# Indonesia's regional welfare development, 1900-1990: new anthropometric evidence

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**Abstract**

The study of heights provides a promising approach to a better understanding of the biological welfare of countries and regions, for which conventional economic data are relatively sparse. This paper uses a unique dataset of nearly 10,000 Indonesian soldiers recruited for the Royal Netherlands East Indies Army (KNIL), in combination with the data of another 10,000 individuals from the Indonesian Family Life Surveys (IFLS). Both datasets contain information on an individual basis on, amongst others, height and place of birth for almost the entire twentieth century.

The aim of this paper is first to present the development of heights in Indonesia and its regions in the twentieth century. We find that heights in the Outer Provinces were consistently higher than on Java until around 1970 when Java surpassed the Outer Provinces both in height and per capita income. Following the literature, we try to explain the (regional) height developments in terms of the available income. We find that in the first half of the century heights were largely driven by the distribution of income whereas from ca. 1950 onwards they moved in line with average income.

## 1. Introduction

Recent years witnessed a large increase in the study of anthropometrics (i.e. Komlos 1998; 2004; Stegl and Baten 2009). It allows a way into the welfare analysis of regions and periods with scarce data. This is also the case for Indonesia where the data on economic and social welfare before 1993 are impaired (Van der Eng 2002). This has led to widely divergent views of welfare development (i.e. Booth 1998; Dick *et al* 2002). Especially in the first half of the twentieth century, government policy on welfare (e.g. the "ethical policy") was by some authors classified as a success and by other as a failure (Van de Eng 1996a). This discussion is even bigger when one tries to analyze the different regional development within Indonesia. Therefore, the use of height development, which allows us a consistent way to assess the biological welfare in Indonesia over time and across regions, is a valuable addition to current research.

In this paper, we try to construct a consistent dataset of heights of Indonesia and make a subdivision between Java and the Outer Provinces. In the next Section we present the data. In section 3, we move on to the relationship between height and income. We will address how this relationship functions (or not functions) via food consumption and health measures. This seems to indicate that there was little evidence before the 1930s that it was average income that drove heights. Instead, the income and the intake of calories and proteins seemed to become increasingly uneven. This is analyzed in Section 4 where we decompose the growth in height into a level effect of income, a distribution effect of income, and a residual factor. We end with a brief conclusion.

## 2. Height data for Indonesia

Few data on inequality and income are available for developing economies before the 1950s.[1] Therefore, more and more studies direct their attention to anthropometric data (i.e. Komlos 1985; Austin, Baten and Van Leeuwen 2009). For Indonesia, such studies include Van der Eng (1995) and Baten, Stegl, and Van der Eng (2010).

The latter study estimates the development of heights in Indonesia between ca. 1750 and 1990 based on four different main sources, being slave data, migrant data, medical/anthropometric studies, and a recent dataset of the Indonesian Family Life Survey (IFLS) covering birth cohorts in the 1940s to 1980s. For the first half of the twentieth century, they rely on a combination of several different medical/anthropometric studies.

[1] An exception is Baten *et al* (2009). However, they estimate many of their Gini coefficients on the basis of anthropometric data.

Although these may reflect the over-all development of height within Indonesian society, the underlying sources of the data are still relatively fragmented. Equally, the paper does not go into possible interregional patterns while in the literature often the difference between Java and the Outer Provinces is often stressed. Therefore, we use a new dataset for the period 1900-1980 that, with all its related problems, is consistent and allows us to look at interregional development.

The data are derived from two main sources. We have data from Indonesian military personnel that were born between ca. 1890 and 1935 and joined the Dutch forces between 1945 and 1947. Although the original muster rolls are missing up to now, the data are still reported in the "pension schemes" (Nationaal Archief). These military recruits number 9,085 in total with most of them recording data on names, ages, place of birth, and height. Most birth years are located between 1900 and 1930 (see Table 1). We extend this information to the post-War period using the Indonesian Family Life Surveys (IFLS-1 and -4) for 1992 and 2007. These contain the same information on people with birth years ranging from the 1930s to the 1990s.

The problems in using military data to derive an over-all trend in population development are well known (i.e. Komlos 2004). Since our post 1930 data is based on a sample of the complete population while the pre-1930 data are based on military recruits, three main problems have to be addressed in order to make these data comparable over time. First, the age range of the military recruits varies between the 20s and 50s, with the majority being between 20 and 40 years old. Therefore, we only included men from above age 20 and under age 60 from the IFLS. We used age 20 since growth after this time is often insignificant (i.e. Guntupalli and Baten 2006). Yet, people at an older age may be shrinking (Galloway 1988; Cline, Boyer and Burrows 1989; Chandler and Bock 1991), even though this effect may be relatively small because those who survive till those ages generally had better nourishment. Yet, since these studies are all European, one could question their applicability. Morgan (2010), however, using a sample of Chinese migrants in Australia, arrived at the conclusion that ethnicity is not important in shrinking at old ages. Following Cline, Boyer and Burrows (1989), he found that up to age 60 shrinking was about 1 centimetre. We therefore follow the suggestion of Baten, Stegl, and Van der Eng (2010) and add one centimetre to those people in the IFLS sample above age 54 (hence, the 1930s age cohort). An additional argument for doing so is that our calculations using the (corrected) military data, which are far less subject to shrinking bias because of old age, show that the average height in the 1930s is about a centimetre higher than those of the IFLS.

These results for the IFLS together with the military data are reported in Table 1. The table seems to give a plausible picture. We see a move over time from people in the lowest

**Table 1**

**Distribution of Indonesian conscripts by height intervals in 1895-1935 (military) and 1935-1985 (IFLS)**

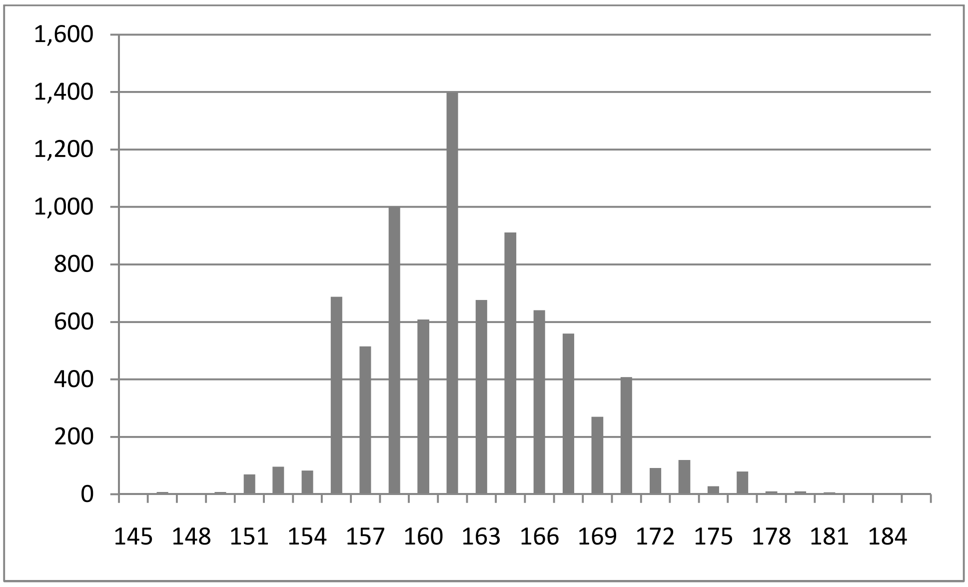
| Source | No. Observations | year | Height in cm >166 | >164 | >158 | >155 | >150 | <150 |
|---|---|---|---|---|---|---|---|---|
| **National Archive** | 65 | 1895 | 16.9% | 23.1% | 35.4% | 10.8% | 7.7% | 6.2% |
| | 82 | 1905 | 25.6% | 26.8% | 24.4% | 4.9% | 7.3% | 11.0% |
| | 1,310 | 1915 | 20.7% | 24.9% | 29.9% | 10.2% | 4.7% | 9.7% |
| | 6,713 | 1925 | 15.0% | 22.2% | 32.0% | 12.5% | 6.4% | 11.8% |
| | 124 | 1935 | 5.6% | 17.7% | 33.9% | 15.3% | 8.9% | 18.5% |
| **IFLS** | 871 | *1935 | 11.7% | 17.1% | 27.7% | 10.0% | 5.4% | 28.0% |
| | 1,058 | 1945 | 15.5% | 20.2% | 28.3% | 8.7% | 6.0% | 21.3% |
| | 1,571 | 1955 | 19.7% | 24.7% | 27.3% | 8.1% | 5.3% | 15.0% |
| | 1,289 | 1965 | 20.6% | 25.9% | 27.0% | 7.1% | 5.3% | 14.0% |
| | 3,527 | 1975 | 30.4% | 27.0% | 22.8% | 6.3% | 3.1% | 10.5% |
| | 2,877 | 1985 | 34.9% | 28.0% | 21.3% | 4.9% | 2.5% | 8.4% |

*the IFLS data for people older than age 54 are increased with 1 cm (e.g. the age cohort 1935).

height class to higher classes. Equally, the size of the higher height classes is declining in the 1930s and 1940s, even after correcting for shrinking at older ages. Finally, after the 1930s, the data are obtained from the IFLS which are not subject to height truncation. Hence, we expect the lower height classes to be bigger than for the military data. Indeed, there is a jump from on average 14% in the lowest height category till over 20%.

The second problem in making the data comparable is height truncation. The military data are likely to be biased since there was a minimum height requirement for being enlisted in military service. Yet, whereas for the Dutch (and Ghanese) soldiers in the Royal Dutch Indies Army this was initially set at 162 centimetres (Austin, Baten, and Van Leeuwen 2009), figure 1 seems to indicate that the truncation point for the soldiers in the sample was, with 155 centimetres, considerably lower. This biases the results since the mean height will be overestimated as the lower heights are omitted from the sample. The most common

**Figure 1: Distribution of height of Indonesian recruits born between 1890 and 1935**




method to correct for this bias is to assume a normal distribution of heights in the population and use a modified likelihood function to correct for truncation when estimating the population moments. The normality assumption of heights may be justified in modern samples but it is not necessarily realistic for historical periods when a large share of the population has an average income very close to the subsistence level. In such cases, even minor fluctuations might have significant impact on their nutrition, and height (i.e. A'Hearn, Peracchi and Vecchi 2008). In the case of Indonesia, this bias may be important since in the 1930s a large percentage of the people became close to subsistence level. Indeed Van Leeuwen and Foldvari (2009) estimate in the 1930s over 65% of the population at the poverty line of 1 USD/day set by the World Bank (or 2 USD using survey data) lived. For this reason we use a 3 parameter skew-normal (SN) probability distribution that will capture the non-normality of the height distribution when correcting for truncation (i.e. O'Hagan and Leonhard 1976 or Azzalini and Capitano 1999) (see appendix A.1).

Finally, we encountered the problem, especially in the military data, that the regional shares of recruits changes over time. For example, the 1900 50% of the recruits came from Java while in the 1910s this number had risen to 60%. This may bias the results when there are height differences among the different regions. Also, our data show that ethnicity and region are highly correlated. Yet, most studies seem to show that ethnicity does not have a strong effect on height. Yet, even if we assume that both regional differences and genes do not play a role in height development, cultural aspect in food consumption may have an effect as well. To give just one example, as pointed out by Holleman, Koolhaas, and Nijholt (1939, 306-320) the Chinese diet deviates considerably from the Javanese one, even among those Chinese born in Indonesia. Koolhaas *et al* (Table V) show that the average Chinese family in Batavia in the 1930s consumes 48.7 g of proteins and a total of 1,448 kcalories per capita. This contrasts with ca. 40.2 g and 1,520 kcal for Javanese respectively. This suggests that the amount of proteins for Javanese on average was lower while the amount of kcalories (largely vegetarian diet) was higher. That means that, even assuming the same genetics, Chinese are expected to be taller on average since proteins are important for growth (Steckel 1999). Indeed, in our dataset we find that Chinese on average to be almost a centimeter taller than the average Indonesian and 2 centimeters compared to a Javanese. Hence, where applicable, we added a variable capturing the changing provincial/ethnic shares.

The results are given in Table 2 below for Java& Madura, the Outer Provinces and Indonesia. Two interesting points can be deduced from this Table and figure 2 below. First,

**Table 2**

**Height of men in Indonesia**

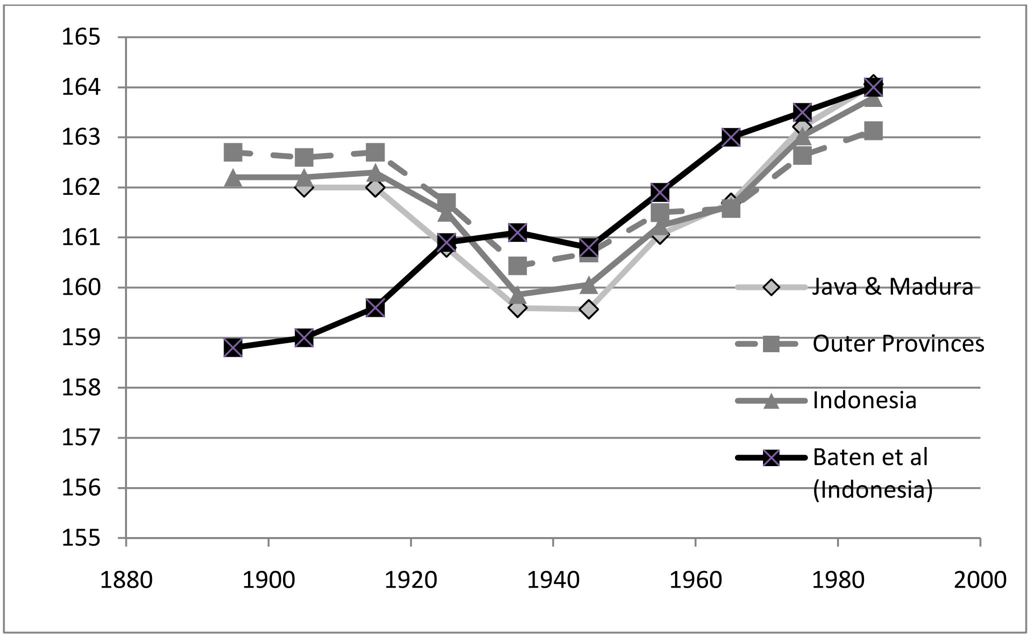
| | This text Java & Madura | Outer Provinces | Indonesia | Baten Stegl, and Van der Eng Indonesia |
|---|---|---|---|---|
| *1895 | 160.8 | 162.7 | 162.2 | 158.8 |
| 1905 | 162.0 | 162.6 | 162.2 | 159.0 |
| 1915 | 162.0 | 162.7 | 162.3 | 159.6 |
| 1925 | 160.8 | 161.7 | 161.5 | 160.9 |
| 1935 | 159.6 | 160.4 | 159.9 | 161.1 |
| 1945 | 159.6 | 160.7 | 160.1 | 160.8 |
| 1955 | 161.1 | 161.5 | 161.2 | 161.9 |
| 1965 | 161.7 | 161.6 | 161.6 | 163.0 |
| 1975 | 163.2 | 162.6 | 163.0 | 163.5 |
| 1985 | 164.1 | 163.1 | 163.8 | 163.4 |

*Note:* *IFLS data from people over age 54 (birth decade 1930) are increased with 1 cm.

* Outlier in 1905 for Java corrected using truncreg.

the data generally move in line with those of Baten, Stegl, and Van der Eng (2010). However, whereas we find either stability or a modest decline between ca. 1890 and 1930, they find a substantial increase.[2] Our finding corresponds with their findings for female migrants (and to

**Figure 2: Height (cm) 1895-1985**




*Source:* Baten, Stegl, and Van der Eng (2010); This text

some extent even with their adult migrants, but is at odds with the data they present based on anthropological and medical surveys. Secondly, we find that heights on Java are consistently lower than those in the Outer Provinces until ca. 1965, when this pattern is reversed.

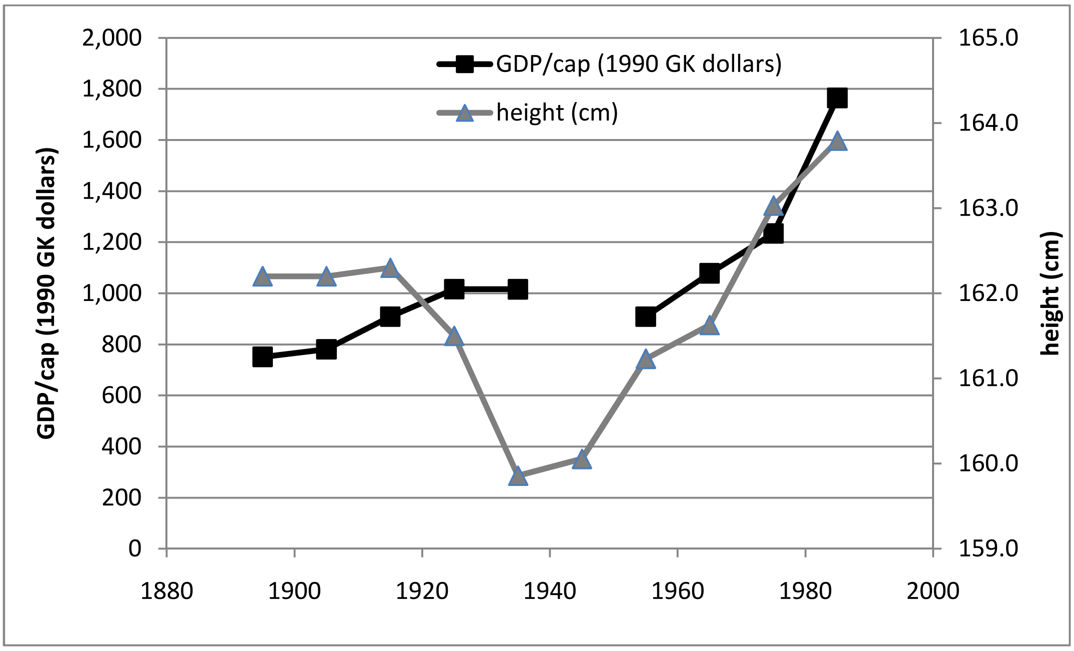
## 3. Height development and income in Indonesia

As Table 2 and Figure 2 show, we find stability, or a small decrease, in heights between ca. 1890 and 1930 with a further through during the economic crisis in the 1930s and World War II. After World War II we find a continuous increase where the height increase in Java outperformed that in the Outer Provinces.

These data are, as is also argued by Baten, Stegl, and Van der Eng (2010) strongly, although imperfectly, correlated with GDP per capita. Indeed, if we look at Figure 3, we see that the relation between capita GDP and stature is only strongly related after ca. 1950 when both variables increased. However, before 1930 we see an increase in GDP/cap which

[2] As a cross-check we also applied a standard truncated regression correcting for birth region and ethnicity and derived the trend in heights using time dummies. However, this did not lead to different results.

**Figure 3: comparison of height and GDP/cap for Indonesia**




*Source:* Maddison (2003); BPS (2010); This text

*Note:* GDP per capita from 1960 onwards without oil and gas.

is accompanied by a stability/decrease in height.

Following Steckel (1995, 1914) and Bassino (2006, 73), we estimate the relation between height and income. They start by assuming that the relationship between income and height can be specified as:

$$h_i = \alpha + \beta \ln y_i + \sum_{j=1}^{p} \gamma_j X_{j,i} + u_i \qquad (1)$$

where h and y denotes height and some measure of per capita income respectively, X denotes p different other exogenous variables (geographical, social factors etc) while u is an error term ($u \sim iid(0, \sigma_u^2)$). We use data for 6 regions: West Java, Central Java, East Java and Batavia (all from Java) and Sumatra and "Other Outer Provinces". Height data were calculated from our dataset as described in the previous section. As income data, we used wage data of unskilled labour from Dros (1992) for the period up to 1940. The BPS provided GDP/cap data (non oil) for 1970, 1980, and 1990.

Table 3 shows that the logarithm of wages affects height with a factor of 1.11 over the entire century. That is, for every percentage increase in income, heights increase with ca. 1.11

mm. This is relatively low compared with the results from Bassino (2006) who found for Japan a coefficient of between 1 and 3. Since Indonesia is a poorer country, we would only for this reason (lower budget) expect a stronger relation, though. However, Bassino (2006)

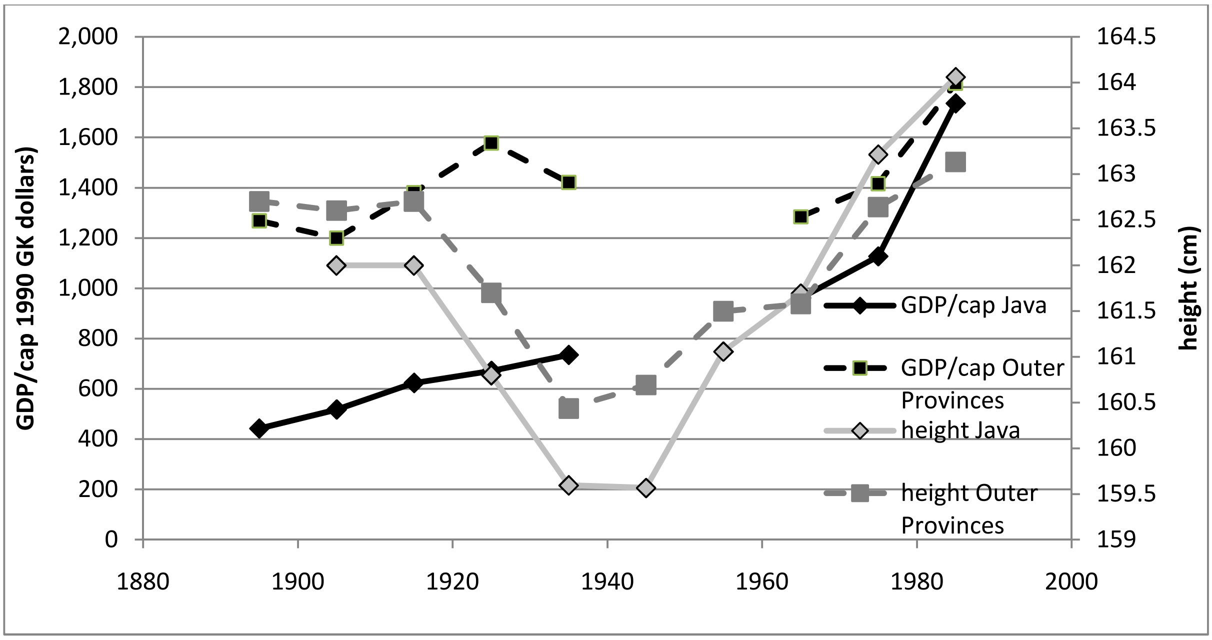
**Table 3**

| Dependent variable: height (cm) | Coefficient | Robust standard error |
|---|---|---|
| Consta4nt | 155.803 | 3.054 |
| Ln GDP/cap | 1.111 | 0.416 |
| D lnwage | -29.897 | 18.157 |
| Ln GDP/cap*Dlnwage | 3.590 | 2.374 |
| DJava Central | -0.407 | 0.619 |
| D Java East | -0.386 | 0.455 |
| D Jakarta | -0.576 | 0.596 |
| D Sumatra | -0.914 | 0.426 |
| D “Other Outer Provinces” | -1.584 | 0.551 |
| | | |
| R2 | 0.593 | |
| N | 31 | |

used per capita income, which is not completely comparable to GDP per capita. From Table 3 we can deduct that if we express this relation for Indonesia in wages the coefficient becomes 1.11+3.59=4.70, which about the same as found by Steckel (1995). This suggests that unskilled wages are stronger related to height than is per capita GDP. And this is even stronger the case in Java than in the Outer Provinces. All region dummies are insignificant, except for Sumatra and the “Other’ Outer Provinces. This suggests that, given GDP per capita, heights are lower in the Outer Provinces than on Java, possibly because of a weaker disease environment.

The same can also be deducted from Figure 4. From Van der Eng (2002) and Van Zanden (2002) and the BPS (2010), we can obtain the GDP/cap for both Java and the Outer Provinces, which after converting to 1990 GK dollars, is plotted versus stature. As we can see, heights seem to be stable both on Java and the Outer Provinces up to the 1930s, when GDP/cap increases. Only after World War II we see that GDP/cap and heights are stronger related in both regions. Hence, over-all GDP/cap and heights are at best weakly related. Furthermore, we find that over-all, heights and per capita GDP in the Outer Provinces are consistently higher than on Java up to 1955. Thereafter, we can see that heights keep

**Figure 4: height and per capita GDP for Java and the Outer Provinces**




*Source:* Van Zanden 2002; Maddison 2003;

*Note:* GDP per capita from 1960 without oil and gas.

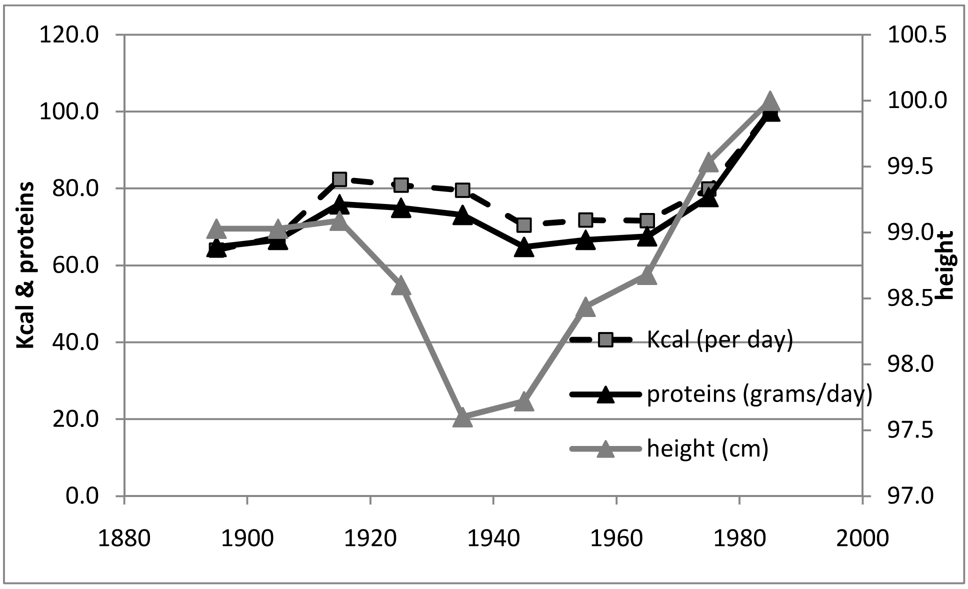
increasing on Java, while they seem to stagnate in the Outer Provinces.[3] This stagnation of heights in the Outer Provinces went hand in hand with a stagnation of per capita GDP which led to the per capita GDP (excluding oil and gas) of Java surpassing that of the Outer Provinces around 1990. However, stature in Java surpassed that of the Outer Provinces already in 1965, suggesting, as we found above, that the relation between height and GDP/cap is weaker in the Outer Provinces than on Java.

Java and the Outer Provinces thus seem to exhibit a convergence in both GDP/cap and heights. However, in the first half of the twentieth century both regions exhibit a rising per capita GDP together with stable/declining heights. So, what is then driving height development? As has been often argued in the literature (i.e. Steckel 1995), GDP/cap increases health provisions and protein and caloric intake, both factors increasing average height.

Indeed, figure 5 depicts the height development and the caloric and protein consumption per day. As one can see, there is a strong relation between, on the on hand,

[3] There are distinct regional patterns. West Java, Jakarta, and East Java showed a remarkable increase in heights while Central java lagged behind. Equally, in the Outer Provinces Sumatra lagged behind while the "other" Outer Provinces managed to keep up with Java.

**Figure 5: proteins & kcal supply per day and heights (1985=100)**



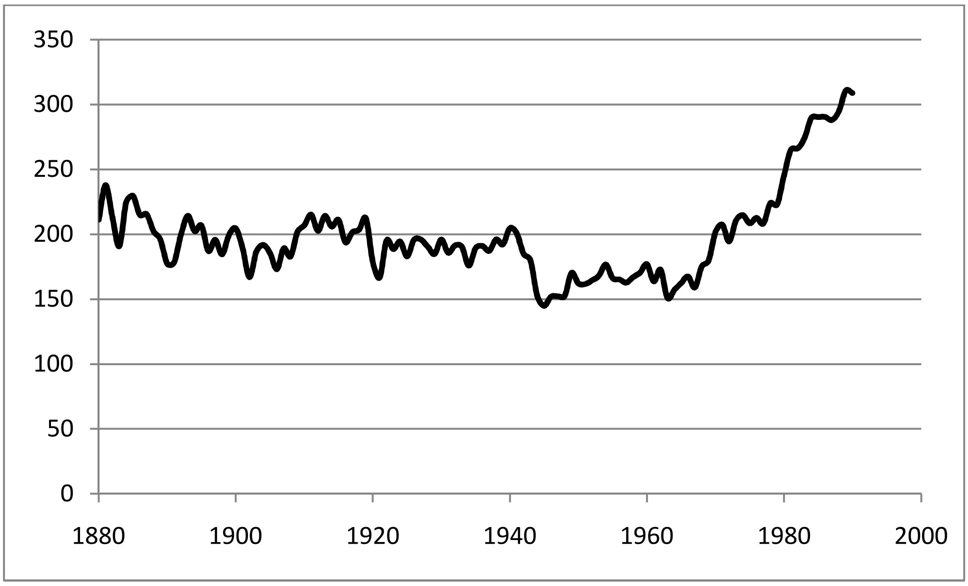

*Source:* Van der Eng 2000, Table 6; This text

kcalories & proteins and, on the other hand, growth after ca. 1950. In the first half of the twentieth century, however, the relation is much weaker. Clearly, heights went down after 1905, while proteins and kcalories only saw a marginal decline from 1915 onwards. Yet, no matter how marginal, there is a correlation between heights and kcalories & proteins even though GDP/cap went up over the period.

For the period after 1950 the explanation of this pattern seems straightforward: with increasing incomes, also food consumption and health expenditure increased considerably. Indeed, if we look at indicators of health such as life expectancy at birth, we find a staggering increase from 41.5 years in 1960 to 70.6 in 2007 (World Bank 2009). Other social indicators, most notably education, also increased. Where average years of education did not exceed 1 year before World War II, in the years up to 2000 it increased sevenfold (Van Leeuwen 2007, appendix 4A). This increase in social services was partly driven by the decolonization, requiring the government to increase its support for the population and partly by the oil crises in the 1970s which increased government revenue. Especially the 1970s and 1980s thus saw strong investments in health and education. Not only did government expenditure rose considerably as a percentage of GDP, but also the share of other services (including health and education) rose from 16.5% in 1971 to 21.6% in 1995 (Marks 2009, Table 2.15).

The other factor affecting height development after WWII was the increased food consumption. Caloric intake increased from a low point of 1,626 in 1946-50 to 2,830 in 1991-95 (Van der Eng 1994; 2000). At the same time, the amount of proteins increased from 33 to 65 grams a day. This increase was largely caused by an increase in per capita rice output (see figure 6). From the supply side, this was caused by heavy government investing

**Figure 6: Rice output (kg per capita)**




*Source:* Van der Eng 1996b, Table A.6

in high yielding varieties and irrigation, made possible by the expanding of the government budget caused by the increase in oil prices in the 1970s. From the demand side, this increase was caused by fast per capita economic growth. Between 1970 and 1990, average incomes almost tripled from 1,181 to 3,276 GK dollars with an income elasticity for rice of about 0.7 (Van der Eng 2000). In addition, the pro-poor growth policy (Timmer 2004) increased the purchasing power of the poor with allowed them to substitute low quality rice for cheap cassava. This increased the availability of proteins, and hence increased height, since rice has a far higher level of proteins. Furthermore, the consumption of cassava increases the synthesis of the enzyme rhodanes, necessary to eliminate some dietary toxins. However, it does so by increasing the body's demand for amino acids, which are the building blocks of proteins, hence effectively reducing the amount of proteins available (Padmaja, 1996). Hence, its reduced consumption further rincreased the available proteins and increased average heights. Indeed, a survey from the 1950s shows that cassava was only eaten as the main dish in the very poor regions on Madura and East Java while these regions had about

2/3 of the level of protein and only 1/2 of the levels of vitamin B1 intake per day witnessed in the rice and maize consuming regions (Bailey 1962, 5). This not only hampered their growth, but also increased their susceptibility for diseases.

Indeed, it had been only in the early twentieth century that cassava, being a less favoured but more productive crop, started gaining ground. This was in a period of both rising incomes and rising caloric intake (Van der Eng 2000). Indeed, in figure 6 we can see that per capita rice production remained about the same between 1880 and 1940. Hence, the increase in calories per day up to ca. 1915 as shown in Figure 5 must have largely come from other crops like cassava and maize. At the same time, Van der Eng (2000, 599) shows that the amount of proteins slightly increased between 1900 and 1920. The increase was mainly caused by an increase in peanuts and soybeans (largely eaten in side dishes).

How do we square this increase in income and caloric consumption with decreases in height? In general, being the less favored crop, the increase in cassava is associated with impoverishment of the population. Indeed, there is a large colonial literature on the "decreasing prosperity" (or "Mindere Welvaart") in the decades around 1900 (i.e. Steinmetz 1914; Meijer Ranneft en Huender 1926; Rohrman 1932; Hugenholtz 1986, 180). Although the actual decrease in prosperity is doubted by some (i.e. Van der Eng 1996), it seems clear that the unskilled wages decreased in the first half of the century (see Table 3). Recognizing the decline in unskilled wages, the constant share of people in absolute poverty (Van Leeuwen and Foldvari 2009), and the actual decline in kcalories per capita for the lower classes based on the underlying survey data (although we recognize that they are not always representative) (see Van der Eng 2000, Table 6), we expect an impoverishment and reduction in consumption of the lower classes in the population. In this respect, the fact that the small increase in kcalories between 1880 and 1915 was caused almost exclusively by cassava and maize (Van der Eng 2000, 598) can be considered indicative of impoverishment of the bottom income classes of Indonesian society. Indeed, cassava was largely eaten as a side dish. Only in "some poor regions of central Java, such as Bojonegoro and Gunungkidul, did cassava replace rice" (Van der Eng 2000, 600) while the same tendency took place in Madura where the consumption of rice slowly was replaced by other crops in the 1920s (Boeke 1926).

This problem worsened in the 1920s when expanding rice cultivation was no longer possible and kcalories per capita decreased. Van der Eng (2000) argues that this decline is largely cosmetic, caused by very high production of food in 1918 (due to high international prices), and that the decline largely took place in cassava exports. Hence, according to Van der Eng, the food production does not fully account for the decline in heights in the 1920s.

Therefore, he follows Komlos (1998) in arguing that, with a rise in average income, and a rise of food prices relative to manufactures, consumers may have delegated part of their food products to purchases of other goods. Indeed, this argument implies that the substitution effect must be bigger than the income effect. This can have two causes. The first one is if rice is an inferior good. Yet, as pointed out by Van der Eng, the income elasticity in the 1970s was around 0.7. It is unlikely therefore, that before WWII it has been inferior. Indeed, this has also been explicitly stressed in a study at coolie expenditure in Batavia in 1937 when it is argued that the expenditure on food decreases in importance when wages go up, but increase expressed in money also when the wage increases (CKS 1939, 31).

The second reason for a decline in per capita food consumption with rising income is if the price of rice increases faster than the price of other goods. However, the price of rice does certainly not outperform the rise of the retail price index in the 1920s. This is certainly true for the 1930s when the price of rice even fell sharper than those of other products. This conclusion is also reached for Koetowinangoen by Ochse and Terra (1934, 93, 139) who find that rice is neither substituted nor that it increases in price versus the other products.

The increase in income in the first half of the century did do something for health care as well. First, it worked via government expenditure. Van Zanden and Marks (2011 forthcoming) argue that (government induced) services was rather successful. Indeed, there was a training of indigenous medical staff, building of hospitals, and campaigns against infectious diseases. However, as pointed out by Boomgaard (1986, 74) only the plague killed over 200,000 people in Indonesia during 1910-1942 (i.e. Hull 1987), which, compared to other diseases at this time “was not excessive”. Indeed, only influenza already killed 1.5 to 2 million people in1918 alone.

The practical result of the new government interest in health therefore seems limited, especially when one considers that many activities in the early 1920s were cut short because of lack of funding. Yet, the food situation also has a big effect on the health situation. First, because of the vitamin and caloric intake effectively can prevent illnesses and, second, if a population lives at bare subsistence, hygiene levels go down, ;less work is done on houses and agriculture. As we already mentioned, the food situation does not seem to be excessively low, but neither is it, on average, improving up to WWII. Indeed, De Langen (1934, 351) concluded for a study in Koetowinangoen in the 1930s that there is no real malnutrition nor is there an excessive evidence of illnesses. However, at the same time he stresses that the poorer households live at a level that can be called “bare bone subsistence” Overall, as pointed out by Baten, Stegl, and Van der Eng (2010, 12), health is gradual process and can thus not really account for change in height over this period.

The change in GDP/cap thus does not seem to explain the decrease in height in the period up to ca 1950, nor via decreased average consumption nor via decreased health. However, below table shows that unskilled real wages seems to be a far better indicator of the development of average heights as we also found in Table 3. In Table 4 we compare height, GDP/cap, and unskilled wages (1985=100). As becomes apparent, whereas GDP/cap

**Table 4**

| | Indonesia, 1985=100 | | |
|---|---|---|---|
| | male heights | GDP/cap | wage |
| 1895 | 99 | 43 | 133 |
| 1905 | 99 | 44 | 105 |
| 1915 | 99 | 52 | 99 |
| 1925 | 99 | 58 | 92 |
| 1935 | 98 | 58 | 97 |
| 1945 | 98 | | 55 |
| 1955 | 98 | 51 | 68 |
| 1965 | 99 | 61 | 41 |
| 1975 | 100 | 70 | 59 |
| 1985 | 100 | 100 | 100 |

*Source:* GDP/cap Van der Eng, Heights (this text), Wages Van Leeuwen (2007)

shows an almost continuous increase, unskilled wages decline first, and increase after the 1940s, more or less in line with heights.

Why is this the case? This decrease in Indonesian incomes can be caused if Indonesian GDP/cap goes down while that of Europeans and Chinese increase. However, the existing data from Polak (1979) and Maddison (1989) does not provide evidence for this, although Van Zanden and Marks (2011, forthcoming) argue that "income per capita of the Indonesian population increased by about 38% between 1880 and 1925, but inflation in this period was almost as large (27%), leaving almost no room for an increase in real income". Yet, whether or not we find an increase in GDP per capita for Indonesians, a general agreement seem to exist that GDP per capita for Asian people (largely Chinese) had increased considerably. However, the limited number of observations we have in our data for Chinese do not seem to indicate an increase in heights of Chinese over this period. Hence, no matter if

Indonesian GDP per capita goes up or not, it seems that in any case there is only a weak (or no) positive relation between height and GDP per capita.

The situation that unskilled wages seem to reflect height development better than GDP/cap suggests that income became increasingly unequally distributed. Indeed, we know that in the 1920s a strong increase in inequality took place (Booth 1988; Leigh and van der Eng 2009; Van Leeuwen and Foldvari 2009). Indeed, this argument that the ratio of unskilled wages to GDP/cap is indicative of the development of inequality is forcefully brought forward by Williamson (1998; 2000) and used in many other studies (i.e. Prados de la Escosura 2008; Baten *et al* 2009a). The main idea is that if GDP/cap grows faster than the unskilled wage, it reflects a growing inequality. In other words, the lower classes seem not to have equally profited from economic development. Their access of proteins and calories may even have decreased while that of the higher classes excessively went up. Indeed, Steckel (1995, 1912) argues that at a given level of income, height changes imply changing inequality.

## 4. Level -and distribution effects of income on height

Above discussion seems to indicate that prior to ca. 1950 the distribution of income had a large effect on height development while this pattern shifted after the 1950s and the level of income drove heights. To analyze this question, we decompose the height development in the level effect of income, the inequality effect of income, and a residual factor incorporating such things as illnesses etc. that are not directly influenced by income.

We start, as we did in Section 3, with assuming that the relationship between income and height can be specified as:

$$h_i = \alpha + \beta \ln y_i + \sum_{j=1}^{p} \gamma_j X_{j,i} + u_i \quad (2)$$

We would like to know how height was affected by the change in average income (with other factors taken as fixed), and the change in the distribution of income (measured by a change in variance). Since we have data on the average income and the Gini coefficients only, we need to assume that the income is lognormally distributed $\ln y \sim N(\mu, \sigma^2)$, the mean and standard deviation of the income is denoted by *m* and *d*. We can estimate the standard deviation of the log income from the Gini coefficient under lognormality as follows:

$$\sigma = \sqrt{2}\Phi^{-1}\left(\frac{1+G}{2}\right) \quad (3)$$

We know the following about lognormal distribution:

$$m = e^{\mu + \frac{\sigma^2}{2}} \text{ and } d^2 = e^{2\mu+\sigma^2}(e^{\sigma^2} - 1) \quad (4)$$

Using these, after some substitutions, we arrive at the following expression for the mean of height:

$$E(h) = \alpha + \ln\left( \frac{m}{\frac{m^2 + d^2}{m^2}} \right) + \sum_{j=1}^{p} \gamma_j E(X_{j,i}) \quad (5)$$

Using above expression, with fixed Xs, we can estimate the total effect of a change in the average income and income inequality on average heights:

$$\text{total effect} = \beta \left( \ln\left( \frac{m_t}{\frac{m_t^2 + d_t^2}{m_t^2}} \right) - \ln\left( \frac{m_{t-1}}{\frac{m_{t-1}^2 + d_{t-1}^2}{m_{t-1}^2}} \right) \right) \quad (6)$$

$$\text{mean effect} = \beta \left( \ln\left( \frac{m_t}{\frac{m_t^2 + d_{t-1}^2}{m_t^2}} \right) - \ln\left( \frac{m_{t-1}}{\frac{m_{t-1}^2 + d_{t-1}^2}{m_{t-1}^2}} \right) \right) \quad (7)$$

$$\text{variance effect} = \beta \left( \ln\left( \frac{m_{t-1}}{\frac{m_{t-1}^2 + d_t^2}{m_{t-1}^2}} \right) - \ln\left( \frac{m_{t-1}}{\frac{m_{t-1}^2 + d_{t-1}^2}{m_{t-1}^2}} \right) \right) \quad (8)$$

This decomposition requires information on $\beta$ (the coefficient of a regression between height and the log of per capita income) and the Gini coefficient. The coefficient $\beta$ can be obtained from Table 3, being 1.11 since we use GDP/cap. The Gini coefficients can be obtained from Leigh and Van der Eng (2010) and Van Leeuwen and Foldvari (2010). The results of the height growth decomposition are given in below Tables.

In Table 5 we reported the effect income had on height (in centimeters). As becomes immediately clear, for earlier periods the income level has almost no effect on the increase in heights. For example, between 1925 and 1935 the effect of the level of income explains -0.1 cm while the variance in income explains -0.5 cm out of a total decline in heights of -1.1 cm. Above results expressed as percentage of height change is given in Table6. As one can see,

**Table 5**

| Decomposition of the income effect on height development (beta =1.11) | | | | | |
|---|---|---|---|---|---|
| | Effect avarage income | effect variance of income | sum | Actual height change (cm) | Residual change |
| 1925-1935 | -0.1 | -0.5 | -0.6 | -1.1 | -0.5 |
| 1932-1939 | 0.1 | -0.5 | -0.4 | -1.6 | -1.2 |
| 1939-1953 | -0.2 | 0.5 | 0.3 | 1.7 | 1.4 |
| 1953-1970 | 0.2 | 0.6 | 0.8 | 1.3 | 0.5 |
| 1970-1980 | 0.5 | 0.2 | 0.7 | 1.0 | 0.3 |
| 1980-1987 | 0.2 | 0.0 | 0.2 | 0.6 | 0.4 |

the most obvious change is a decrease over time of the effect of the distribution of income and the likewise increase of the effect of the level of income on change in stature. This is not surprising since, after 1950, income inequality was almost continuously declining while GDP/cap and stature went up. It is also not terribly surprising that mean income started to

**Table 6**

| % distribution with coefficient=1.11 | | | | | |
|---|---|---|---|---|---|
| | **Income effect** | | | **Residual** | **Total change** |
| | Effect average income | effect variance of income | *sum* | | |
| 1925-1935 | 5% | 41% | *46%* | *54%* | *100%* |
| 1932-1939 | -6% | 33% | *27%* | *73%* | *100%* |
| 1939-1953 | -10% | 32% | *22%* | *78%* | *100%* |
| 1953-1970 | 13% | 48% | *60%* | *40%* | *100%* |
| 1970-1980 | 50% | 18% | *68%* | *32%* | *100%* |
| 1980-1987 | 36% | -4% | *31%* | *69%* | *100%* |

have a bigger effect in the 1950s than the distribution since distribution only has a strong effect when a population is close to subsistence level. In the 1950s, however, an increasingly lower percentage of the household budget was spent on food. In addition, inequality decreased fast due to the pro-poor growth policy.

In a wider perspective, this pattern found for Indonesia is not uncommon. In the late 18th century England and USA it was found that heights declined, notwithstanding rapid industrialization (Margo and Steckel, 1983; Komlos, 1998). The same pattern can also be observed for other countries such as Italy and the Netherlands (Haines 2004; Perachhi 2008). In all cases, though, GDP/capita seemed to increase during this period (Maddison 2003).

This is not necessarily though for real wages though. Whereas GDP/cap increased, real wages remained constant or even declined (Allen 2001). In such a case height development is almost solely driven by inequality because, as is argued by Steckel (1999, 8), “the gain in height at the individual level increases at a decreasing rate as a function of income, one would expect average height at the aggregate level to rise, for a given per capita income, with the degree of equality of the income distribution.” Indeed, inequality must have risen in cases with constant or decreasing unskilled wages and rising GDP/cap as is argued by Williamson (1998; 2000).

In the later twentieth century, however, both GDP/cap, real wages and heights increased. Indeed, Steckel (1995) found that there is a high correlation between income and height in the second half of the twentieth century. This is not surprising given that an increase income means, given a lower than unit income elasticity, that an increasingly lower percentage of the household budget is spent on food and health. Hence, the level of income becomes more important than its dispersion. This pattern is again the same in Indonesia which, in the 1950s, as Van der Eng (2000, 606) argues, “managed to escape the decline in the biological standard of living that stunted Western Europe and North America during the late eighteenth and early nineteenth centuries”.

## 5. Conclusion

In this paper we utilize a new dataset on heights for Indonesia between ca. 1890 and 2000 combining data on the heights of Indonesian military recruits together with the IFLS data.

As is commonly acknowledged in the literature, we find that for Indonesia up to ca. 1950, the correlation between per capita GDP and heights is relatively low. Even though proteins and kcalories on average increased, increasing inequality caused a decline in average stature. Partly, this is reflected in a real unskilled wage that better predicts height development which, according to Williamson (1998; 2000), is indicative of the development of inequality.

After the 1950s, increase in average income caused the percentage spend on food in the total budget to decline. This seriously reduced the no of people at subsistence level and thus the effect of inequality had to be bigger in order to create a decline in height. Equally, inequality reduced, partly due to pro-poor growth policies. At the same time, rice as a source of calories and proteins became more abundant.

This pattern of decreasing height in the first half of the twentieth century and increasing heights in the second half was prevalent in all regions of Indonesia, but especially in Java after where heights (and incomes) surpassed that of the Outer Provinces in the 1960s-1980s (if we exclude oil income). This pattern seems a common pattern of development and we thus find examples of this pattern in several (Western) countries in the 19$^{th}$ and early twentieth century.

We can also formalize this pattern by a decomposition of height growth in the level and distribution effects of income and a residual. It turns out that up to 1950 the distribution explains close to 50% of the change, the other 50% being made up by the residual factor. In the latter part of the twentieth century, 50% of height change is explained by the level of GDP/cap while, again, the remainder is made up by the residual factor.

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**Appendix A.1: Correcting for truncation with regards to skewed normal distributions**

The pdf of the SN is $f(\alpha, x) = 2\phi(x) \cdot \Phi(\alpha x)$ where $\phi(x)$ is the density function of the standard normal distribution, and $\Phi(\alpha x) = \int_{-\infty}^{\alpha x} \phi(t)dt$. Since $x = \frac{y - \mu_y}{\sigma_y}$, this probability distribution has three parameters: $\mu_y$, $\sigma_y$ and the skewness parameter $\alpha$. If $\alpha=0$, we have the standard normal distribution and then $\mu_y$ and $\sigma_y$ equal the mean and the standard deviation of the variable, otherwise the sign of the parameter is indicative of the skew (positive (right) or negative (left)). As pointed out, because of a large share of the population at absolute poverty level before World War II, we expect there to be a right skewness (the mode is lower than the median and mean), indicating a larger base of people with lower heights. The parameters are estimated with an ML procedure.

We used above distribution with our truncated sample (recruitment data with minimum height requirement): in this case we followed the standard procedure, that is, the density of a truncated skew-normal distribution is:

$$f(\alpha, x \mid x > a) = \frac{f(\alpha, x)}{1 - \int_{-\infty}^{a} f(\alpha, z)dz},$$

**Table A.1.1**

| | **μ** | **Σ** | **α** | **mean (cm)** | **std dev (cm)** |
|---|---|---|---|---|---|
| truncated data | | | | | |
| pre-1920 | 156.6 | 8.06 | 2.77 | 162.5 | 5.47 |
| 1920-1940 | 157.2 | 6.78 | 1.84 | 161.3 | 5.11 |
| IFLS data | | | | | |
| 1930s | 154.9 | 7.25 | 0.93 | 158.9 | 6.09 |
| 1940s | 162.9 | 6.55 | -0.64 | 160.1 | 5.91 |
| 1950s | 164.3 | 6.55 | -0.74 | 161.2 | 5.76 |
| 1960s | 159.1 | 6.17 | 0.60[a] | 161.6 | 5.62 |
| 1970s | 166.5 | 6.87 | -0.81 | 163.0 | 5.94 |
| 1980s | 167.0 | 6.75 | -0.74 | 163.8 | 5.95 |

Note_ [a] this is the only case when the skewness parameter was not significant at 1%.

where *a* denotes the truncation point.

The importance of correcting for truncation when estimating the population mean and standard deviation is well known. What using the skew normal distribution adds, besides a more exact estimation of mean population height, is the possibility to observe hoe the asymmetry of height changed over the century. We can see in Table A.1.1 that initially there was right skew (the mode is lower than the median and mean). This suggests that there was a large share of people living at subsistence. This changed slowly in the 1960s. During the second half of the century, however height seems to have become left skewed. This is not strange since, as we argued before, that the percentage people at absolute poverty declined drastically. Indeed, most people were well fed and an increasing part of the budget was spent on other things than food and shelter.