Anthropometric within-country Inequality and the Estimation of Skill Premia with Anthropometric Indicators

Please note: This is not the final version of this paper. A later version has been published in the Review of Economics – Jahrbuch fuer Wirtschaftswissenschaften.

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The authors thank Dorothee Crayen, Robert Fogel, Nadine Frerot, Ricardo Godoy, Laurent Heyberger, John Komlos, Michał Kopczyński, Kerstin Manzel, Stephen Nicholas, Sunyoung Pak, Valeria Prayon, Inas Rashad, Daniel Schwekendiek, Mojgan Stegl, Yvonne Stolz, Linda Twrdek and Greg Whitwell for contributing their data. Péter Földvari, Alexander Moradi, Bas van Leeuwen and Jna Luiten van Zanden provided important inputs in related projects, and the editors of this journal helped to improve the clarity. Marianne Hock improved the English language style, and Julia Muschallik provided able research assistance.

1. Introduction

Recently, a method to measure inequality has been proposed that is based on anthropometric indicators. Baten (1999, 2000) argued that the coefficient of variation of human stature (henceforth 'CV') is correlated with overall inequality in a society, and that it can be used as indicator, especially where income inequality measures are lacking. This correlation has been confirmed in further analyses, for example by Pradhan et al. (2003), Moradi and Baten (2005), Sunder (2003), Guntupalli and Baten (2006), Blum (2010a), van Zanden et al. (2010), see also Figure 1 and Table 1. The idea is that average height reflects nutritional conditions during early childhood and youth. Since wealthier people have better access to food, shelter and medical resources, they tend to be taller than the poorer part of the population. Hence, the variation of height of a certain cohort may be indicative of income distribution during the decade of their birth.

The aim of this study is firstly to provide an overview of different forms of within-country height inequality. Previous studies on the aspects of height inequality are reviewed. Inequalities between ethnic groups, gender, inhabitants of different regions and income groups are discussed. In the two final sections, we compare height CVs of anthropological inequality with another indicator of inequality, namely skill premia. We also present estimates of skill premia for a set of countries and decades for which "height CVs", as they will be called in the following, are available.

[include Figure 1 and Table 1 around here]

2. Advantages of anthropometric inequality measures

What are the advantages and disadvantages of anthropometric inequality measures? Heights offer a good complement to conventional inequality indicators and constitute perhaps an even better indicator in some respect (see Moradi and Baten (2005) on the following). If the distribution of food and medical goods in an economy becomes more unequal, heights should also become more unequal. Yet while a correlation with income does exist, this correlation is only partial. Some important inputs are not traded on markets but are provided as public goods, such as public health measures or food supplements for schoolchildren. Public goods lead to modest deviations between purchasing power-based and height-based inequality measures.

Moreover, income neglects transfers within households. If there is, for example, only one income earner in the household, it cannot be assumed that transfers to other household members reach the same degree everywhere. Deaton (2001) and Pradhan et al. (2003) have argued convincingly that measures of health inequality are important in their own right, not only in relation to income. Heights do capture important biological aspects of the standard of living (Komlos, 1985; Steckel, 1995), irrespective of the fact that some problems regarding the stature variable may exist.

Anthropometric methods are even more advantageous for studying developing countries of the 20th and the generally poorer countries of the 19th century. To date, the development of inequality within LDCs could not be sufficiently explored because reliable data were lacking. The well-known Deininger and Squire data set (1996), for example, provides only eight gini coefficients of income for Sub-Saharan Africa for the period before 1980, labelled as “acceptable”. Atkinson and Brandolini (2001) convincingly pointed to serious flaws in the income inequality data collected by Deininger and Squire, arising from insufficient consistency across countries and over time. For those countries, height inequality measures can provide important additional insights. We certainly do not claim that height is the only accurate measure of inequality, but argue that it generates new insights on inequality while serving as a useful countercheck for other indicators, thereby leading to more meaningful results overall.

3. Different forms of within-country inequality

The following chapters discuss the literature on inequality between social classes, urban-rural differences, differences between ethnic groups, economic systems, and among regions within the same country. In reality, however, several of those issues occur at the same time. Hence, the estimation of height inequality is a complex process. For example, differences in stature between ethnicities are often linked to differences in social affiliation while it is not unusual that urbanization processes are connected to certain regions of a country. In the literature reported below, height inequality is often studied in a multidimensional way. Therefore, this article can be considered as an introduction to the economics of the forces behind inequality and a guide to their investigation.

3.1 Differences between ethnicities

Steckel (1979) as well as Margo and Steckel (1982) are considered as pioneer works on the living standards of Afro-American slaves. Both studies are based on data from so called ‘slave manifests’, containing records of tens of thousands of slaves, mainly shipped via the ports of Baltimore, Charleston, Mobile, New Orleans, Norfolk and Richmond. The data used in those studies employ growth and final height of the shipped slaves in order to gain information on their biological living standard.

They report that contemporary African Americans ended up being shorter compared to the white Americans. On the other hand, their height indicates that slaves were even taller than Whites born in Europe. Therefore, they conclude that the nutritional status of African Americans was worse compared to white Americans but superior to European levels.

Furthermore, light-colored slaves were taller than their dark-colored counterparts (Steckel 1979; Margo and Steckel 1982). Bodenhorn (2002) confirms this by analyzing free rural Blacks in Virginia. Both male and female light-colored African Americans were taller mainly due to economic and behavioral reasons. Since Mulattos were often wealthier than Blacks, they had better access to nutrition. Furthermore, a contemporary attitude might have helped the light-colored female black slaves, because slave owners tended to prefer them over darker Blacks as household servants and for sexual reasons.

In addition, height varied significantly among occupations, regions and birth cohorts. Particularly plantation size, crop-mix and food supply were major determinants of slave heights (Margo and Steckel 1982). Bodenhorn (1999) reports that although free African Americans experienced discrimination, such as restricted occupational choices, education and even property rights, they did surprisingly well. They reached almost the same height as white Americans and enjoyed an even higher biological welfare compared to many Europeans.

Maloney and Carson (2008) not only confirm the height gap between African Americans and Whites during the 19th century, but using prison data from Ohio, they also report that both height trends follow a similar path (see Figure 2). At the end of the 18th century both Blacks and Whites started on a high level, but lost height between the 1820s and the 1840s. This might indicate that both trends were influenced by the same economic process.

However, the height of African Americans declined earlier than the one of their white contemporaries, as their lower living standards were more vulnerable to income shocks.[1]

[include Figure 2 here]

Komlos (2010) investigates the period between the 1920s and the 1980s using adult height data collected for the NHANES (National Health and Nutrition Examination Survey). He reports that height differences between white and black Americans are still prevalent. In the course of the 20th century the male height gap was on average one centimeter. He also observes a height gap between black and white females. The average gap of about two centimeters was mainly caused by differences of the low and middle strata. In contrast, height differences between rich Whites and rich Blacks were only modest, indicating that primarily differences in purchasing power lead to differences in the biological standard of living.

There are studies which deal with ethnic minorities in other parts of the world. Twrdek and Manzel (2010), for example, apply prison records to gain information about the individual's height, ethnicity, age, place of birth, occupation and religion of convicts in 19th century Peru. They find that particularly Whites benefited from the earnings generated by the guano exports. In contrast, Mestizos and Peru's native inhabitants were suffering due to increasing prices. Blacks were the tallest population group during the entire period under observation. Twrdek and Manzel conclude that Blacks were considered as an investment which had to be kept vital and strong in order to be productive.[2]

Cameron (2003) reports that after the abolition of Apartheid in South Africa the political, social and economic transition did not lead to short-term improvements of the

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[1] Komlos and Coclanis (1997) suggest that Georgia's black population was less integrated into the commercialized food production because they were either living on subsistence farming or because their owners wanted to maintain their economic value.

[2] Twrdek (2010) concludes that freed blacks on the isle of Cuba grew even taller than the Cubans of European descent.

nutritional status of non-white children in the 1990s. Differences in growth exist at the time of birth as well as during the growth process. Another kind of transition is investigated by Mironov (2007). In his study on mothers and infants in Russia he reports that the length at birth in St. Petersburg between 1980 and 2005 depended to some extent on the mother's ethnicity. Russians, Ukrainians and Byelorussians had significantly taller babies compared to the reference category (Azerbaijanians). On the other hand, the newborn babies of Jewish mothers were shorter by over one centimeter. Correspondingly, Aschoff and Hiermeyer (2009) find that in the beginning of the 19^{th} century the stature of Jews in the German Principality of Salm were more than 7 cm shorter compared to the non-Jewish population. This finding suggests that during this time German Jews suffered from extreme nutritional deprivation.

For the Taiwanese case Olds (2003) reports that the economic upswing just after the beginning of Japanese rule also resulted in a stature increase. Olds distinguishes between Taiwanese aborigines and Chinese Taiwanese and finds that both groups benefited from the improved nutritional status and better disease environment. However, native Taiwanese height increased only by 3 cm, while Chinese Taiwanese gained additional 6 cm between the 1920s and the 1970s.

3.2 Gender differences

An entirely different field is gender inequality measured by different biological living standards. Besides the natural differences in growth and final stature, there are socio-economic factors which determine a deviation of the gender dimorphism of a population from the natural norm. The overwhelming majority of such deviations are caused by discrimination. In this regard, Osmani and Sen (2003) show that maternal deprivation is not only a matter of maternal health. In fact, health and nutrition of mothers are a crucial factor of a nation's health since it influences the long-term health risks. They argue convincingly that the determination of adult health starts with the determination of fetal health and birth weight.

Dangour, Farmer, Hill and Ismail (2003) use data of four-year-olds from Kazakhstan in the 1990s to investigate the influences of the transition from a centrally-planned economy to a market economy. Their results suggest that the anthropometric status among boys remained unchanged. However, Kazakh girls experienced an average height decline of 0.25 cm per annum between 1992 and 2000. In addition, the authors present data on nutritional intake of girls and boys in 1994 and conclude that girls were facing discrimination in terms of intra-household food allocation (for a Spanish study on the topic, see Costa-Font and Gil 2008).

Deaton (2008) uses the NFH (National Family Health) Survey in order to obtain information about gender-specific well-being in India. He reports that sexual height dimorphism in the 1960-65 period was 7.8 percent, increasing to 8.2 percent in only 15 years. The trend lines in Figure 3 suggest a growing height gap between male and female height, since height gaps of elderly generations were smaller compared to younger birth cohorts. Deaton concludes that this is a result of unequal access to the rising availability of nutrition and health care during the period under observation. He also argues that this is just the continuation of the trend that had been in existence during the entire 20th century. However, if Delhi – where the natural gender ratio is massively disturbed by uneven migration – is excluded from the sample, it turns out that migration also seems to have played a role, aside the discrimination. Koepke and Baten (2005) as well as Guntupalli and Baten (2009) discuss and review other studies on gender inequality.

[include Figure 3 here]

3.3 Differences caused by institutional systems

History has provided some huge institutional experiments regarding the wealth of nations. Changes of political and economic systems belong to the most dramatic ones, particularly if the two parts undergo different types of institutional transition, such as in Korea or postwar Germany.

Pak (2004) compared heights of Koreans from the North and the South and reveals that by the end of the 1940s Korean heights were quite homogenous (Figure 4). The divergence began in the late 1940s. Pak concludes that this divergence reflects the unequal economic, medical and nutritional development of the two Koreas. The advantage of the Republic of Korea in terms of biological well-being over the communist North grew steadily and was on average about 6 cm in the 1980s. Schwekendiek (2008a, 2008b, 2009) significantly extends those Korean studies by identifying differences of living standards within North Korea: for example, he studied the effects of military and communist-party-related food distribution systems.

[include Figure 4 here]

Komlos and Kriwy (2003) come to a similar conclusion in their study on the two Germanies. Although differences were not nearly as severe as in the case of Korea, the authors report that height differences existed throughout the entire period of separation. In addition, height differences started to diminish just after reunification, implicating the improvement of the socioeconomic and environmental circumstances (see also Heineck 2006).

Furthermore, the different features of the two economic systems also caused different dimensions of economic inequality within the two parts of Germany. The German Democratic

Republic had a significantly smaller service sector causing difficulties regarding the distribution of nutritional resources (Komlos and Kriwy 2003). In contrast, Hiermeyer (2008) reports that the inequality of heights in the West was higher compared to the East. However, he concludes that this might be caused by the geographic diffusion of the Western population and the greater diversity rather than a system-driven inequality.

Quite a different clash of systems was investigated by Steckel and Prince (2001). Their comparison of living standards in the expansion- and productivity-oriented Anglo-American economy and the Native American subsistence economy of the 19th century reveals surprising results. Despite their technological and institutional advantages, European-Americans were about 1-2 cm shorter than the Native inhabitants. The authors explain these differences by the low population density and the fact that Native American tribes used to move several times per year. Therefore, sanitary and hygienic problems known in large cities were unknown. In addition, the common practice of sharing and caring about other tribesmen in need worked as a social insurance. The combination of those factors led to a superior biological living standard and made Native Americans the *'tallest of the world'* during the mid-nineteenth century (Steckel and Prince 2001). Komlos (2003) argues that populations living near the North American frontier were generally taller compared with urban centers due to abundant productive land, low population density, a great deal of protein availability (bisons) and a better disease environment although they might have been poor in monetary terms. In the case of New Zealand, however, Inwood, Oxley and Roberts (2010) do not find evidence for differences in height between Maori and New Zealanders of European descent.

In their analysis of the native Tsimane people in Bolivia, Godoy et al. (2006) find that individual characteristics such as being fluent in Spanish and indicators of human capital go along with higher stature of both mothers and daughters. In general, however, the height development of the Tsimane does not show a secular trend during the 20th century. These results indicate that the majority of the Tsimane were living in autarchy with only sporadic contact with the market economy. Women being in contact with the Spanish speaking, market-oriented part of the population were significantly taller than the women living in the traditional subsistence sector. Particularly modern medical technologies helped to improve the disease environment of the people being open to Western influences.

3.4 'Urban penalty'

A phenomenon that has frequently been observed during the industrial revolution is the lower living standard of urban areas. On the one hand, the organizational structure of cities should have allowed low transaction costs, and public facilities such as schools, universities and hospitals that can be run with economies of scale. Cities and their suburbs were generally a hotspot of economic activity. After the era of medical and sanitary advancements of 1900, cities could use their superior purchasing power to acquire medical care and superior nutrition. Over the course of the development process cities benefited from urban development, purification of water supply, sanitation, less child labor and the accessibility of medical services (Martínez-Carrión and Moreno-Lázaro 2007).

On the other hand, the early years of urbanization were characterized by overcrowded housing and insufficient sanitary conditions, particularly compared to modern standards. Srzeter and Mooney (1998) argued that cities during the 19th century did not invest significantly in their infrastructure. As a result, diseases occurred more often, causing more severe epidemics and therefore often created a worse disease environment compared to rural places. Furthermore, the nutritional status of cities largely depended on the supply from surrounding rural areas. The higher the transportation costs the more difficult it was to supply the urban citizens. Needless to say, transaction costs increased dramatically with distance, particularly the costs to transport animal products before the invention of refrigerators, pasteurization and the integration of rural areas into the railroad network (Baten 1999). Hence, it is possible that heights are declining although the economy is growing in conventional measures (Komlos 1998, Cuff 2005). Margo and Steckel (1983) analyze the height of soldiers who served during the American Civil War and find that individuals born in places with more than 10.000 inhabitants were significantly shorter than those born in smaller places. Floud, Wachter and Gregory (1990) address the issue for the UK.

It is the trade-off of advantages and disadvantages of the above described kind that determined the living standards in cities and rural areas, yet every single case study has to investigate the prevailing conditions carefully and evaluate their influences on a case-to-case basis. Baten's (2009) analysis of Bavaria, France and Prussia, for example, revealed that the nutritional status in the 19th century was low in areas *near* towns, since their agricultural economy was targeted towards close urban markets, but high in some of the administrative cities. Therefore, especially the city of Munich benefited from a very special situation because the urban and rural advances occurred at the same time. Urban structures combined with the nutritional supply from the nearby rural places near the Alps allowed a high living standard in the 19th century. The height in more remote regions, however, was mainly shaped by their agricultural strategies. Areas specialized in milk and meat production enjoyed higher biological living standards compared to areas whose focus lay on the production of carbohydrates (mainly grain and potatoes).

For the case of 19th century Spain, Martínez-Carrion and Pérez-Castejón (1998), Quiroga (2002) and Martínez-Carrion and Moreno-Lázaro (2007) report a rural disadvantage. The latter, however, report only slight height differences and conclude that underdeveloped regions suffer from typical disadvantages to a limited extent since the transformation into an industrial society was not completed yet.

[Include Figure 5 here]

In modern times, cities tend to provide superior biological living standards since low transportation costs and high productivity allow fresh and cheap foodstuffs to be sold on urban markets. The disease environment is also generally better. This, combined with other benefits of cities, often lead to taller heights in cities compared to towns and villages. Accordingly, Komlos and Kriwy (2003) find that German males living in cities both in the Eastern and Western part were significantly taller than those living in towns and villages.

The same seems to be true among transitional and developing countries. Eiben and Mascie-Taylor (2004), for instance, find that Hungarian boys born between 1960s and the 1980s were taller in larger cities. The tallest ones lived in the capital. Sahn and Stifel (2003) confirm this finding for several Sub-Saharan countries during the second half of the 20th century. Both of their measures, child stunting and adult malnutrition, reveal that the nutritional status in rural areas lags far behind those in urban centers.

3.5 Differences between regions

Probably the most intuitive case of within-country inequality is the divergence of living standards between regions. Regions are characterized by particular properties because often each of them was shaped by a unique history although being an integral part of the same state. Therefore, among others, population density, urbanization, industrialization, infrastructure, religion, geography, climate, soil quality, the social, cultural and economic history as well as the interaction of the latter give every region a unique character in terms of economic performance and well-being. As a result, living standards across regions in a country might differ depending on the economic activity they develop. Figure 6 shows the geographical height distribution in France during the 17th and 18th centuries.

[include Figure 6 here]

One of the pioneer studies in this field compares biological living standards across several regions of the Habsburg Monarchy (Komlos 1985). Komlos analyzes conscript data from four provinces between the 1740s and the 1830s and finds significant differences in stature. His results indicate that Bohemia and Lower Austria, two early industrialized regions, could improve their income because of increasing productivity of labor. But the industrialization process went along with decreasing average heights, as observed in many other places.

A recent study on Russian children revealed that there are significant differences between provinces of the Russian Federation (Fedorov and Sahn 2005). A striking result of their study is the dramatic height difference between the civil war affected regions of the Northern Caucasus and other provinces.

Alter, Neven and Oris (2004) conduct a study on 19th century Belgium finding significant regional differences even in a relatively small area in eastern Belgium. At the same time in Ireland, people in Connaught and Munster had the worst living standards, measured as the height of Irish-born female convicts in Australia. In contrast, Ulster benefited from a very special situation since the industrialization in the northern part of the Irish isle was not followed by its usual disadvantages (Oxley 2004). Sandberg and Steckel (1987) draw a similar conclusion for the Swedish case. In 18th and 19th century northern Italy heights in Lombardy were among the lowest while the Venetian provinces of Vicenza and Verona enjoyed relatively good living standards (A’Hearn 2003). This finding is confirmed by Arcaleni (2006), who investigates the whole of Italy between 1854 and 1980. In addition, she finds a strong North-South divide in heights as well as in illiteracy, per-capita income, unemployment and mortality. The divergence is persisting but decreased in the course of economic development. In a comparison of Puerto Rico and the American mainland between the late 19th century and the mid-20th century, Godoy et al. (2007) find that differences in adult stature exceeded 8 centimeters.

Accordingly, Chinese living standards also greatly differed in the 19th and early 20th century. Individuals from the northern parts were almost three (two) centimeters taller than their counterparts from the center (south) due to different nutritional endowments (Morgan 2004). Bassino (2006) studies the regional convergence of 47 Japanese provinces between 1842 and 1941. He finds that income and height are highly correlated and regional convergence of heights occurred before World War I. These findings suggest that the main driving force of regional differences in well-being is predominantly a result of unequal economic development and its nutritional consequences. A similar conclusion was drawn for Argentinean, Mexican and Indian cases (Salvatore 2004, López-Alonso and Condey 2003, Guntupalli and Baten 2006). In their investigation of colonial Burma, Bassino and Coclanis (2008) find that regional height developments do not correlate with the development of economic power. Although lower Burma experienced a rapid economic development due to the expansion of rice production, average heights were stagnating because tropical diseases were able to spread more easily. Hence, stature in Lower Burma was higher than in Upper Burma. Furthermore, height variation within Upper and Lower Burma can be explained partly by the nutritional status and the development of rice prices.

3.6 Differences by social group

Reasons for differences in well-being between social strata are manifold. The most profound one is the difference in purchasing power. On the one hand, high quality foodstuffs, particularly foodstuffs containing animal protein such as meat and milk, are more expensive than carbohydrates because livestock breeding requires more input in terms of fertile farmland and time. On the other hand, animal based nutrition is often considered as superior to a vegetarian diet – at least in times when it is scarcely available – and wealthy individuals consume animal products as long as it is affordable. As a consequence, the quality of one's nutrition is linked to the supply and demand mechanisms. This usually leads to a situation in which high social strata enjoy a high quality diet. The lower strata's diet, however, is rather based on carbohydrates, due to the fact that it offers more energy per monetary unit compared to meat. Since meat and milk are driving forces in the growth process, the high social strata mostly end up being significantly taller.

In addition, lower income groups tend to have more children compared to upper ones after the early 19th century (Clark 2007). When their limited purchasing power has to be allocated among a higher number of children, the negative influences associated with poverty are multiplied. As a result, children growing up in large (small) families tend to be shorter (taller). This phenomenon is known under the *Quantity-Quality tradeoff* and has been found for several countries and periods (Becker, Cinnirella, Woessmann 2010).

Another link exists between education and health. Human capital, particularly the ability to read, enables parents to gain information about how to provide their children with a clean and hygienic environment. Since families from upper social classes tend to be more educated, their children tend to be ill less often and the course of disease in those strata is less severe. The human body has to invest energy in order to fight diseases. Hence, illness may delay growth less often in upper class families.

There is a great deal of empirical evidence on growth differences among social classes coming from entirely different societies and periods. The picture that is drawn, however, is often the same. Komlos (1987), for instance, reports that population growth and urbanization in Antebellum America induced increasing demand for foodstuffs. As a result, the nutritional status declined in some parts of the population. Particularly children of blue-collar workers and surprisingly farmers showed declining heights (see Table 2). While the blue-collar workers' wages did not keep up with rising food prices, farmers had the incentives to sell high quality food instead of consuming it themselves. Komlos (1990) also reports that in mid-18th century Germany, the biological standards of living diverged considerably between the social classes. Students of an elite school in Stuttgart displayed height differences of 12 centimeters compared to the lower class and their counterparts of the upper aristocracy. In the case of early-modern France, Komlos (2003) reports that social differences in well-being were one driving force on the way to the French Revolution. Cardoso and Caninas (2010) find that in Portugal between 1910 and 2000 socioeconomic differences have diminished but are generally persistent.

[include Table 2 here]

In a study on 19th century Belgium Alter and Oris (2008) find that the stature of brothers from wealthier families was stronger correlated than that of brothers from lower class families. They conclude that upper class families were more successful in dealing with socioeconomic challenges due to higher purchasing power. Salvatore (2004) finds that differences in biological well-being in Argentina during the first half of the 20th century were determined by differences in education, skills, and social standing. He reports that individuals with secondary education were on average 2-3 centimeter taller than the average while illiterates were significantly shorter.

This systematic pattern persists up to modern times. As observed by Cvrcek (2009), even in communist Czechoslovakia between 1946 and 1966 sons of clerks and other professionals are generally taller than sons of blue-collar workers and farmers. Mironov (2007) comes to the same conclusion for the Russian case between 1980 and 2005. Smith et al. (2003) study the height of children from Guatemalan Maya immigrants in the U.S. Low- and middle-class Mayas are significantly shorter than white Americans of the same age (except in the upper tail of the height distribution). In addition, Mayan Americans measured in 2000 are still shorter than the reference standard for American children, but they are, on average, 10.2 cm taller than Maya children in Guatemala. This reflects the successive socioeconomic integration of Mayan Americans and underlines the environmental factors that determine growth.

4. A guide to deal with shortcomings and limitations when analyzing height inequality

Some of the above discussed determinants of economic inequality are also a source of biases and shortfalls when comparing different height measurements that experienced dissimilar selections. For example, if national averages are not calculated from a representative mix of urban and rural height the result might be biased. The same is true if values are calculated from selective samples, such as heights of only low or high social classes, of workers, illiterates, students, sportsmen, or elite-troops, respectively. Special cases are migrants who often tend to be upward biased compared to the average height in their source country (Twrdek and Baten 2010, Humphries and Leunig 2009).

Furthermore, samples based on soldiers often show a shortfall on the lower end of the height distributions. Since many armed forces introduced a *Minimum Height Requirement*, estimates based on soldiers should be adjusted with appropriate methods. If a shortfall exists and is overlooked, average height (height inequality) is upward (downward) biased. Several strategies have been developed in order to estimate the true distribution of height (Komlos and Kim 1990, Komlos 2004, A'Hearn 2004).[3] In general, measurements of conscripts are mostly unbiased when general conscription was applied. However, it might be worth looking at the recruitment strategies of the recruiters and medical officers in order to check if the general physical condition or education played a role in the recruitment process.

A further quite obvious bias is the measurement of not fully-grown populations.[4] However, it is not that easy to precisely identify that point in time when a group of individuals stops growing. It is difficult to estimate whether growth potential is left among late teenagers and early twens; future catch-up growth causes a downward biased mean. In borderline cases, some individuals might be already fully grown while others expect to have some catch-up growth left. This situation may indicate a higher variation of height than the final adult height distribution would have. Baten and Komlos (1998) use Mackeprang's (1907-11) reports of repeatedly measured Danish conscripts born in the mid-19th century in order to correct this kind of bias. Mackeprang reports that even 19-year-olds were approximately 1.9 cm shorter than their full grown compatriots. In general, the growth potential is reached earlier the better the net nutrition of a population.

A rather modern phenomenon is the use of self-reported heights. Several studies have investigated the determinants of a self-reporting bias and find that among others, gender, age, educational level, occupation (Niedhammer et al. 2000), low actual height, and obesity (Spencer et al. 2002) play a significant role in the severity of the bias. Strauss (1999), however, compared the self-reported height and the actual height of young adolescents and

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[3] An older method, the Quantile Bend Estimator, has been replaced by more effective methods (see Wachter and Trussell 1982).

[4] Needless to mention another important age-related bias. Individuals over a certain age start to become smaller due to age-related shrinking. Therefore, most height studies have to be restricted on individuals under the age of 50.

finds no differences in the accuracy of self-reported heights, whereas Hatton and Bray (2010) adjust self-reported height measurements downward by 0.8 centimeter.

One question to be addressed is whether the distribution of heights is vulnerable to survivor bias, as only survivors could be included. However, considering the gini coefficients of income inequality, it is important to mention that the inequality measures only include survivors. In order to be an income earner in any inequality measure, one must at least survive to the age in which people earn incomes. In other words, also the gini coefficient relates to the living population and does not reflect inequality of newborn babies who might have died during their first year of life. Moradi and Baten (2005) actually tested whether countries with higher infant and child mortality might have had a systematically different height CV (coefficient of height variation). They actually found the expected negative effect. However, only a very small part of the CV's variance was able to be explained by mortality differences between the countries.

The retrospective height CV measure might suffer from an additional bias, namely the mortality between age 20 and 49 (heights are typically restricted to those ages, in order to exclude young and growing, as well as very old and shrinking persons). When comparing the development of height and income inequality in Kenya, Moradi and Baten (2005) found that this measure was not biased towards the expected direction. This might have been caused by offsetting factors, and by the fact that selective mortality between ages 20 and 49 was too small to influence the measurement.

On the behalf of completeness one should bear in mind that subgroups of the same population might differ in their nutritional habits (Blum 2010b). The reasons can be related to biological, religious, and cultural factors. In particular, some populations in Asia and Sub-Saharan Africa suffer from lactose intolerance which deprives them from the positive benefits of cow milk (Sahi 1994). Furthermore, religious beliefs sometimes hinder people from the consumption of meat, such as the taboo of pork among Muslims and Jews (Harris 1986). Finally, also genetic height potentials can play a role, although the literature has reduced the potential for genetic maxima at the population level to a small amount (Moradi and Baten 2005).

5.1 Applications of anthropometric income measures and the estimation of skill premia

Besides the investigation of inequality between special groups, there is another field of research that uses overall measures of within-country inequality. In those cases, the CV of individual data is applied as a proxy indicator, comparable to the gini coefficient of income (Baten 1999).

Moradi and Baten (2005), for example, find that specialized cash cropping in Sub-Saharan Africa increases within-country inequality, measured by the CV of heights. Diversified cash cropping, however, has the opposite effect. They also compare gini values and the corresponding CV measures and provide a formula to estimate gini coefficients. They suggest the following formula to estimate gini values with CVs:

(1) $$Gini = 33.5 + 20.5 * CV$$

Van Zanden et al. (2010) use height gini values calculated with this formula to provide a global picture on the development of world inequality during the 19^{th} and 20^{th} centuries.

Baten and Fraunholz (2004) investigate the influence of globalization on inequality in the Latin American periphery. They find openness to increase inequality (at first) and vice versa. However, inward looking development strategies did not cause less inequality. On the other hand, inequality motivated countries to cause protectionist policies (Baltzer and Baten 2008).

Blum (2010a) argues that a further determinant of biological well-being is the inequality of resources, which are distributed inefficiently, since marginal returns to income differ between individuals and social classes. His results suggest that the reduction of inequality and the increase of redistribution from rich to poor classes increase average height, since the losses of the rich are outweighed by the gains of the poor.

5.2 Methodological background of height CVs

What is the idea of height CVs (or their linear transformation, the height ginis)? The effects of inequality on heights are best understood by comparing the likely outcomes of a hypothetical situation, in which a population is exposed to two alternative allocations of resources A and B after birth (Moradi and Baten 2005):

(A) All individuals receive the same quantity and quality of resources (nutritional and health inputs). This case refers to a situation of perfect equality.

(B) Available resources are allocated unequally (but independently of the genetic height potential of the individuals).

In the case of A, the height distribution should only reflect genetic factors. Despite perfect equality, we observe a *biological variance* of (normally distributed) heights in this case. Yet, how does the height distribution respond to an increase in inequality (B)? The unequal allocation of nutritional, medical and shelter resources allows some individuals to gain and grow taller, while others lose and suffer from decreasing nutritional status. In comparison to the situation of perfect equality, the individual height of the rich strata shift therefore to the right, the heights of the poor strata shift to the left. Thus rising monetary inequality should lead to higher height inequality, although this effect is weakened by the fact that the genetic height variation accounts for the largest share of height variation. Even a bimodal height distribution could result if the resource endowment differed extremely between groups. In practice, since the biological variance continues to contribute a large share to the total variance, most height distributions are normally distributed or very close to normal, but with a much higher standard deviation than the rather theoretical situation of perfect income equality.

The standard deviation is not a satisfactory measure of inequality, since anthropologists argue that the *biological v*ariance increases with average height (Schmitt and Harrison 1988). The coefficient of variation (CV) takes this effect into account and is a consistent and robust estimate of inequality. For a country i and a birth decade t, the CV is defined as:

(2) $$CV_{it} = \frac{\sigma_{it}}{\mu_{it}} \cdot 100$$

Thus, the standard deviation σ is expressed as a percentage of the mean μ.

5.3 The estimation of skill premia with anthropometric indicators

Skill premia are defined in this study as the wage ratio between a skilled worker in the building trades, and an unskilled one. This measure is available for a number of countries since the 19th and early 20th century, whereas the amount of other inequality indicators (such as the gini coefficient of income) is quite limited and sometimes of low accuracy before the 1970s and 1980s. Clearly, the skill premium as a measure of inequality does not cover the entire economy and the assumption that inequalities between skilled and unskilled building workers reflects skill premia in other sectors of the economy might not always hold. On the one hand, sources of income like subsistence farming, household production, public goods and black market economies are not captured by skill premia. Those latter parts of the economy, however, can be covered quite well with anthropometric measures. On the other hand, wage differences are expected to result in differences in biological living standards. Hence, we consider height CVs as valuable basis for the estimation of skill premia. This means that if we find a significant correlation between skill premia, which is one of the most abundant income-based inequality indicators, and height CVs, both measures together will allow to trace inequalities within countries considerably well for the past two centuries.

We collected the available evidence of unskilled and skilled building workers that was compiled by Robert Allen for the 19th century, and the League of Nations and International Labor Organization Statistics for the early 20th century.[5] This evidence yielded a panel of 166 observations between the 1800s and 1950s (Table 3). In most cases, around 10 observations were available per decade (mostly from the Allen compilation), but in 1950 there were 33 observations, because the International Labor Organization extended the coverage to a number of poor countries. This is also the reason why the variation of inequality is slightly higher in this decade.

[Insert Table 3 around here]

As noted above, Moradi and Baten (2005) have argued that the coefficient of variation can also be expressed as a “height gini” with a simple linear transformation derived from a regression analysis. When we compare some individual observations of skill premia with overlapping evidence on height inequality expressed in these gini units, there seems to be a

[5] We collected the ILO data from Bureau International de Travail: Annuaire des Statistiques du Travail 1949/1950, 11eme edition. BIT Publisher, Geneve 1951, pp. 212-227. Where more than one city was available, we took the city with an average unskilled wage. Where wages for 1950 were not available, we took the ones for 1949. For the 1920s to 1940s, we took the data from the internet page ‘Prices and Wages’ at the University of Utrecht, accessed on May 2nd, 2010, http://www.iisg.nl/hpw/data.php. The earlier data comes from the internet page documented in Allen (2001), lastly accessed on June 3rd, 2009. Further details in appendix available from the authors.

positive correspondence between the both (Appendix Tables 6 and 7). For example, Spain in the 1850s-1890s, Mexico in the 1950s and the U.S. had relatively high inequality, whereas inequality was rather low in Denmark and Switzerland in the 1920s. Testing this more systematically, we examine in three different regression specifications whether the relationship between anthropometric inequality measures and skill premia is significant (Table 4). The overlap between our database on height ginis and skill premia yields 50 observations, and each observation reflects one country and birth decade. Given the panel nature, we estimated both fixed and random effects models in order to study the robustness of the relationship (and also simple OLS in column 3). The relationship is statistically significant and positive. The explanatory power of these models is reasonably high, although a lot of random fluctuation cannot be explained.

[include Tables 4 and 5 here]

In order to assess the robustness, we repeated the test with a slightly larger sample of height ginis, for which we used some conservative interpolation for Europe, America and Asia (for which the amount of data allows some interpolation). This brought the number of observations to 125 for the whole period and 101 for the "long" 19th century (until the 1910s). Adding these values reduces the size of the coefficient somewhat (which can partly be explained by the fact that the constant is now estimated to be around 1, whereas it was below 1 in Table 4 and the Col. 4 of Table 5). In general, the relationship between anthropometric inequality and skill premia remains robust. Neither is it affected by the inclusion of decadal or country dummy variables.

Finally, we have also studied the experience of the period until 1910 separately, which might be different from the 1920s to 1950s period, in which a number of parameters changed in the world economy (column 5 in Table 5). Once again, the estimation results are relatively robust.[6] The height ginis and the resulting skill premia are reported in Tables 6 and 7, although it should be noted that those values are raw values – they might contain some biases and a certain degree of measurement error, especially if they would be taken for the analysis for individual countries. For global comparisons and the use as instrumental variables, they might be a valuable tool.

6. Conclusion

In this study, several facets of inequality are analyzed and described, such as differences between ethnicities, genders, regions, social groups, differences caused by unequal institutional systems, and rural-urban differences. In addition, this article gives advice on how to (and how not to) study anthropometric within-country inequality.

A direct comparison with skill premia has not been introduced in the previous literature. We found the relationship between the two inequality indicators to be relatively strong and robust in different estimation procedures. We developed a model to estimate skill premia based on those height-based measures. This allows extending the study of inequalities in general and skill premia in particular by more than a century.

[6] The constant and coefficients of column 5 suggest that skill premia for the 19th century can be estimated as 1.05995 +.0151313 * height gini. This can be done with the height ginis that we reconstructed from the large amount of anthropometric inequality values based on anthropological and anthropometric publications; see notes to Table 6.

Abstract:

We provide a literature review of anthropometric studies of within-country inequality. Then we discuss the relationship between skill premia and inequality indicators based on height variation. Skill premia describe the wage gap between an unskilled and a skilled building worker, while height CVs (coefficient of height variation) display the variance in net nutrition. We find that the two measures are correlated and that CV values are suitable to estimate skill premia. We supplement the existing literature by an additional tool, namely the estimation of skill premia based on the coefficient of height variation.

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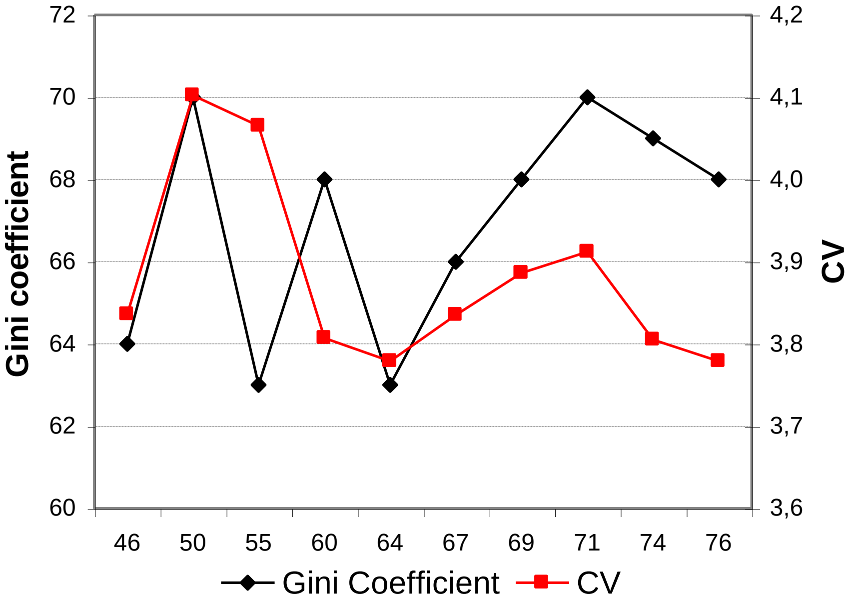
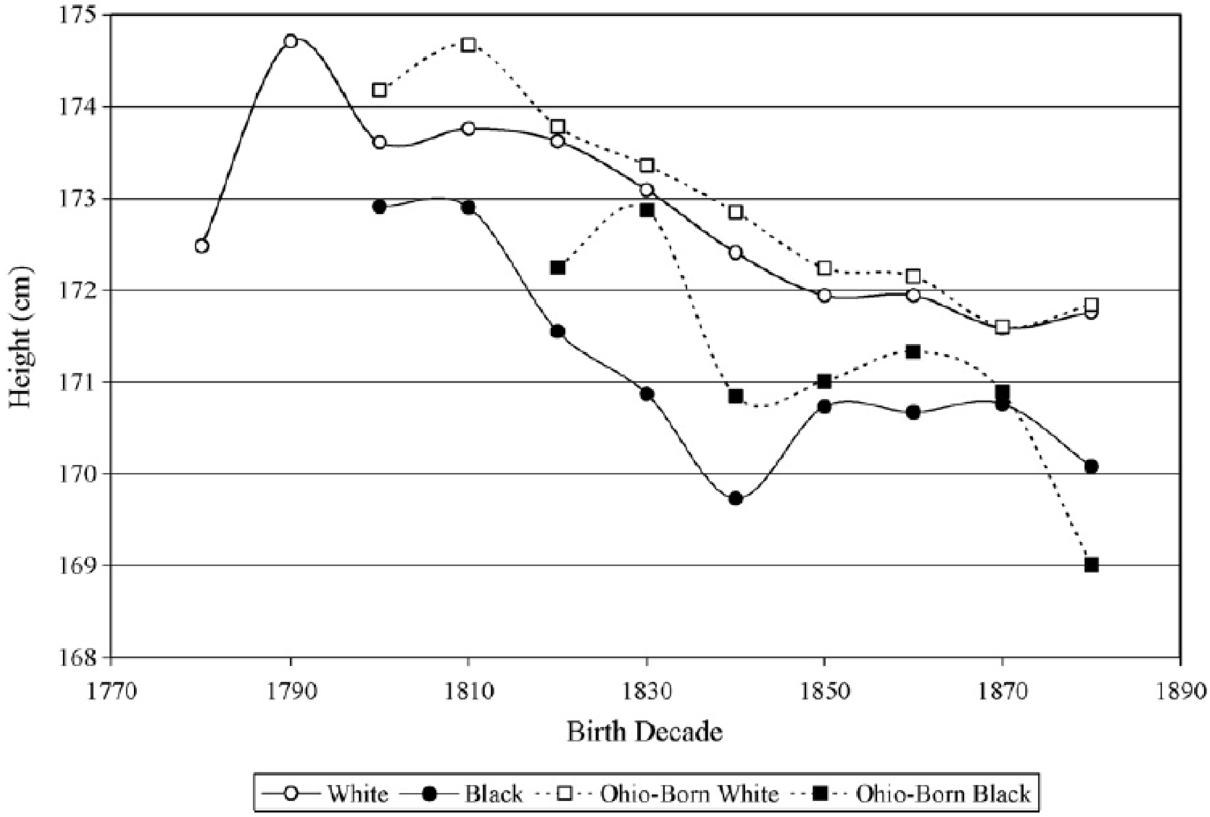
[In clude Appendix Table 6 and 7 around here]



Source: Moradi and Baten (2005).Notes: The gini coefficients are from Bigsten (1986) with a national coverage but based on national accounts of income groups, although Deininger and Squire (1996) label them as being based on taxpayers. Bigsten (1986) admits that his estimation technique overestimates the gini coefficients by about 20 percentage points. Birth cohorts were averaged from Kenya II and Kenya III, weighted by the coverage of female population.

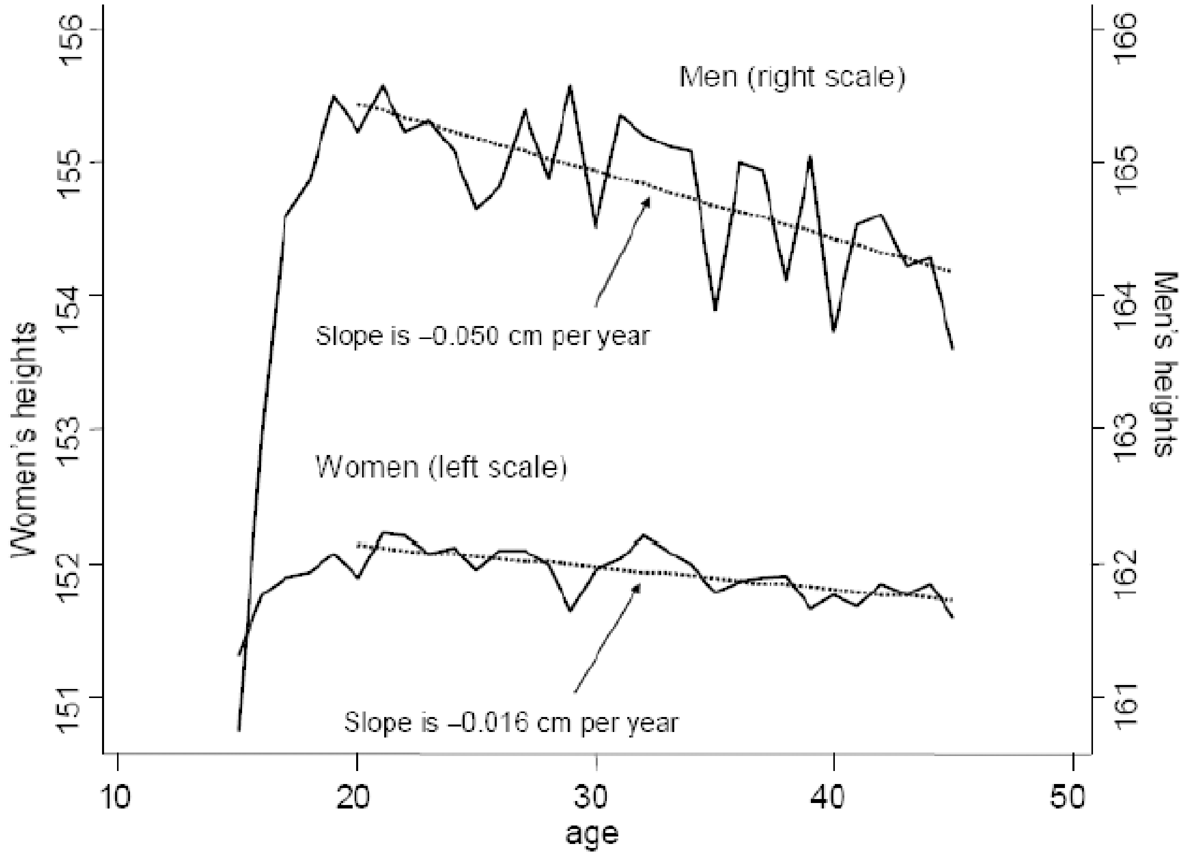
Note: Moradi and Baten argued that an excellent case for comparing the development of both income and height-based inequality measures is Kenya, for which the estimates by Bigsten (1985) offer a consistent source with a sufficient number of data points. They conclude that the development of CVs over time serves as a promising measure of inequality, even more so because in periods and countries in which other data on inequality are either non-existent or unreliable.

Figure 1: Development of income and nutritional inequality in Kenya



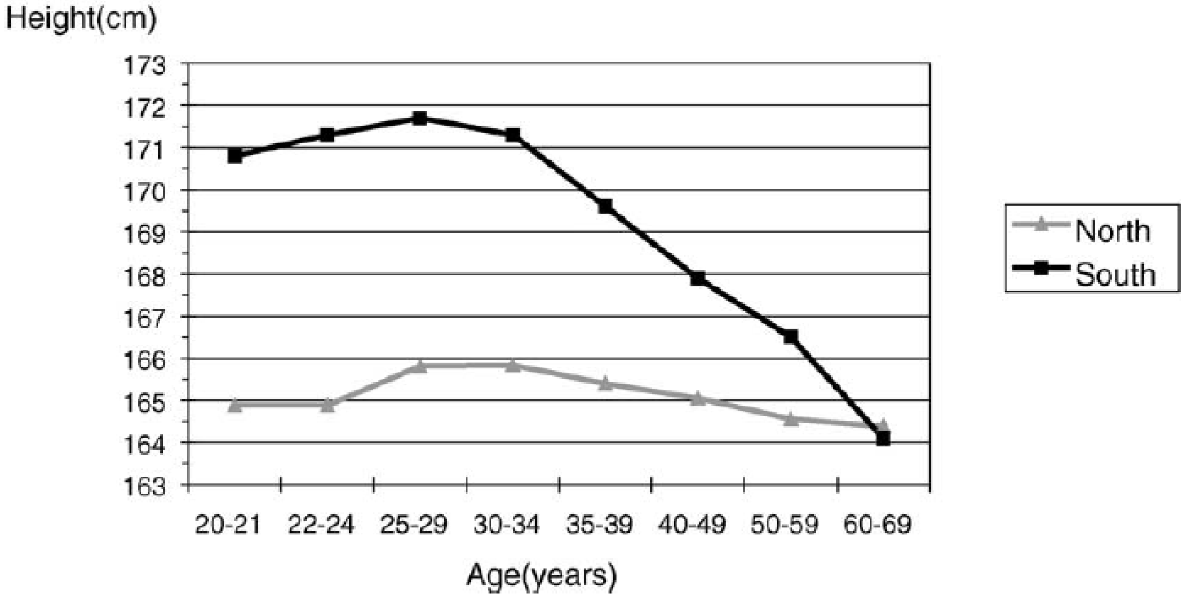
Source: Maloney and Carson (2008)

Figure 2: Mean height by race and year of birth of 19th century American inmates



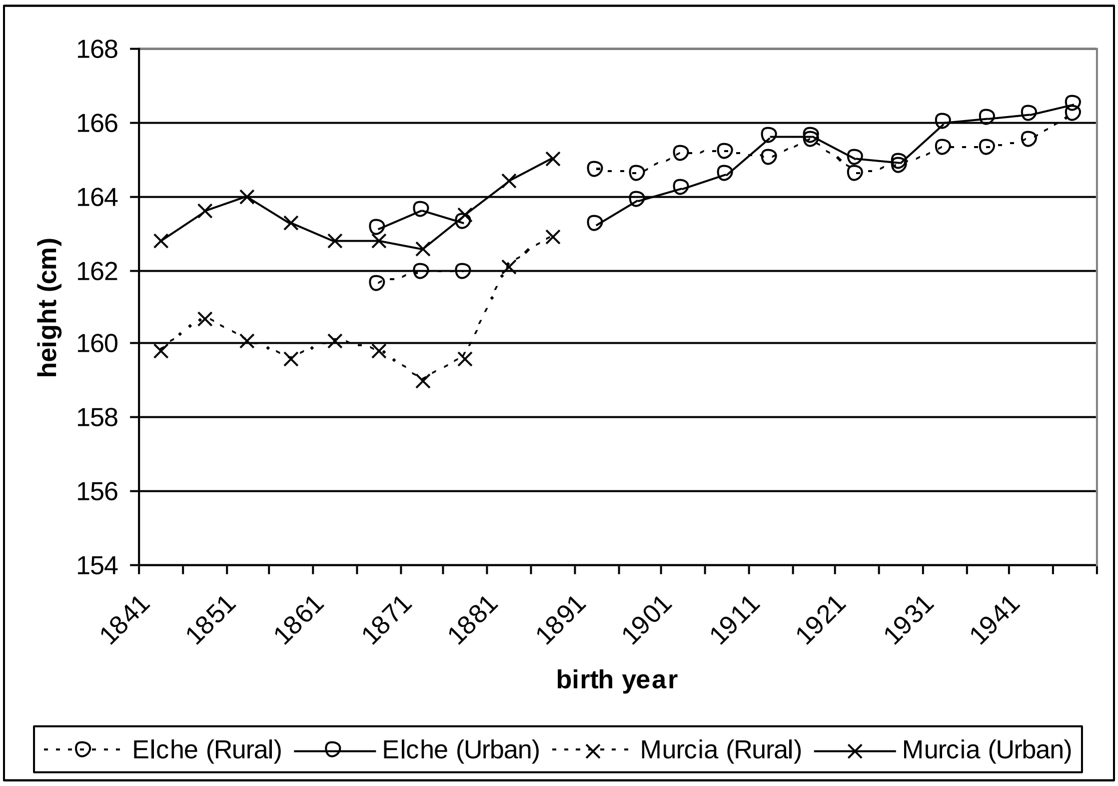
Source: Deaton (2008). Note: Please note in this Figure and in the Figure 4, the horizontal axis is organized by age, whereas in the other Figures, it is organized by birth years

Figure 3: Heights by age and gender in India



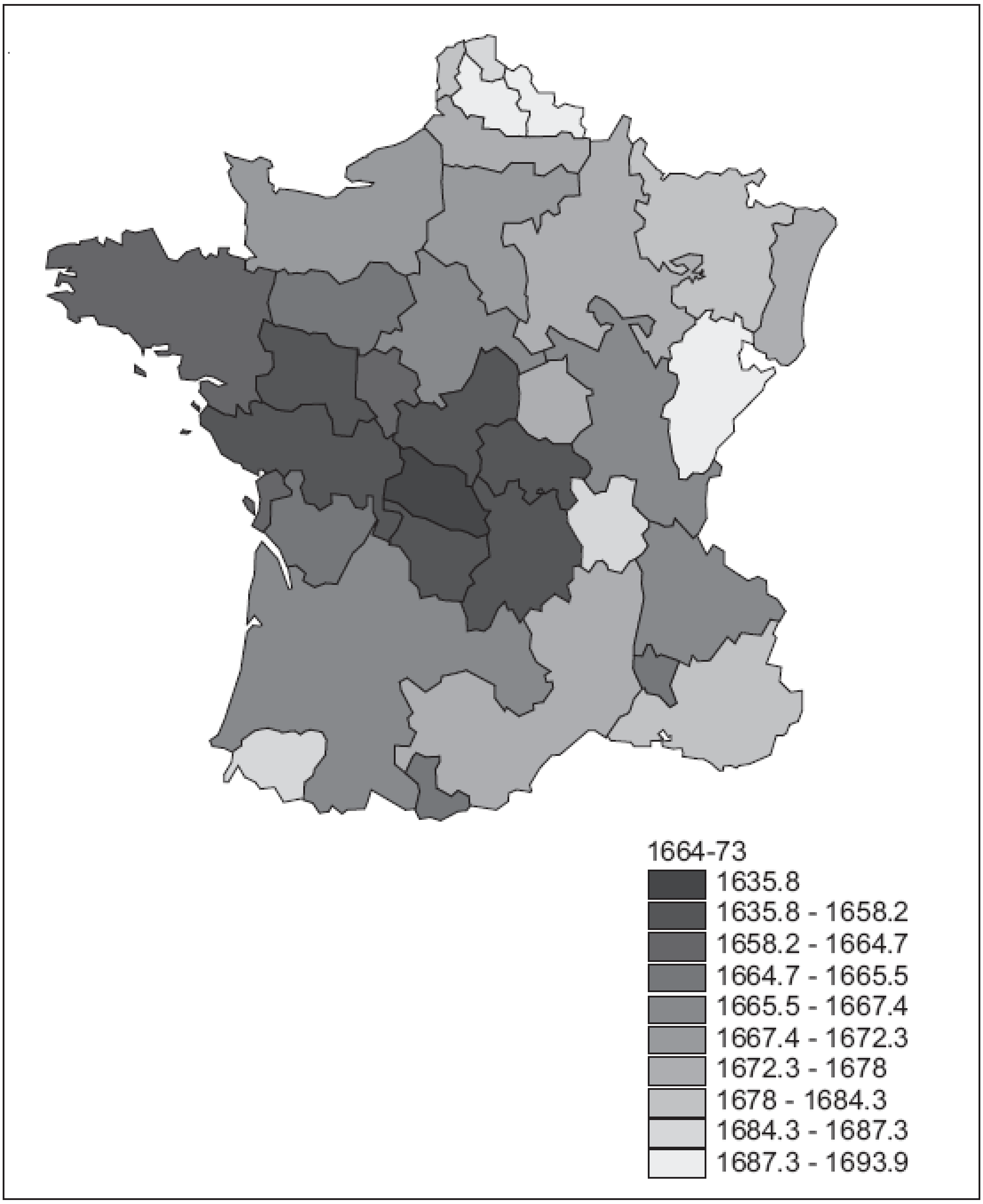
Source: Pak (2004)

Figure 4: Mean male height of North Korean escapees (1999.2003) and South Koreans (1997)



Source: Martínez-Carrión and Pérez-Castejón (1998)

Figure 5: Rural and Urban heights in two Spanish municipal districts



Source: Komlos (2003). Note: the color of the first threshold (1635.8) refers to those regions with values below this threshold.

Figure 6: Adult male height in France during 1664-1763

Table 1: Relationship between income (gini) and height inequality (CV)

Gini-coefficient of income	(1)	(2)	(3)	(4)
Constant	-23.429 (-0.80)	-65.912 (-2.06)	19.235 (0.23)	-33.557 (-0.70)
CV	13.182 (1.72)	20.932 (2.87)	8.988 (0.42)	20.547 (1.67)
Coverage of female population (in %)	0.016 (0.20)		0.024 (0.13)	
Age group 20-24 (1=yes, 0=no)	-2.073 (-0.85)			
Age group 45-49 (1=yes, 0=no)	-2.343 (-0.60)			
Gabon		19.582 (4.22)		21.167 (3.01)
Country fixed-effects [p-value]	[0.000]		[0.387]	
Fixed effects for population coverage and income definition [p-value]	[0.000]	[0.000]	[0.810]	[0.026]
Fixed effects for primary source [p-value]	[0.000]	[0.052]		
Weighted by	share of female population		multiple country-periods	
R^2-adj.	0.812	0.521	0.324	0.436
N	78	78	29	29
Degrees of freedom	42	58	6	19

Source: Moradi and Baten (2005). Notes: Gini coefficients which were not based on a national coverage were excluded; t-values in circular parentheses. Number of countries: 14. The reference category represents a gini based on gross income, which covers the total population and persons as reference units. When dummies for countries and the source of gini are included, the reference category additionally represents Kenya and Bigsten (1986). The population coverage controlled for refers to households, economically active population, income recipients and taxpayers, with the income definitions referring to expenditure, net income and income not nearer specified. In cases where two DHS-surveys offer information on the same birth cohort, we took the average weighted by the female population they cover. The gini coefficients were derived from twelve primary sources listed in Deininger and Squire (1996). Coverage/Age: Additionally, we would have expected a negative coefficient for the percentage of the female population measured, correcting for the somewhat higher CV when based on more women. Obviously, however, the impact is almost zero. Similarly, age effects have the expected negative sign but do not introduce a significant bias.

Table 2: Index of stature by occupation of father and decade of birth of West Point cadets

Birth Decade	Farmer		Blue Collar		Merchant		Profes-sional		Govern-ment		Total		Harvard Students		
	N	$\overline{X}$	N	$\overline{X}$	N	$\overline{X}$	N	$\overline{X}$	N	$\overline{X}$	N	$\overline{X}$	Index	cm	N
1820s	50	101.3	17	100.1	29	99.7	35	99.6	14	100.5	78	98.8			
1830s	169	101.0	70	99.7	132	99.6	144	99.7	62	100.0	338	99.7	100.0	172.5	550
1840s	88	100.0	57	98.9	93	100.4	106	100.1	50	100.4	249	100.3	100.5	173.3	1089
1850s	107	99.5	98	98.7	114	99.2	143	99.8	48	99.9	305	99.6	100.2	172.9	335
1860s	198	100.0	169	99.2	226	100.0	233	99.5	91	100.0	550	99.8	101.1	174.4	506
1870s	35	100.0	26	99.9	60	100.7	41	100.2	20	101.7	121	100.7	101.8	175.6	307
Average	647	100.3	437	99.2	654	99.9	702	99.7	284	100.2	640	99.9			

Source: Komlos (1987)

Table 3: Descriptives for the skill premia data set

Decade	Observ.	Mean	Std. Dev.	Min	Max
1800	9	1.66	0.26	1.30	2.00
1810	9	1.73	0.32	1.32	2.42
1820	11	1.82	0.29	1.32	2.32
1830	11	1.86	0.37	1.32	2.60
1840	11	1.80	0.35	1.32	2.43
1850	11	1.80	0.37	1.32	2.65
1860	11	1.75	0.31	1.32	2.48
1870	10	1.77	0.31	1.32	2.13
1880	9	1.69	0.22	1.32	2.00
1890	8	1.67	0.27	1.32	2.10
1900	10	1.67	0.29	1.32	2.16
1910	10	1.69	0.25	1.32	2.11
1920	4	1.31	0.08	1.24	1.42
1930	5	1.34	0.16	1.20	1.61
1940	4	1.22	0.04	1.17	1.26
1950	33	1.64	0.48	1.08	3.00
Total	166	1.65			

Source: see text.

Table 4: Regressions of skill premia on height ginis

Model	(1)	(2)	(3)
Estimation technique	Fixed Effects	Random Effects	OLS
Height gini	2.13*	1.99***	2.49***
	(0.059)	(0.0028)	(0.000011)
Time fixed effects included?	No	Yes	No
Constant	0.69	0.92***	0.53**
	(0.16)	(0.0062)	(0.025)
Observations	50	50	50
R-square within	0.18	0.33	
R-square overall	0.23	0.34	0.23

Notes: Robust p-values in parentheses, ***, **, * indicates significance at 0.01, 0.05, 0.10 levels. The results of the Hausman test between model 1 and 2 were Chisq(1)= 0.03, Prob>chi2 = 0.8663, hence the fixed effects effects model would be preferred. Descriptive statistics can be found in Table 3.

Table 5: Regressions of skill premia on height ginis

Model	(1)	(2)	(3)	(4)	(5)
Estimation technique	Random Effects	Fixed Effects	Fixed Effects	OLS	OLS
Which years	All	All	All	All	Until 1910
Height gini	1.04*	1.04*	1.35**	2.53***	1.51***
	(0.09)	(0.09)	(0.02)	(0.00)	(0.00)
Time fixed effects	Yes	Yes	No	No	No
Country fixed effects	Yes	No	No	No	No
Constant	1.08***	1.28***	1.06***	0.52***	1.06***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	125	125	125	125	101
R-square within	0.36	0.36	0.08		
R-square overall	0.83	0.27	0.23	0.23	0.09

Notes: Robust p-values in parentheses, ***, **, * indicates significance at 0.01, 0.05, 0.10 levels. The results of the Hausman test between model 1 and 2 were Chisq(1)= 2.36, Prob>chi2 = 0.1243, hence the fixed effects effects model would be preferred. We used the changes in height gini of the following countries as reference countries in case interpolations were necessary for individual decades of countries in brackets: Brazil (for Argentina, Columbia, Guatemala, Mexico), Columbia (Nicaragua, Peru), China (North Korea, South Korea, Japan), Czech Republic (Poland), Germany (Austria, Switzerland), France (Belgium, Germany, Netherlands), Indonesia (Myanmar, Thailand), India (Bangladesh, Pakistan), North Korea (China), Poland (Czech Republic, Estonia, Hungary, Latvia, Russia), Portugal (Cyprus, Spain, Greece, Italy), Sweden (Denmark, Finland, Norway), United Kingdom (Ireland), United States (Australia). In the cases of missing Canadian values, both the US and the UK were used as reference countries.

Appendix Table 6: Estimated Height ginis (based on anthropometric inequality values)

Light grey color indicates interpolation based on growth rates of similar countries (see notes to Table 5), in the first column it is explained which country. Dark grey color indicates linear interpolation. It should be noted that those values are raw values – they might contain some biases and a certain degree of measurement error, especially if they would be taken for the analysis for individual countries. For global comparisons and the use as instrumental variables, they might be a valuable tool.

Sources: internet address of literature list: http://www.wiwi.uni-tuebingen.de/cms/fileadmin/Uploads/Schulung/Schulung5/Joerg/ref_anth.pdf

co	1810	1820	1830	1840	1850	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980
dr														46	49	47	50	
gy										46								
ht															49	49	49	44
cn		38	37	35	35	34	34	33	33	40	41	37	51	45	41	46	42	
hk		38	37	35	35	34	34	33	33	40	41	37	51	45	41	46	42	
kp		31	30	28	28	28	28	27	26	33	34	31	44	38	35	39	36	
kr		31	30	28	28	28	28	27	26	33	34	31	44	32	33	35	31	35
tw		38	37	35	35	34	34	33	33	40	41	37	51	28				
al								27	27	18								
am									36	35								
bg								39										
cz	33	35	36	33	35	32	54	50	51	41	39	41	41	41	40	38	40	43
ee	40	42	43	40	42	39	38	34	35	33	36	37	36	34	38	36	39	
ge									30	35								
hr													48					
hu	38	41	48	48	51	47	46	42	43	44	41	44	42	41	41	41	41	
kg									45	37	46	36		39	42	40	41	
kz									56		28		36	36	45	45	48	
lv	48	49	51	48	50	46	46	41	41	42	39	42	40	39	42	40	42	
mk												43						
pl	45	47	48	45	47	44	43	39	39	40	38	40	39	37	41	39	41	44
ru	51	52	54	51	53	49	49	45	45	62	42	40	36	34	38	36	38	41
si						31						38			35		34	
sk													38	40				
tj										47	49							
tm									29		41							
ua		38	42	36														
uz									42	40	42			39	45	47	43	
at	54	53	46	47	52	48	50	44	47	46	45	45	48	47	48	42	42	
au	47	47	45	44	47	45	45	42	42	39	42	33	35	37	39	46		
be	47	57	59	54	53	50	47	46	47	45	44	44	47	43	48	47	50	
ca	38	37	37	42	29	32	37	38	44	47	42	45	42	45	47	40	39	
ch	45	44	45	42	47	44	45	43	37	36	37	37	40	39	40	39	41	
cy	52	59	48	41	45	45	50	31	38	40							43	
de	45	45	46	43	48	45	46	41	44	43	41	41	44	44	44	43	45	
dk	42	33	42	40	42	41	41	41	40	37	41	33	33					
es	62	70	58	51	53	51	65	53	59	61								
fi	46	36	46	44	46	45	45	45	43	38	42	42	42	40	36	43		
fr	43	53	55	50	49	46	43	41	43	41	40	40	43	39	44	43	46	
gr	46	53	42	35	39	39	44	37	33	39			37		35	40		

ie	51	36	37	35	33	29	35	35	41	45	40	42	39	40	42	41		
it	34	41	44	37	41	41	45	41	46	48			41		38	44		
jp		37	36	34	34	33	33	32	45	43	44	43		36	40			32
nl	43	42	44	41	46	43	44	39	42	40	39	39	42	41				
no	37	28	38	36	38	36	36	36	35	32	42			36				
pt	49	56	45	38	42	42	47	42	48	50							43	42
se	43	34	43	42	43	42	42	42	41	38	42			34	45			
uk		40	42	39	37	34	40	40	46	50	45	47	44	45	47	45		
us	42	42	40	39	42	51	38	45	50	44	46	44	47	48	51	54	57	
ar		49	48	45	42	43	46	45	43	47	47	41						
bo														36	34	41	35	33
br		59	57	54	52	50	50	47	53	55	58	70			49	49	49	
co		70	68	65	63	61	61	52	54	63	57	52	52	50	48	47	46	
gt		73	72	68	66	64	64	56	57	66	60	56	55	53	51	55	54	
mx		63	62	59	38	51	46	47	51						57	59	62	64
ni		68	67	64	62	60	60	51	53	62	56	51	51	49	49	45	47	44
pe		79	78	80	64	60	50	53						42	45	43	43	44
af													38					
dz											35	34	33					
eg										45			45		42	42	39	36
il													42					
iq									45	49								
ir																59	61	60
lb									44	48								
ma								41							44	44	43	41
sy									36									
tr								35					36		42	40	41	40
ye										49								
bd				42	48	40	44	48	45	46	48	51	50	50	41	43	42	41
in				46	52	45	40	44	41	42	44	47	46	46	44	42	45	
pk				43	49	42	37	49	54	55	57	60	59	59	57	55	57	
id				42	42	43	48	51	40	42	38							
mm				35	35	36	36	36	25	26	23							
pg													47					
th				35	36	37	41	45	34	35								
ao										39	43	58	42	63				
bf												37	42	42	43	42	42	42
bi												49						
bj	53														47	48	45	47
cd											46	41	41					
cf															56	51	58	
cg	48										40	32	46	41				
ci															43	44	45	
cm									36	30	46		37		45	46	47	45
et														48	50	50	51	
ga															49	48	46	56
gh								50	46	46	42	41			48	46	48	46
gn											44				49	49	46	
gw													43	48	42			
ke								37			57	57	45	51	49	48	47	48
km															39	44	47	
mg												43			42	44	42	

ml													47	53	50	52	45	43
mw												36	39	37	42	45	45	49
mz							41				34				48	46	50	47
na								49						44	49	50	46	
ne											48			45	41	45	43	
ng	54	56							44									
rw											38	48			54	51	50	48
sd												45	48					
sn	58											39		47	43	46	40	
so												44						
td							40						41	30	47	47	47	52
tg															42	45	46	
tz										45	38	38	37	45	49	50	49	
ug											43				53	49	48	50
za										46	40	51	43	43				
zm														51	46	46	46	49
zw										39					47	47	48	

Appendix Table 7: Estimated Skill Premia, 1810 – 1980, based on height ginis (see Table 4-6)

Co	1810	1820	1830	1840	1850	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980
Cu														1.62	1.71			
Gy										1.72								
Ht												1.48	1.63					
Jm									1.74		1.60	1.59	1.63					
pr									1.63	1.70	1.68	1.69	1.84					
cn	1.68	1.59	1.58	1.55	1.51	1.61	1.54	1.52	1.52	1.63	1.64	1.59				1.74		
kp								1.42							1.55	1.62	1.56	1.51
kr														1.51	1.52	1.55	1.49	1.55
tw											1.27	1.14	1.20	1.45				
al								1.43	1.43	1.29								
am					1.53	1.96			1.56	1.67					1.57	1.64	1.75	1.70
az						2.14									1.56	1.58	1.83	1.58
bg								1.62					1.67	1.49				
cs					1.63		1.82	1.82	1.75							1.81		
cz	1.53	1.55	1.57	1.52	1.76	1.66	1.84	1.68	1.71	1.64	1.60	1.64	1.64	1.64	1.63			
ee							1.63	1.66	1.54	1.52	1.56					1.57	1.61	
ge									1.47	1.54								
hr					1.76				1.73	1.54			1.75		1.88	1.62		
hu	1.59	1.65	1.75	1.75	1.80	1.54	1.60								1.65	1.65	1.64	1.77
kg								1.56	1.70	1.59	1.72	1.56	1.53					
kz									1.87		1.44		1.57			1.69		
lv			1.54					1.65	1.64	1.65								
mk											1.58	1.68	1.58					
pl				1.70	1.74	1.68	1.67	1.61	1.62	1.73	1.71		1.61	1.59	1.64	1.61	1.64	1.69
ro				1.30	1.78		1.81			1.69								
ru				1.65	1.64	1.61		1.59	1.70	1.96	1.66	1.62	1.57	1.54	1.60			
si							1.49					1.60			1.56		1.54	
sk					1.77							1.74	1.59	1.62				
tj							1.60	1.55	1.74	1.74	1.77							
tm									1.45		1.64							
ua		1.59	1.66	1.56	1.92		1.62	1.74										
uz								1.68	1.65	1.62	1.65							
at		1.82	1.71	1.73	1.76											1.66	1.65	
au					1.73	1.71	1.70	1.65	1.66	1.61	1.65	1.52				1.71	1.66	
be														1.67		1.65		
ca	1.94	1.58	1.58	1.65	1.46	1.50						2.16	1.65	1.70	1.74	1.62	1.62	
ch		1.48	1.67				1.70	1.67		1.57	1.58							
cy						1.53	1.78	1.50	1.47									
de	1.71	1.70	1.71	1.68	1.75	1.70	1.72	1.64	1.68	1.59	1.55		1.69	1.68	1.69	1.68	1.71	
dk									1.62			1.52	1.53	1.44		1.69		
es				1.80	1.83	1.80	2.01	1.82	1.72	1.65	1.84					1.72		
fi								1.70		1.60			1.65	1.63	1.57	1.66		
fr	1.67	1.83	1.85	1.78	1.76	1.72	1.68	1.65	1.67	1.65	1.63	1.63	1.68	1.61	1.68	1.67	1.72	
gr							1.68	1.59					1.58		1.55	1.63		
ie	1.80	1.57	1.58	1.54			1.76	2.12	1.70	1.57	1.57					1.80		
it	1.82	1.64			2.19		1.39	1.64	1.79	1.69	1.70		1.65	1.74	1.60	1.68		
jp								1.51	1.71	1.67		1.67	1.61	1.56	1.62	1.61		1.50
nl							1.76	1.77						1.65		1.66		
no	1.72	1.54	1.50	1.59			1.57			1.51				1.56				
pt	1.76	1.87	1.70	1.59	1.66	1.65	1.73	1.66	1.75	1.78	1.66	1.69	1.52	1.71	1.67	1.70	1.67	1.66

se	1.67	1.53	1.68	1.65	1.68	1.66	1.58	1.66	1.64	1.60	1.66		1.52	1.54	1.71	1.68		
uk	1.86	1.62	1.65	1.62	1.59	1.54	1.62	1.63	1.71	1.77	1.70	1.73	1.69	1.70	1.73	1.71		
us	1.66	1.65	1.63	1.61	1.65	1.79	1.60	1.70	1.78	1.69	1.72	1.68	1.73	1.75	1.85	1.87	1.89	1.85
ar	2.29	2.22	2.30		1.66	1.67	1.72	1.70	1.67	1.73	1.73	1.64						
bo							1.50						1.43	1.41	1.37	1.54	1.39	1.35
br	1.76	1.91	1.89	1.84	1.81	1.78	1.78	1.73	1.83	1.86	1.90	2.08					1.74	
cl															1.50			
co							1.94	1.81	1.84	1.97	1.88	1.81	1.80	1.78	1.81	1.80	1.75	1.72
gt									1.63			1.50	1.50				1.74	
mx				1.91	1.60	1.79	1.72	1.74	1.79						1.89	1.92	1.96	1.98
pe		1.94	2.20	2.23	1.99	1.93	1.78	1.82				1.62						
af								1.67					1.59					
dz											1.55	1.53	1.52					
eg						1.99	1.16	1.45		1.70	1.66	1.77	1.69					
il							1.94						1.66					
iq								1.70	1.70	1.77	2.30							
ir							1.66	1.52	1.72	1.85	1.57					1.91	1.94	1.93
lb									1.69	1.75								
ly									1.57									
ma								1.64										
sy								1.95	1.56	1.83								
tr						1.64	1.67	1.55	1.54	1.68		1.56	1.56		1.63	1.78	1.70	1.62
ye										1.63								
bd					1.90	1.63	1.69	1.75	1.85	1.78	1.86							
in				1.71	1.81	1.70	1.63	1.68	1.64		1.69	1.73	1.72	1.71	1.80	1.76	1.78	1.81
lk																1.73		
np													1.55		1.96			
pk					1.52		1.58	1.76	1.65	1.86			1.58	1.64				
id				1.65	1.67	1.67	1.74	1.80	1.63	1.65	1.59							
mm					1.57	1.57	1.57	1.57										
pg						1.43		1.65					1.73					
ph						1.63	1.76	1.95	1.70	1.99	1.49							
th										1.55								
vn												1.66						
ao	1.93	1.69							1.45	1.61	1.67	1.90	1.66	1.97				
bf												1.58	1.66					
bi												1.76						
bj	1.82	1.66									1.69							
bw											1.52							
cd								2.25	2.09	2.55	1.71	1.65						
cg	1.75										1.63	1.50	1.72	1.65	1.65			
cm	1.90								1.57	1.47	1.72		1.58					
er								1.60										
eret							1.61											
et							1.62	1.42				1.87	1.47					
ga												1.82						
gh	2.11	1.50						1.43										
gn									1.56		1.69							
gw												1.93	1.67	1.75	1.66			
ke								1.57			1.88	1.88	1.70	1.70				
mg												1.68						
ml													1.73	1.82	1.87	1.95		
mr												1.53						
mw							1.56					1.57	1.61	1.61				
mz	1.58						1.65				1.54	0.95						
na							2.20	1.76					1.66			1.58		

ne											1.75							
ng	1.84	1.86							1.68									
rw							1.94				1.59	1.75						
sd							1.81				1.47	1.70	1.75					
sn	1.89	1.60									1.69	1.60			1.78			
so								1.71	1.68		1.65	1.69	1.42					
sz															1.81	1.72	1.73	1.82
td						2.02	1.63						1.64	1.47	1.75			
tz										1.70	1.60	1.60	1.58					
ug											1.68							
za									1.63	1.71	1.67	1.79	1.66	1.67				
zw										1.61								