficient high-level personnel. This means that a substantial increase in capacity is needed if South Africa's educational system is to meet the challenge. Increased production of skilled human personnel may generate an absorption bottleneck in the short term, but for longer term development, a greater skill capacity is essential. Apart from the increasing personnel needs, in the form of high-level skills and competencies, the economy can only hope to answer the challenges and demands of growth and job creation in the context of globalization and internal competitiveness to the extent that the infrastructure and capacity for acquiring and applying new and relevant knowledge are developed and advanced. A globally competitive economy depends on an industrial set-up which is characterized by continuous technological improvement.

Many economic and social factors will exert an influence on the future of science and technology in South Africa. On the negative side, there is an ongoing, historical decline in the share that mining and other primary products contribute to South Africa's gross domestic product (GDP). Another factor that has in the past and will, without doubt, in the future contribute to the declining demand for engineers is that productivity in South Africa seems to increase at a slower rate than that of its trading partners.

Output per employee in manufacturing increased on average by only 1.4 per cent per annum over the period 1970 to 1989, compared to 2.8 per cent in the USA; 5.8 per cent in Japan; 2.2 per cent in Germany; 3.1 per cent in the United Kingdom, and 9.3 per cent in Korea. Labour productivity increased by 1.0 per cent per annum in 1980 to 1993. The growth in labour productivity accelerated from -0.6 per cent in 1990 to 2.2 per cent in 1991 and, even more significantly, to 3.2 per cent in 1993.

There has been and possibly will still be factors that distort the cost of capital versus that of labour which, compared to the relative scarcity of these resources. This has resulted in the demand for capital being stimulated and the demand for labour being discouraged as is the case portrayed by the outcome of the above future engineering demand projections. Negative interest rates, below inflation, generous tax concessions on certain types of investment, and overvalued exchange rates have, for instance, in the past kept the cost capital relatively low, although it is a scarce factor of production. One of the results of the distortion of the prices of capital and labour is a very sharp increase in the capital intensity of the economy. An increase in the capital labour ratio has meant that, to an increasing extent, labour is being replaced by capital in the South African economy. This is contrary to the relative shortage of capital and abundance of labour, especially the unskilled labour (Barker, 1995:91).

Overall, South Africa has one of the highest unemployment rates in the world of 32.6% in 1994, ranging from 6% for whites, 17% for Asians and 23% for coloureds to 41% for Africans. Similarly, income distribution in South Africa is among the most unequal in the world. Based upon estimates of the Gini-coefficient during the 1970s and the 1980s, the bottom 60% of income earners captured a mere 13.5% of national income, while the share of the richest 10% of households was 50%. The mean income of the lowest 10% of households was 139 times lower than the mean of the richest 10%. Inequality between racial groups has lessened somewhat since 1970, but remains heavily biased towards whites, who make up 12.8% of the population and earn 58.5% of total personal income. This has resulted in thwarted consumer demand due to low disposable income and few assets of the majority of the population, particularly those in rural areas.

Recommendations

South Africa needs to adopt a national strategy to address the supply and demand and interaction between supply and demand of engineering and technological skills in the labour market. A strategy must be developed and pressure brought to bear to ensure that such a policy is developed and implemented as a matter of urgency. This calls for a dialogue between the engineering profession and the education authorities as well as leading employers and the private sector for support, including funding to implement the detailed recommendations emanating from the dialogue. The engineering profession should join forces with the major employer bodies, Federated Chamber of Industries (FCI), "Afrikaans Handelsinstituut" (AH), Associated Chamber of Commerce (Assocom) and Steel and Engineering Industries Federation of South Africa (SEIFSA), in their endeavour to reform the education system so as to give higher priority to the needs of the economy and employers. Such a strategy should focus on, amongst other issues, establishing feedback mechanisms between the education system and the economy on skill requirements; addressing issues pertaining to funding of qualified students; more reliance on local human resources; addressing career guidance in schools, and setting up partnerships with industrialized countries to establish practically oriented industrial training institutes for students as well as employees already in service.

Although economic growth as such is very important for job creation, a country such as South Africa also needs to create more employment opportunities for every percentage point increase in real GDP than is the case at the moment. Unfortunately the opposite has been happening over the past two decades.
The labour absorption capacity of the economy has been and is still witnessing a continued decline. In order to arrest and reverse this trend, attention must be given to, among other things, appropriate technology, that is technology which takes into account the relative shortage of capital, and the relative abundance of semi- and unskilled labour in South Africa. The process of inward industrialization could also assist in turning around the declining trend of employment elasticity. Inward industrialization would increase the effective demand for locally produced basic goods and products because of various factors operating together. These factors are, for instance, increasing real income among lower income categories; falling birth rates among communities; higher urbanization rates; and more government spending on less privileged communities. The combination of these factors should unleash an effective demand for basic consumer goods, namely clothing, shoes, furniture, food and other facilities, for example, low cost housing. Most of these goods and services can be produced in a labour intensive manner, but have low import content and also require a lower skilled labour component to produce. Little additional pressure will thus be placed on the balance of payments or the supply of skilled labour. Housing is especially important in this regard. It has been ascertained that more job opportunities are created for every million Rand invested in construction than in any other sector.

One of the other important preconditions for the success of inward industrialization is that real wage increases should be combined with productivity increases. This will lead to an increase both in real incomes, i.e. effective demand, and concomitantly in production. A further precondition is the stimulation of the small business and informal sectors, so that the benefits of the inward industrialization process can be spread widely among the South African population. The process will probably not be sustainable without active government involvement and targeted expenditure. There is a need to increase the output of engineers from our universities with emphasis on micro-technology in view of the globalization of economies. It has been indicated earlier that the new South Africa will make exceptionally high demands on technology and the question is whether we realize this and are already planning for it. The fact is that we have built up such a backlog and that it will be difficult to catch up, if ever. The role of the engineer will become increasingly important. The use and training of engineers should be the cornerstone of future strategic planning as a contributory factor to a healthy and prosperous new decade in South Africa.

An improvement in productivity is important to attain a higher economic growth rate. As indicated earlier, improvements in productivity are making a relatively small contribution to economic growth in South Africa. In the case of many of its competitors, productivity is responsible for a noticeably higher share in economic growth. Increased productivity is the catalyst which successfully transforms resources into larger output and requires managerial skill, ingenuity and creativity. The quality of management and the ability to organize and motivate are the factors which determine the effective utilization of resources. Managers therefore have the task of creating a more productive work force by educating the work force and enhancing skills. Another factor affecting productivity relates to the poor utilization of high-level human resources and the shortage of supporting staff. Engineers, technicians and graduates employed in various scientific fields could indeed be more optimally utilized if the necessary supporting staff is available. This does not imply, however, that labour alone is responsible for improving productivity. Any measurement of productivity reflects the combined influence of a number of factors, including change in technology; capital investment; utilization of production capacity; management skills; the quality of labour; economies of scale, and the structure of the economy.

Another important recommendation pertains to a need for more focus on training and upgrading of the existing technical skills in the South African labour market, especially in the light of the declining jobs in production-related activities. An efficient education and training programme will play a major role not only in supporting higher economic growth, but will also contribute to finding a better match between the availability of skills and the demands of the labour market.

The GEAR strategy should serve to empower more of the black majority, at least in the near term, through job creation and access to basic facilities and services, and thus widen the customer base for many of the industrial and agricultural fruits of technology. Executing the programme will require great creativity in combining technology with labour intensive methods. The former is indispensable for "delivering the goods" on the scale and within the time frame socially desirable. The latter is fundamental for job creation. The combination could be important in construction of housing, schools, roads and other infrastructure and in extending potable water supply, electricity and telecommunications to rural areas and townships. All this means that there will be an increased demand, at least in the short to medium term, for a whole array of applied scientists, engineers and technologists with university training. The demand for a host of technicians and artisans in the related fields could even be greater.

There can be no doubt that the scarcity of high-level skills is hampering economic development as well as South Africa's competitiveness in the world market. If South Africa is to compete economically on the world stage, it will need increasing numbers of competent, higher-education trained professionals and knowledge workers with world-class skills to strengthen its enterprises. These skills include the higher level technological and
management capacities required for value-added world-class manufacturing; the capability to generate innovative solutions to the problems confronting basic services and infrastructure provision, and the competencies required for the effective management of the economy and public service. If South Africa is to build this necessary skills base, many thousands of new or retrained professionals in the next generation must come from the black community. There is still a possibility of brain gain, namely attracting back to the country South African scientists and engineers who found opportunities for work abroad, particularly in the USA, Western Europe and Africa. Both "gain" and "drain" may depend greatly on the new decision makers' capacity to articulate a challenging, inclusive vision for science and technology. It is thus imperative to mention that one of the biggest influences on the future demand and supply of science and engineering skills is the strategic framework within which they operate. When the strategic vision of leadership changes, whether at national, industry, or individual firm level, a host of other changes in human resource flows eventually have to follow. A science and engineering snapshot of South Africa taken today, with all its strengths and imbalances, in numerical, racial, occupational and even cultural terms, reflects not only political history and individual genius, but also the strategic framework in which present resources were developed.

In the recent past South Africa has been forced to fall back on its human resources to meet the technical skills demands of the economy. This has meant drawing on black human resources to meet the balance. But the education of black people has in the been past skewed in the direction of academic education, leading successively to lower numbers of black matric pupils prepared and competent to take on technical studies in universities and technikons. There is thus a need for the development of academic support programmes at technikons and universities to introduce an appropriately structured bridging year to facilitate the progress of students from disadvantaged backgrounds. It is also important to consider the support and expansion of the programme for technological careers (PROTEC) in order to increase the supply of suitable matriculants to tertiary engineering education. Above all, the shortage of mathematics, science and language teachers and the building and equipping of laboratories and libraries in schools should be addressed. Added to this is the need to improve access to funding for those students with suitable qualifications from disadvantaged backgrounds who apply for entrance to technical colleges, technikons and universities.

References


