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DEDICATION

To my wife Zuzanka

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CHAPTER I

MOTHERS, WIVES AND WORKERS: THE DYNAMICS OF WHITE FERTILITY, MARRIAGE AND WOMEN'S LABOR SUPPLY IN THE UNITED STATES: 1870 – 1930

"In woman's discovery of her ability to be independent, self-supporting, and self-sufficing, in her wish to work for humanity and not for one man, and in her fear that the appropriating power of a man's love will not be reverence for womanhood, her desire for marriage has lessened. The ideal of marriage is as beautiful as ever, but until she is sure that it can be hers she abides in her friendships and believes that the time will come when all noble women and men will be married. Meanwhile, she waits."

Kate Gannett Wells in "Why More Girls Do Not Marry",
North American Review, February 1891

1. Bargaining power and the changing role of women

How to make a living, whether (and when) to marry and how many children to have are three crucially important decisions with lifetime consequences. Around the turn of the century, American women increasingly arrived at substantially different answers to these questions than their mothers and grandmothers had. While the average age at marriage of women was increasing up until the 1890s, it declined thereafter (Haines, 1996; Taeuber and Taeuber, 1958: 153). While the young mothers of the 1870s had as many as 5 births, those who married in the 1920s were firm believers in a two-child family (Hernandes, 1996; David and Sanderson, 1987). While only one in seven women was engaged in "gainful employment" in 1870, one in four was by the 1920s (Hill, 1929: 19). While only a tiny minority of married women worked for wages outside of the home before 1900, their market labor supply began to increase after this date (Goldin, 1990: 46 – 50). While a large fraction of pre-1900 female employment consisted of domestic service and factory work, women increasingly ventured into other types of occupations such as teaching and office work afterwards (Rotella, 1981; Davies, 1982). Throughout the 20th century, women have steadily increased their influence in all areas of public life. The seeds of this growing self-assertion were sown between 1870 and 1930.

The shifts in the labor and marriage markets presumably had strong effects on – and were strongly affected by – the ongoing changes in the character of the American family. Each of these aspects has been the subject of empirical study.[1] The extant theoretical work either concentrates on post-World War II developments or is ahistorical (Becker, 1981; Greenwood et al., 2003, 2005a, 2005b; Grossbard-Schechtman, 1993; Lundberg and Pollak, 1993, 1996; Manser and Brown, 1980; McElroy, 1990; McElroy and Horney, 1981; Pollak, 1985). The complex interdependence of the three lifetime questions of work, marriage and fertility, however, calls for a unified explanatory framework in which the women's changing answers can be all analyzed simultaneously. The model developed in this paper seeks to achieve just that.

What exactly unleashed women's emancipation has long been a matter of some debate. The argument that changes in the legal status of women such as the married women's property laws of mid-19th century were responsible has met with skepticism (Basch, 1982: 29 – 30; Zeigler, 1996; Roberts, 2006). Goldin (1990: 58) notes that economic progress alone does not guarantee greater gender equality either. Greenwood et al. (2003, 2005a, b) highlight the role of advancing household technology but many of the household gadgets did not come into their own until the second quarter of the 20th century long after many of the emancipatory changes had already begun (Lebergott, 1993; Lomborg, 2001: Figure 37). I make an historical and theoretical argument that starts with technological change affecting the employment of single women. As the opening quote asserts, the labor market experience (and the independently earned income that

[1] See Combs (2006) and Moehling (2005) on the relationship between earnings and bargaining power. Angrist (2002) and Haines (1996) describe some of the characteristics and workings of the American marriage market. On women's labor market behavior, see Goldin (1990) and Mincer (1962).

goes with it) affected young women's expectations regarding marriage. To bring about a broader change in the role of women, however, the mere fact of an independently-earned income was not enough; it also had to be used as a bargaining chip on the marriage market. As the ranks of working single women swelled, their bargaining power increased and, after 1900, both the private (household) and public (labor market) sphere of life slowly began to adjust to the women's views.

2. The mechanism of historical change

With the rise of American industrialization after the Civil War, single women were pushed and pulled into the labor force in ever greater numbers. The changing nature of domestic work, the decline of agriculture and, in some families, poverty were among the push factors (Kessler-Harris, 1981: 57, 70 – 76; Blackwelder, 1997: 12). The pull factors included causes as varied as the division of labor due to new technology, the use of women as strikebreakers – and also, from the women's point of view, the independence that comes with having one's own, earned income.[2] This independence was enhanced for working single women who lived away from their families. Goldin (1990: 53) cites several turn-of-the-century surveys that showed that working single women living away from home usually retained most of their earnings and over two-thirds of them retained 100 percent whereas those who lived at home while working usually remitted most or all of their earnings to their parents. Even then, women enjoyed the benefit of having a greater say over how family finances were distributed (Moehling, 2005).

So strong, in fact, was the desire for independence that many single women had a clear preference for factory work over domestic service even though servants usually received free

[2] On the effects of technology on women's employment in various sectors, see Senate Report (1910) Vol. 9, p. 15 – 17. On women as strikebreakers in the cigar industry, see Abbott (1919), pp. 196 – 208. For women as strikebreakers in the printing industry, see, for example, Senate Report (1910), Vol. 9, p. 57.

board and might command a higher pay (Sutherland 1981: 109 – 110).[3] Table 1 illustrates the force of this preference among the 20-24-year olds. By 1930, the proportion of single white women working as domestic workers collapsed to between a quarter and a third of what it had been in 1860. Operative employment, on the other hand, was consistently above 30% and only went out of favor after 1910 as new occupations, promising not only higher salaries but also shorter hours and cleaner work environment, emerged. These were professional, clerical and sales jobs. Domestic service simply entailed too strong a curtailment of the women's freedom including, it seems, the freedom of social and dating life.[4] Department stores, on the other hand, presented ample opportunity to meet prospective dates. Indeed, so great was the attraction for both the woman employees and the male customers that some stores implemented policies to discourage the practice because it had the potential for adverse publicity.[5]

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[3] Senate Report (1910), Vol 9. pp. 182 – 183. Part of the difference in wages stemmed from regional differences of relative supply and demand for domestics: in Montana, a "good housekeeper could command $75 to $100" a month (p. 182) compared to "$10 to $14" in New York (p. 180) and compared to a New York factory worker's "$10 to $18 and even $22 a week" in the textile and shoe industry (p. 173). The report also quotes a discussion of this topic in The Revolution, a Boston paper, where, as early as 1870, the problem is repeatedly stated: "The reason girls don't live in private families is because they lose their independence there. They can't go out and buy a spool of thread until their appointed afternoon or evening comes around for it. When mistresses learn to treat their girls as human beings, they can get enough of them." By the 1920's, as American and white immigrant women were increasingly reluctant to take up domestic service, the demand was answered by black women. Due to discrimination and other reasons, domestic service then lost even the small income advantage that it may have had in the late 19th century (Palmer, 1987).

[4] Senate Report (1910), Vol 9., p. 183: "…if a girl goes into the kitchen she is sneered at and called the Bridget; but if she goes behind the counter, she is escorted by gentlemen to the theater, dined and called a lady."

[5] Senate Report (1910), Vol. 5, pp. 28 – 36. The department store owners seem to have believed they were acting to discourage covert prostitution, although at the same time, many of them openly admitted that they paid such low wages because they expected their woman employees to get by with a little help from a "man friend." (p. 30)

	Table 1: Marriage and labor market characteristics of white women aged 20-24 (%)										
			1860	**1870**	**1880**	**1890**	**1900**	**1910**	**1920**	**1930**
	Proportion married	Non-metro area	53.35	51.97	50.23		48.87	50.15	53.94	54.21
		Metro area	**42.52**	**39.69**	**34.35**		**34.58**	**39.56**	**42.99**	**42.68**
	Labor force participation		**1860**	**1870**	**1880**	**1890**	**1900**	**1910**	**1920**	**1930**
	Married women	Non-metro area	5.09	1.60	1.73		1.98	5.62	4.69	8.00
		Metro area	**3.77**	**2.55**	**3.29**		**2.42**	**5.41**	**8.81**	**15.06**
	Single women	Non-metro area	32.46	26.94	31.39		39.91	49.76	51.01	53.48
		Metro area	**55.03**	**56.62**	**57.09**		**64.13**	**73.06**	**79.98**	**79.14**
	Proportions employed as:		**Married women**							
			1860	**1870**	**1880**	**1890**	**1900**	**1910**	**1920**	**1930**
Occupations	Professional, clerical and sales	Non-metro area	3.42	13.55	13.27		13.60	12.08	28.37	46.83
		Metro area	**11.92**	**2.85**	**6.77**		**14.19**	**14.87**	**37.53**	**57.93**
	Craftswomen and operatives	Non-metro area	21.55	36.46	28.62		39.23	16.51	27.26	32.63
		Metro area	**54.77**	**71.49**	**76.10**		**58.83**	**50.27**	**46.66**	**29.70**
	Service workers	Non-metro area	59.30	34.14	27.98		22.60	11.28	12.90	11.05
		Metro area	**28.54**	**24.21**	**13.53**		**16.20**	**24.07**	**8.72**	**9.03**
	Other	Non-metro area	15.74	15.85	30.13		24.57	60.13	31.47	9.50
		Metro area	**4.77**	**1.45**	**3.60**		**10.78**	**10.79**	**7.09**	**3.35**
	Proportions employed as:		**Single women**							
			1860	**1870**	**1880**	**1890**	**1900**	**1910**	**1920**	**1930**
Occupations	Professional, clerical and sales	Non-metro area	15.50	18.25	21.76		35.40	48.89	63.58	60.02
		Metro area	**7.06**	**5.71**	**12.19**		**28.49**	**40.00**	**62.21**	**65.94**
	Craftswomen and operatives	Non-metro area	24.44	23.76	25.40		22.96	16.65	13.43	15.10
		Metro area	**37.62**	**37.92**	**44.14**		**37.18**	**36.91**	**25.54**	**19.19**
	Service workers	Non-metro area	54.41	52.26	45.08		34.68	23.55	14.68	16.41
		Metro area	**54.12**	**51.59**	**40.52**		**32.16**	**20.52**	**9.65**	**12.30**
	Other	Non-metro area	5.65	5.72	7.75		6.95	10.92	8.31	8.48
		Metro area	**1.21**	**4.78**	**3.16**		**2.17**	**2.57**	**2.60**	**2.58**

Source: IPUMS. The 20-24 age group is selected because many single women started their employment at this age, moreover, between 1870 and 1930, the average age at marriage mostly oscillated between 22 and 25 years of age. White women have been selected for analysis here because other groups, such as blacks and Native Americans are represented in relatively low numbers in IPUMS samples which makes any computations of averages and proportions less reliable.

For women, the relative independence of working single life contrasted with the much stricter routine of married life (Rothman, 1984: 245 – 253).[6] In marriage, women lost many of the legal rights they enjoyed while single (Zeigler, 1996). Peiss (1987) notes that husbands had much greater discretion in spending than wives.[7] There was also a significant difference in how married and single women spent their free time. Single women could and did attend theatres and dances whereas married women spent most of their leisure time at home and largely alone or with children, their husbands having gone out with friends (Peiss, 1987: 106; Coontz, 2005: 191 – 193).

This sharp and potentially growing disparity between a woman's single and married life may go some way toward explaining the marked postponement of marriage at the end of the 19th century. Data assembled by Sanderson (1979) and Haines (1996) imply that between 1870 and 1900, the women's mean age at first marriage grew by about 1.5 year.[8] Table 1 shows that, before 1900, the proportion married declined. This development was particularly strong in the metropolitan areas where the proportion married fell by 8 percentage points, or about a fifth, between 1860 and 1880/1900.[9]

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[6] Admittedly, Rothman (1984) relies on evidence that is likely skewed towards middle class women (diaries, letters, literary journal contributions). But using these sources, she documents a growing recognition among women and men that the reality of marriage was far behind the companionate ideal and that women were particularly unhappy with the situation. She quotes a 26-year old Sadie Treat who wrote to her fiancée: "Marriage makes such a difference to me – while with you it's all gain… I must give up more than you." (p. 248)

[7] Regarding the spending discretion, Peiss also quotes (p. 103) an investigator Elsa Herzfield as claiming: "The husband brings his wages to his wife at the end of the week or fortnight. He gives her the whole amount and receives back carfare and 'beer' money; or he gives her as much as 'he feels like' or 'as much as he has left after Saturday night'."

[8] This estimate relies on the singulate mean age at marriage (SMAM) which stood at 23.85 in 1900. While post-1880 calculations of SMAM in Haines (1996) are based on census data, pre-1880 estimates of Sanderson (1979) are more tentative. In gauging the extent of marriage delay, I rely on Haines' (1996) argument that Sanderson's (1979) estimates are too low in absolute value (compared to what census data would yield if they were available for pre-1880 years) but that they capture the overall trend in SMAM reliably.

[9] Interestingly, the sex ratio (men per 100 women) in the 20-29 year group was actually more favorable to women prior to 1910 and less favorable afterwards. However, overall it fluctuated between a peak of 106.5 (1910) to a trough of 95.3 (1950) for the white population (Table 2 in Haines (1996)). See also Ogburn and Nimkoff (1955:70 – 71).

The turn of the century, however, marked the nadir of this decline in marriage. Fully 51.8 percent of the women of the 1865-1874 birth cohort, who reached age 20-24 in the 1890s, were single but in subsequent cohorts this share declined (Taeuber and Taeuber, 1958: Table 47). Mirroring this development, the proportion of young women who were married in Table 1 rebounded after 1900 and, by 1930, surpassed the 1860 level. Mean age at marriage declined, falling back to the 1870 level by 1930. A study of three generations of Ohio women indicates that the extra 1.5 years of single life that the late-Victorian women enjoyed compared to their mothers or daughters was probably due to longer courtship and engagement period rather than due to later entry into the marriage market or a higher number of relationships (Koller, 1951).[10]

During this period, the nature of marriage and the public perception of gender roles within marriage were undergoing a substantial transformation (Coontz, 2005: 196 – 215). In the public sphere, American courts were increasingly willing to grant women a divorce from cruel husbands.[11] In the private sphere, Koller (1951) reports that, in each successive generation, pre-marital discussions about future family operation (e.g. control of finances, wife's work, number of children etc.) were becoming more frequent. One aspect of the change concerned married women's labor force participation which, as Table 1 illustrates, was on the increase after 1910, particularly in the metropolitan areas.[12]

Inevitably, this process entailed a change in the prevailing attitudes toward a wife's employment. In the 19th century, most women, even if they worked while single, withdrew from

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[10] While Koller (1951) relies on a voluntary questionnaire survey and his sample is limited and biased towards rural population for the oldest generation, he shows, that over 85% of women in each of the three generations considered no more than two serious candidates for marriage and that, in each generation, they had their first date with their (first) future husband at about age 19. Women of older generations reported to have known the men that eventually became their husbands for a much longer period of time.

[11] For changes in divorce law, see Griswold (2001). Not only physical but mental cruelty also was increasingly viewed as legitimate grounds for divorce.

[12] The participation rates in Table 1 in fact misrepresent the difference between urban and rural areas. Goldin (1990) shows that the 19th century censuses likely underenumerated wives who were supplying unpaid work at a family farm. The omission could be as large as 5 percentage points. See Goldin (1990), Appendix to Ch. 2, pp. 219-227

employment once they married.[13] Some wives continued to work because their husbands were unable to provide for the family – a signal that a reasonably well-earning husband might not want to send. Because of this social stigma, many wives were discouraged (or prevented by their husbands) from entering the labor market (Goldin, 1990: 133 – 134). Thus, even though most US states granted married women property rights over their earnings by the late 19th century, married women's labor supply remarkably failed to respond to this change (Roberts, 2006).[14] The prevailing domestic ideology exalted women primarily as mothers. The Brandeis brief, documenting the negative effects of excessive labor hours on women's fitness for child-bearing in the 1908 *Muller v. Oregon* Supreme Court decision, was motivated precisely by this very specific understanding of a woman's role: namely that women's work must be regulated so that it does not compromise, and interfere with, their future motherhood.[15] As late as the Great Depression, 89 percent of the public believed that married women with husbands present should not work (Kessler-Harris, 2001: 59). Even so, married women were joining the labor force in growing numbers and family life had to adjust.

An important piece in the puzzle was the changing pattern of marital fertility.[16] Prior to 1900, a large portion of the decline in overall fertility was due to falling marriage rate

[13] Baxandall and Gordon (1995), p. 103, cite an 1890 letter of one Knights of Labor leader, concerning the "career future" of one of his female co-workers, Leonora Barry, who was about to marry: "…Sister Barry's days are numbered. You will never, in all probability, rest eyes on her again… She has not yet been called across the dark river but she will soon be buried in the bosom of a Lake that shall wash away all claim that we may have to her…"

[14] Khan (1996) shows that, in fact, American women responded to property acts, for example, by increasing their patenting activity and Combs (2005, 2006) shows that analogous property act in Britain (1870) increased British wives' share of ownership inside a family and changed their investment behavior. Thus, married women did respond to the legal changes in their status but not in terms of market labor supply.

[15] See Brandeis and Goldmark (1969). The report had a special section on "Specific Evil Effects on Childbirth and Female Functions" (pp. 36 – 42), and another on "The Effect of Women's Overwork on Future Generations" (pp. 51 – 55). Of the benefit of shorter hours, the report said: "Wherever sufficient time has elapsed since the establishment of the shorter work day, the succeeding generation has shown extraordinary improvement in physique and morals." (p. 57)

[16] The following analysis omits out-of-wedlock fertility. While accurate information of the rate of out-of-wedlock births is hard to find, Taeuber and Taeuber (1958) put it at 4% (p. 266) for the period 1938 – 1950. If, in the previous decades, the rate was similar in value, it is unlikely that it would influence the analysis much.

(nuptiality). Sanderson (1979: 344) calculates that a decline in nuptiality was responsible for about one third to three fifths of the decline in total fertility in the last four decades of the 19th century. Post-1900, however, fertility declined through control exercised inside marriage.[17] It was clearly no longer controlled primarily through the postponement of marriage (as average age at marriage started decreasing). While other factors were likely at play, it seems that the increase in married women's labor force participation and the steep decline in marital fertility are a sign of reallocation of labor from home to the labor market, a result of the changing opportunities for married women.

To summarize, women's answers to the three big questions of work, marriage and childbearing changed significantly between 1870 and 1930. This transformation, I argue, started and ended in the labor market and it changed family life in the process. For a variety of reasons, the gap between the employment and lifestyle opportunities of single and married women was widening in the late 19th century. As wage earners, young single women could enjoy a certain level of independence and freedom which they lost upon marriage. These perquisites of single life increased the opportunity cost of marriage as well as the young women's threat point in bargaining with men on the marriage market. Some previously acceptable matches became unacceptable as a result and the marriage rate declined. The turnaround in the marriage rate around 1900 suggests that men eventually acquiesced to the growing bargaining power of women who won a greater say in the distribution of family resources and in the allocation of their own time between market and household. These changes made marriage more attractive again, the age at marriage declined and the marriage rate rebounded. Fertility was affected first by the postponement of marriage, then by the increased labor supply of women.

[17] Note that early 20th century was a time when information on methods of contraception proliferated, providing the means, if not the motivation, for the birth control. See Coontz (200), p. 197

In the model below, I put this mechanism on a more formal footing. The empirical facts to be explained include (a) the increase in single women's labor force participation from the Civil War onwards; (b) the decline in the marriage rate in late the 19th century and its rebound in early 20th; (c) the decline of total fertility and of marital fertility; (d) the eventual rise in married women's labor force participation after 1900 and the improvement in their position inside the family as measured by their share of consumption and their contribution to family budget. The calibration exercise that follows and the related simulations show that the model is able to capture the main observed trends in labor force participation, marital behavior and fertility in US history. The main points of divergence between the historical reality and the results of simulation arise in marital behavior. The simulations produce the swing in marriage rate for a wide array of parameters but the actual rate of marriage is overestimated and is sensitive to the value of the discount factor, δ.

3. The model

The model is based on the search-theoretical guidelines of Mortensen (1988) and on Nash-bargaining models of Manser and Brown (1980) and McElroy and Horney (1981) but it is not a dynamic general equilibrium model, as seen, for example, in Greenwood et al. (2003). The long-term changes in marital and labor decisions are analyzed in terms of comparative statics as the model is solved separately for each generation of young marriage-seeking men and women.

Time is split into discrete periods. Within each period, each unmarried individual must make a decision whether to work during the current period (having a time endowment of 1 each period), whether to marry during the period and, if so, what the characteristics of the newly formed family will be (i.e. number of children, wife's labor supply etc., see Figure 1).

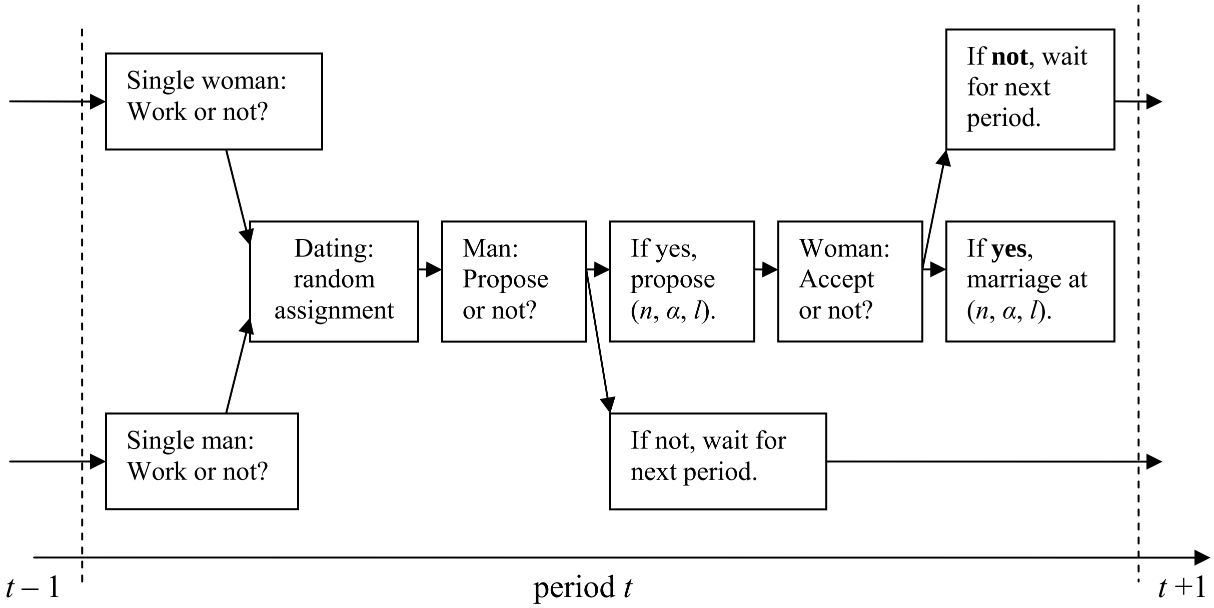

Figure 1 - Sequence of decision-making during each period

The utility function takes the following form:

Men	Women
$U = \pi\sqrt{n} + c_M - \rho(\theta_M)l$ subject to $c_M \leq (1-\alpha-\beta n)(w_M - R)$	$U = \sigma\sqrt{n} + c_F$ subject to $c_F \leq \alpha(w_M - R) + w_F l$ or $c_F \leq C$

In this quasi-linear utility function, c_M and c_F stand for man's and woman's consumption; n represents the number of children a person has; α is the fraction of a husband's wages consumed by a wife and l represents a wife's labor supply.[18] Before marriage, workers – both men and women – are assumed to live in their own household which costs a constant R ("rent")

[18] Since the model allows the possibility that married women do not supply any labor and thus earn no wages, αw_M is the monetary transfer from their husband that is their sole source of consumption. See Combs (2006), pp. 70 – 71, for a brief description of how such a monetary transfer worked in the late 19th century. For a more recent period, see Woolley (2003).

to maintain every period.[19] If a woman does not work while single, she is assumed to live in with her parents, pay no rent and receive a stipend *C*. The parameters π and σ are utility weights which determine how a person values children relative to consumption. Since generally $\sigma \neq \pi$, men and women can differ in their subjective evaluations of the two sources of utility. The parameter $\rho(\theta_M)$ in the man's function is a measure of his disutility from his wife's labor supply, l, and it depends positively on the man's personal productivity parameter, θ_M.[20] A non-zero labor supply on the wife's part brings the husband a disutility that is greater the more productive he is.[21] Finally, the consumption good can be purchased at unit price for wages. The quasi-linear functional form has the convenient property that it treats children (n) as a normal (household public) good, but since each child claims a fraction β of a father's income, it also allows for a negative relationship between income and fertility which is the historically observed relationship.

The matching mechanism ('dating') can be viewed as a simplified version of a partner search as described in Mortensen (1988).[22] Adults are indexed by a productivity level (denoted θ_M for men, θ_F for women), cumulatively distributed according to $F(\Theta_i)$ over $\Theta = [\underline{\theta}, \overline{\theta}]$. Together with a production function, the productivity parameter determines each person's wage. Assume that men's production function is $f = A\theta_M l_M$ and wage $w_M(\theta_M) = A\theta_M$ where A is a technological parameter. For women, assume $g = B\theta_F l$ and $w_F(\theta_F) = B\theta_F$. Again, parameter B describes technology. Men and women are identical *ex ante* but when a pair meets (on a 'date') they observe each other's labor force status, productivity and utility parameters. Upon mutual

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[19] Thus, there are economies of scale in marriage, as two separate households are reduced to one. See Greenwood et al. (2005b) for a similar argument.

[20] Note that the woman's disutility function does not include any such disutility term. Implicitly, this assumes that 19th century women did not internalize any of their husbands' prejudice against their wives' employment which may is a strong assumption. However, from the modeling point of view, adding a similar term to the women's utility function would not, in this specification, alter the model results substantially.

[21] For simplicity, the model takes $\rho(\theta_M)=\rho\theta_M$ where $\rho < 1$ is a constant.

[22] A similar matching mechanism is employed by Greenwood et al. (2003) and Greenwood and Guner (2005b).

observation, the man may or may not formulate a marriage proposal (described in section 3.3) which the woman may or may not accept (as described in section 3.2 and 3.4). Once married, men and women stop searching and I assume there is no divorce.[23] Both men and women expect their next-period wage to be the same as their current-period wage – not so much because they have myopic expectations but rather because their decisions regarding marriage are viewed as life-cycle decisions.

3.1. The Woman's Dilemma: Evaluating a Marriage Proposal

The model is solved by backward induction. Denote a woman's lifetime utility V and her one-period utility v_s if she is single and v_m if married. Depending on her labor force status, a woman enjoys $v_s = w_F - R$ or $v_s = C$ while single. If she accepts a marriage proposal, (n, α, l), she enjoys $v_m = \alpha(w_M - R) + w_F l + \sigma\sqrt{n}$ of utility every subsequent period of her life. If she rejects, she will start a new relationship and face the same decisions next period. Thus, assuming a discount factor $\delta < 1$, a marriage proposal will only be accepted as long as $v_s + \delta V \le v_s + \delta \frac{v_m}{1-\delta}$ which simplifies to $V \le \frac{v_m}{1-\delta}$.

Note that prior to meeting her date each period, all that a single woman knows is that the man she meets may or may not propose to her. Let us assume, then, that there is a set Θ_r such that every man of productivity $\theta_M \in \Theta_r$ is willing and able to present a proposal that is worth accepting. A proportion $r = \int_{\theta_M \in \Theta_r} dF(\theta_M)$ is a fraction of all the men who are "marriageable

[23] Divorce was rather rare between 1870 and 1930. According to Hernandez (1996), there were 1.5 divorces per thousand married women in 1870. By 1930, the divorce rate grew to 8 per thousand married women – considerably lower than the peak 22.8 divorces per thousand married women in 1979.

bachelors". Then, a woman's lifetime utility depends on the probability of her meeting such a man:

$$V = (1-r)(v_s + \delta V) + rv_s + \frac{\delta}{1-\delta} \int_{\theta_M \in \Theta_r} v_m(\theta_M) dF(\theta_M) = (1-r)(v_s + \delta V) + rv_s + \frac{\delta}{1-\delta} E_r v_m \qquad \text{(Eq. 1)}$$

where $E_r v_m$ denotes an expectation of marital utility across the acceptable marriage proposals. Therefore, a proposal that a single woman finds acceptable is such that

$$\frac{1-\delta}{1-(1-r)\delta} v_s + \frac{\delta}{1-(1-r)\delta} E_r v_m \leq v_m \qquad \text{(Eq. 2)}$$

The proportion r of eligible bachelors then consists of those men who can formulate a proposal that satisfies this inequality. But note that each individual man must take the left-hand side of the inequality as given; one man can influence neither r, nor $E_r v_m$, nor v_s. Thus, from the man's perspective, each woman has some given fixed reservation utility which his proposal must match or better, if it is to be accepted. Since men have the power to make a take-it-or-leave-it offer, they will exactly match such reservation utility when they propose.

This also means that, from the woman's point of view, v_m is independent of θ_M and $E_r v_m = r v_m$.[24] Using this result and simplifying the inequality yields $v_s \leq v_m$, or more specifically, $\max(w_F - R; C) \leq \alpha(w_M - R) + w_F l + \sigma\sqrt{n}$. Thus, every woman accepts any proposal that promises her at least as high a per-period utility as she is currently enjoying while single. This result is expected considering that the bargaining rule employed in the model is, according to Manser's and Brown's (1980) typology, a dictatorial one. In a dictatorial setup, one

[24] Note, however, that the woman's utility can potentially come from two sources: consumption and children. While the prospective husband's productivity, θ_M, does not influence the overall level of a woman's utility (or "marital satisfaction"), v_m, it has an impact on the sources of utility. A high- θ_M husband will supply his wife with higher consumption c but will propose to have fewer children (n) whereas a low- θ_M man will do the opposite. Thus, a marriage to a less productive man does not condemn a woman to a "less happy" marriage, rather, the "happiness" will come from a non-consumption source.

of the bargaining parties gets to make a take-it-or-leave-it offer to the other party. The result is that such offer will exactly match the other party's reservation utility, or threat point.[25]

3.2. Optimal proposal

Since a man has the initiative in proposing, his aim is to come up with a vector (n^*, α^*, l^*) that would be utility-maximizing for him yet still acceptable to his partner. His optimization problem can be summarized thus:

$$\max_{n,\alpha,l} \pi\sqrt{n} + (1-\alpha-\beta n)(w_M - R) - \rho\theta_M l$$

subject to:

$\max(w_F - R, C) \leq \alpha(w_M - R) + w_F l + \sigma\sqrt{n}$ (woman's reservations utility constraint – WRUC)

$l + tn \leq 1$ (wife's time constraint – WTC)[26]

$l \geq 0$ (non-negative labor supply condition – NLSC)

The following Lagrangean yields the necessary first order conditions (FOC):

$$L = \pi\sqrt{n} + (1-\alpha-\beta n)(w_M - R) - \rho\theta_M l - \lambda(l + tn - 1) - \mu\{\max(w_F - R; C) - [\alpha(w_M - R) + w_F l + \sigma\sqrt{n}]\} - \nu(-l)$$

First-order conditions:

n: $$\frac{\pi}{2\sqrt{n}} - \beta(w_M - R) - \lambda t - \mu\left[-\frac{\sigma}{2\sqrt{n}}\right] = 0 \qquad \text{(Eq. 3)}$$

α: $$-(w_M - R) - \mu[-(w_M - R)] = 0 \qquad \text{(Eq. 4)}$$

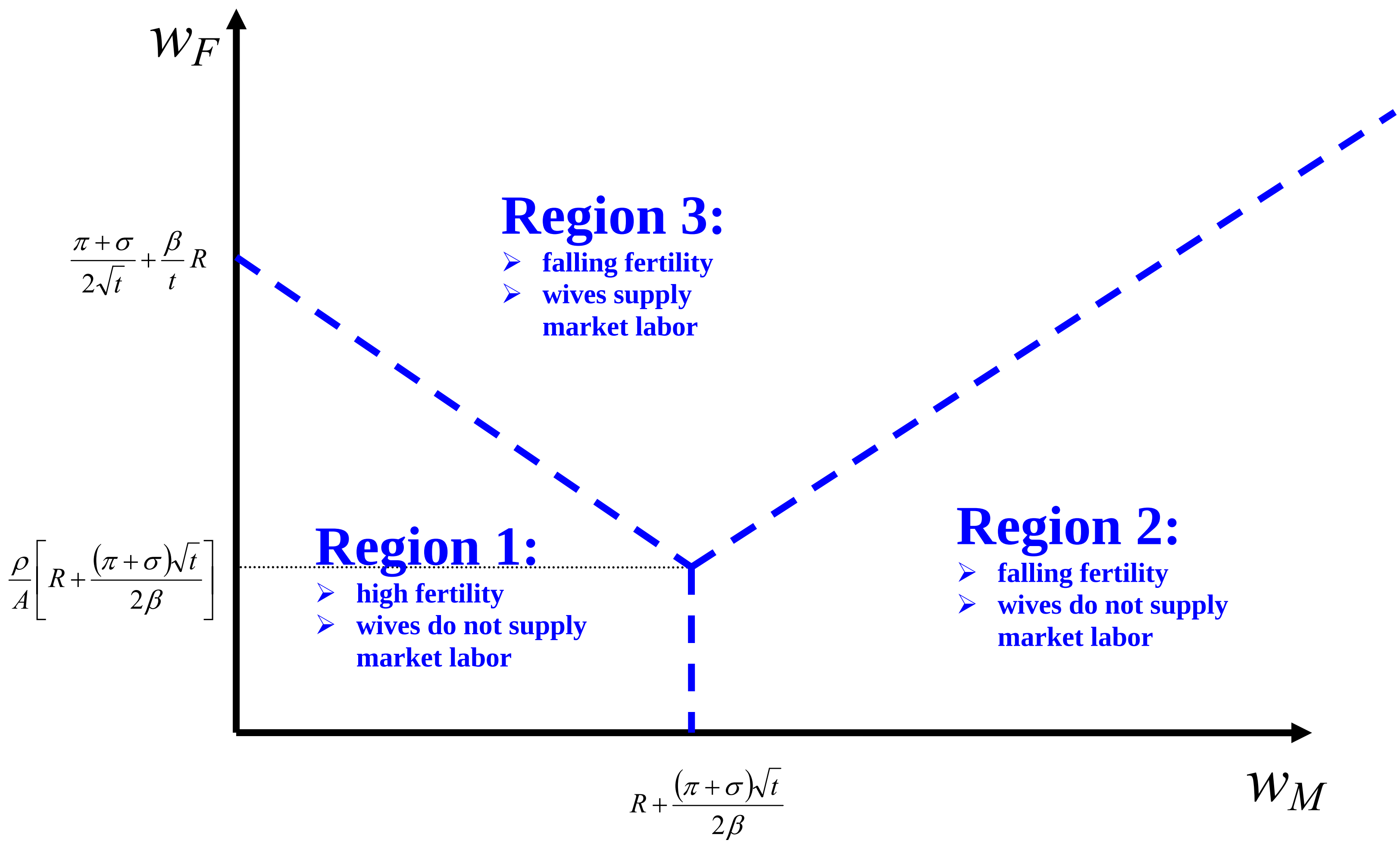
l: $$-\rho\theta_M - \lambda - \mu(-w_F) + \nu = 0 \qquad \text{(Eq. 5)}$$

[25] An alternative is symmetric bargaining where the couple solves some Nash objective function in which the prospective utilities of both partners are treated symmetrically. See Manser and Brown (1980), pp. 36 – 41.
[26] Each child claims a fixed fraction t of a woman's time. It is assumed that $t > \beta$.

Together with the constraints, the first-order conditions form a system of six equations with six unknowns (three optimization variables and three shadow prices-lagrangean multipliers). The solution of this constrained optimization is such that WRUC is always binding ($\mu = 1$). Thus, women's level of utility does not change with marriage. It also means that women never reject such a proposal because waiting for next period would not be advantageous to them in any way. However, this result connects a woman's pre-marriage economic position with the determination of intra-household resource distribution. If the wages earned by single women increase, it will have an important effect on how much they will consume as wives. With regard to the other two constraints, corner solutions are possible, depending on wages.

What is of primary interest is precisely how the optimal proposal – the vector (n^*, α^*, l^*) – responds to changes in male and female wages, w_M and w_F. This is summarized in Table 2 and in Figure 2 which is drawn in a w_F–w_M space. The optimization constraints delineate three regions which affect the nature of the optimal solution. In Region 1, wives do not supply market labor (the NLSC constraint binds) and fertility (n^*) is high as women spend all their time rearing children (WTC binds). In Region 2, the fertility transition gets under way (WTC is relaxed) but married women's employment is zero (NLSC still binds). Eventually, in Region 3, fertility decline is in full swing and married women gradually appear on the labor market (NLSC is relaxed and WTC becomes binding again as women split all their time between child-rearing and labor supply).

Table 2: Solution to the constrained optimization – optimal proposal				
	Binding constraints	n^*	α^*	l^*
Region 1 $w_M < R + \frac{(\pi+\sigma)\sqrt{t}}{2\beta}; w_F < \frac{\pi+\sigma}{2\sqrt{t}} - \frac{\beta}{t}(w_M - R) + \frac{\rho}{A}w_M$	WTC, NLSC	$\frac{1}{t}$	$\frac{\max(C; w_F - R)}{w_M - R} - \frac{\sigma}{(w_M - R)\sqrt{t}}$	0
Region 2: $w_F \le \rho\theta_M = \frac{\rho}{A}w_M; w_M \ge R + \frac{(\pi+\sigma)\sqrt{t}}{2\beta}$	NLSC	$\left[\frac{\pi+\sigma}{2\beta(w_M - R)}\right]^2$	$\frac{\max(C; w_F - R)}{w_M - R} - \frac{\sigma(\pi+\sigma)}{2\beta(w_M - R)^2}$	0
Region 3 $w_F \ge \frac{\pi+\sigma}{2\sqrt{t}} - \frac{\beta}{t}(w_M - R) + \frac{\rho}{A}w_M; w_F > \rho\theta_M = \frac{\rho}{A}w_M$	WTC	$\left[\frac{\pi+\sigma}{2\beta(w_M - R) + 2t(w_F - \rho\theta_M)}\right]^2$	$\frac{\max(C; w_F - R)}{w_M - R} - \frac{w_F l^*}{w_M - R} - \frac{\sigma\sqrt{n^*}}{w_M - R}$	$1 - tn^*$
Note: Optimal proposals differ by region. Desired number of children, *n*, is highest in Region 1 but otherwise decreases in male (Region 2) and female (Region 3) wages. Married women do not work in Regions 1 and 2 because they are prevented either by full-time child care (Region 1) or by their husbands disutility from wife's work (Region 2).				



Note: Man's proposal will vary depending on the region in which a match occurs. The region borders are determined by optimization constraints. For their formal expression, as well as for closed-form solutions for the optimization problem, see Table 2.

Figure 2 – Optimal proposals in a $w_M - w_F$ space

When most men and women earn relatively low wages, most matches will at first fall into Region 1. As wages keep increasing due to technological change, more matches will occur in Regions 2 and 3. How many matches fall into Region 2 and how many into Region 3 depends both on the absolute levels of male and female wages and also on the relative wages of women and men. Table 2 shows that the regional location of a match determines what kind of proposal will be formulated. Because the proportion of matches falling into any one region will differ from generation to generation due to technological change, the resulting marriages will also differ from generation to generation.

To analyze marital behavior, let us consider what happens when an optimal proposal is accepted by a woman and a married couple is formed. Many aspects of the history of the American family at the turn of the 19th and 20th centuries are captured in the optimal proposal. A marriage proposal in Region 1 involves a high optimal n^* that is independent of male and female wage. In Region 2, optimal n^* is lower than that in Region 1 and it also declines in male wage. More productive men demand fewer children because the utility from children exhibits diminishing returns, yet each child costs a given proportion of the man's wage, β. Moreover, for married couples in Region 3, the woman's wage also enters the denominator of n^*, because in Region 3 a married woman's labor supply is positive and the negative effect of diminishing utility is reinforced by the positive time cost of children, t, that women incur.

Married women supply no labor to the market in Regions 1 and 2. Thus, even if a woman works while single, she drops out of the labor market once she marries. Here the model realistically captures what was a frequent practice in the turn-of-the-century urban America (Goldin 1990: Table 2.6). Note that in Region 2, she would have spare time to work, since the WTC is not binding. It is the disutility that her husband gets from her employment that prevents her from earning an independent income. The Region 3 matches, however, are those where the woman's wage, w_F, is so high that the man's opposition becomes "too expensive" so that he cannot afford to propose that his (future) wife stay out of the labor market. Note that an increase in w_F reduces n^* and increases l^*: thus in Region 3, married women's labor supply increases with wage.

The fraction α^* of man's income is a reflection of both a woman's consumption prior to marriage and of the family's fertility. Before marriage, consumption is women's only source of utility. Once married, women obtain the same level of utility (see section 3.1) but now from two sources: consumption and children. This means that a woman's consumption declines in marriage and that children are substituted. The degree of substitution will depend on the productivity of the husband. If a woman is married to a high-productivity man, the couple will have fewer children but the man will supply his wife with a high consumption while if the husband has low-productivity, consumption will be lower and n^* higher.

As time goes on, technological change effects a transformation both on the marriage market and on the labor market. It increases wages and thus shifts the distributions of both male and female wages. As a result, the proportion of matches that place to Regions 2 and 3 will increase from generation to generation and if such matches also lead to marriage, marital fertility will decline and more women will remain in the workforce after marriage (in Region 3).

3.3. Why do single women go to work?

In deciding whether to go to work or not, a single woman considers the costs and benefits of either alternative. Her labor force status and her wage are important because they directly influence how much of the family's resources she will claim in marriage but it also makes her less attractive as a marriage partner relative to non-working or lower-earning women. Note in Figure 1 that men can decide not to propose to a woman if they consider the expected payoff of waiting to be higher than marrying their current match. Thus, by entering the labor force, a woman increases her lifetime consumption and utility but jeopardizes her chances of marriage (since men can adopt a waiting strategy). The costs and benefits of not working are the reverse of that; there is the certainty of proposal but low consumption throughout life.

A woman's lifetime utility is denoted *V*. At the beginning of the period, she has to decide whether to work or not. She chooses the alternative that promises the higher lifetime utility. Thus,

$$V = \max\left\{C + \frac{\delta}{1-\delta}C; (1-r)\left(w_F - R + \delta V\right) + r\left[w_F - R + \frac{\delta}{1-\delta}(w_F - R)\right]\right\} \qquad \text{(Eq. 6)}$$

The first term, $C + \frac{\delta}{1-\delta}C = \frac{C}{1-\delta}$, denotes her lifetime utility if she does not work (i.e. she marries at the end of the current period). The second term denotes the lifetime utility if she does work in the current period. The fraction r represents the probability that she will marry in the current period if she chooses to work, that is, the fraction of men who will propose to the working woman because they do not find it optimal to wait (see section 3.1.). Thus, if a woman is matched with someone who prefers to wait (with a probability $1 - r$) she will consume her current wage net of rent, $w_F - R$, and wait for the next period when she will face the same lifetime prospects (δV) as before. If she is matched with a man ready to propose to her (with probability r), she will also consume $w_F - R$ and then will be married.

The decision, whether to work or not, will depend on which of the lifetime utilities is higher. It is not difficult to show that the problem has a simple solution where

$$V = \max\left\{\frac{C}{1-\delta}; \frac{w_F - R}{1-\delta}\right\} \qquad \text{(Eq. 7)}$$

Therefore, any woman will work if her wage is high enough to ensure her higher utility (net of rent) than what her family can provide her on a stipend. Thus, for the female wages, it must hold that $w_F(\theta_F) \geq R + C$ which implies that working women are those for whom $\theta_F \geq \theta_{F\min} = \dfrac{R+C}{B}$.

If technology increases female wages (across the whole distribution) faster than the family stipend and rent increase, more and more single women will go to work and *p*, the proportion of working single women, will rise:

$$p = \int_{\frac{R+C}{B}}^{\bar{\theta}} dF(\theta_F) = 1 - F\left(\frac{R+C}{B}\right) \qquad \text{(Eq. 8)}$$

3.4. To propose or not to propose?

From the man's point of view, the alternative to making a proposal (as described in Table 2) is to wait until the next period and hope for a better match.[27] Denote a man's utility from marrying a working woman $U = U_W\left(w_M(\theta_M), w_F(\theta_F)\right)$ and his utility from marrying a non-working woman $U = U_N\left(w_M(\theta_M), C\right)$. Marriage with a non-working woman brings men higher utility than marriage with a working woman ($U_N > U_W$) and marriage with lower-earning (low-θ_F) woman is preferable to men over a marriage with a high-earning (high-θ_F) woman because women with lower pre-marital consumption will accept a lower α, ceteris paribus. Non-working women therefore always get a proposal because a man gains nothing by waiting. Among the working women, the decision whether to propose or not is a matter of comparing the potential utility from marriage with the current match and the expected utility of waiting for next period:

[27] Strictly speaking, staying single could be seen as another alternative. Considering that, throughout the period, never more than 10% of women and 12% of men remained lifetime celibate (Haines, 1996:26), it is assumed here that the men and women already have made the decision to get married.

$$U_W(w_M(\theta_M), w_F(\theta_F)) \leq\geq \delta EU \qquad \text{(Eq. 9)}$$

Expected utility must obviously take into account all potential alternatives that may arise in next period's matching. A man might meet a non-working woman, or a low-earning woman he might be willing to marry, or a high-earning woman, he would prefer to pass and wait once more. Expressed mathematically,

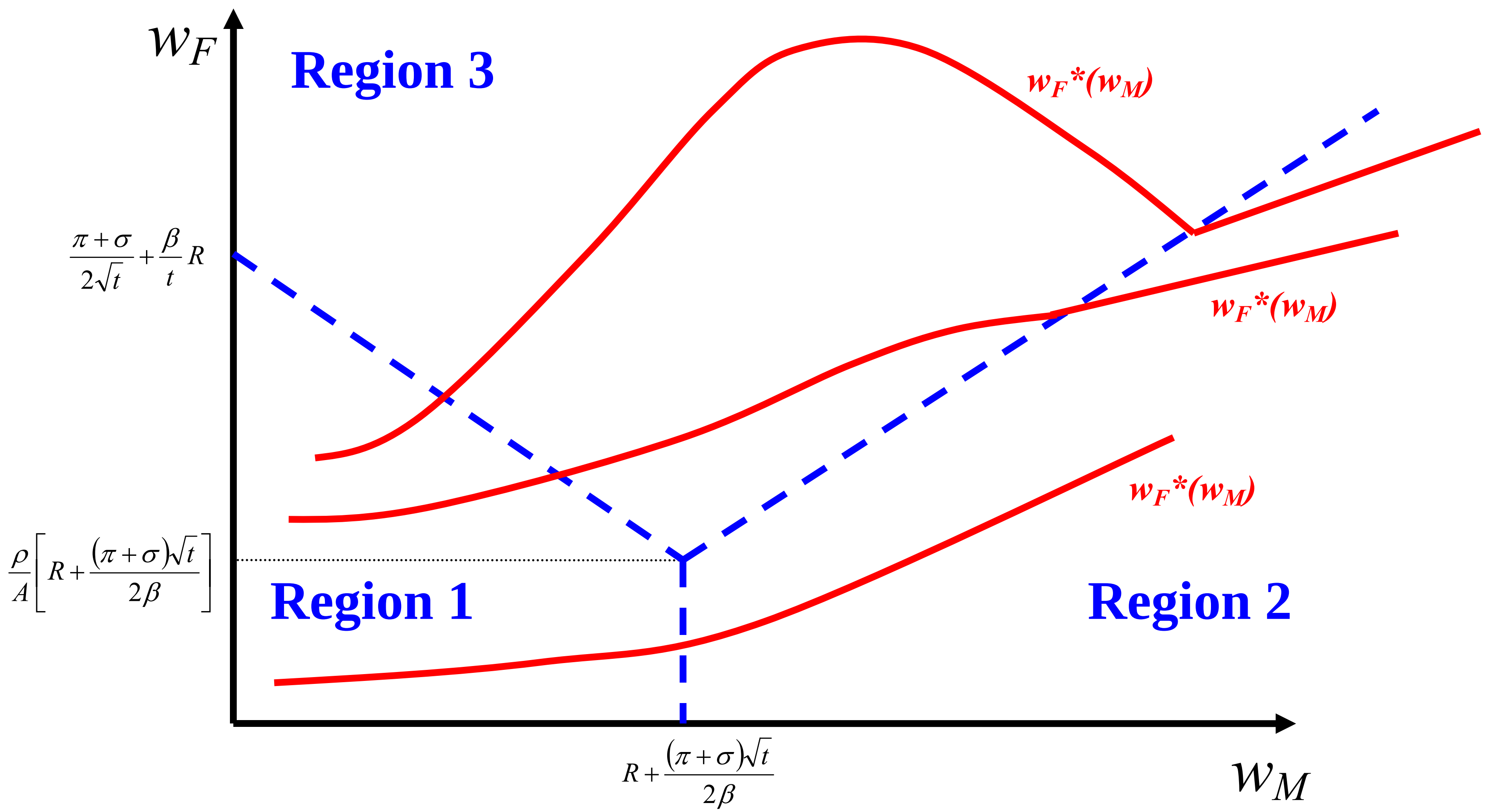
$$\begin{aligned} EU &= F\left(\frac{R+C}{B}\right)U_N(w_M(\theta_M), C) + \int_{\theta_{F\min}}^{\theta_F^*} U_W(w_M(\theta_M), w_F(\theta_F))dF(\theta_F) + \delta EU\left(1 - F(\theta_F^*)\right) = \\ &= \frac{1}{1-\delta+\delta F(\theta_F^*)}\left[F\left(\frac{R+C}{B}\right)U_N(w_M(\theta_M), C) + \int_{\theta_{F\min}}^{\theta_F^*} U_W(w_M(\theta_M), w_F(\theta_F))dF(\theta_F)\right] \end{aligned} \qquad \text{(Eq. 10)}$$

The value of the expected utility hinges critically on θ_F*, which is the highest level of female productivity that a man is willing to accept in his spouse. Since $U_W\left(w_M(\theta_M), w_F(\theta_F)\right)$ decreases monotonically in θ_F, the cut-off point θ_F* is unique for every man so that if a woman has $\theta_F \leq \theta_F*$, he will propose to her; otherwise, he will wait. If a man meets a woman such that $\theta_F = \theta_F*$, he will be indifferent between proposing to her and waiting:

$$U_W(w_M(\theta_M), w_F(\theta_F^*)) = \delta EU\left(w_M(\theta_M), w_F(\theta_F^*)\right) \qquad \text{(Eq. 11)}$$

Because men differ in their own productivity, this cut-off point will be a function of θ_M, $\theta_F* = \theta_F*(\theta_M)$. Notice that the threshold function $\theta_F* = \theta_F*(\theta_M)$ can be turned into $w_F* = w_F*(w_M)$ by a simple positive monotonic transformation.[28] At any given time, only a fraction of matches will result in marriage, those where the pair's wages (w_F, w_M) are below $w_F*(w_M)$. Thus, $w_F*(w_M)$ is a proposal boundary, examples of which are drawn in Figure 3. The shape of these boundaries is determined by the properties of utility functions in Regions 1-3.

[28] Given the productivity functions, $w_F* = B\theta_F*\left(\frac{w_M}{A}\right) = w_F*(w_M)$.



Note: The proposal boundaries determine the marriage rate. Matches which lie below the boundary mature into marriages; otherwise they end in a break-up. Their position and shape depend on model parameters, primarily on the values of δ and ρ. For discussion of the proposal boundary, see section 3.4. For formal treatment of their shape, see Theorem 1 and the Appendix.

Figure 3 – Proposals boundaries in a $w_M - w_F$ space

Table 3: Derivatives of the indirect utility function with respect to productivity			
	Region 1	Region 2	Region 3
$\frac{\partial U_W}{\partial \theta_F}$	$-B$	$-B$	$-B(1-l^*)$
$\frac{\partial U_N}{\partial \theta_F}$	0	0	Bl^*
$\frac{\partial U_W}{\partial \theta_M}$	$A\left(1-\frac{\beta}{t}\right)$	$A(1-\beta n_2{}^*) = A\left[1-\beta\left(\frac{\pi+\sigma}{2\beta(w_M-R)}\right)^2\right]$	$A\left(1-\frac{\rho}{A}l^*-\beta n_3{}^*\right)$
$\frac{\partial U_N}{\partial \theta_M}$	$A\left(1-\frac{\beta}{t}\right)$	$A(1-\beta n_2{}^*) = A\left[1-\beta\left(\frac{\pi+\sigma}{2\beta(w_M-R)}\right)^2\right]$	$A\left(1-\frac{\rho}{A}l^*-\beta n_3{}^*\right)$
Note: The derivatives are calculated using the optimal solutions from Table 2. The expression 'None' in the left-most column reflects the fact that the family stipend *C* is assumed to be sufficiently low that all women who match in Region 3 are working while single.			

Some of these properties are summarized in Appendix A and in Table 3. A more intuitive explanation of the hump shape of the proposal boundary in Region 3, emerges from Figure 4. In this figure, four utilities are plotted against θ_F on the horizontal axis. The utilities differ by θ_M in such a way that $\theta_{M1} < \theta_{M2} < R + \frac{(\pi+\sigma)\sqrt{t}}{2\beta} < \theta_{M3} < \theta_{M4}$, meaning that the two men with θ_{M1} and θ_{M2} will find all their dates either in Region 1 or in Region 3 whereas the two men with θ_{M3} and θ_{M4} will find all their matches in Regions 2 and 3. The θ'_F and θ''_F on the horizontal axis are female productivity levels that produce matches lying exactly at region boundaries. Thus, a match with a woman with $\theta_F > \theta'_F$ (for θ_{M1} and θ_{M4} men) or $\theta_F > \theta''_F$ (for θ_{M2} and θ_{M3} men) is a match in Region 3. Given the partial derivatives of men's utility in Table 3 and the V-shaped division between regions, the utilities of men at θ_{M1} and θ_{M2} will diverge as θ_F increases above θ'_F while the utilities of men at θ_{M3} and θ_{M4} will converge for $\theta''_F > \theta_F > \theta'_F$.

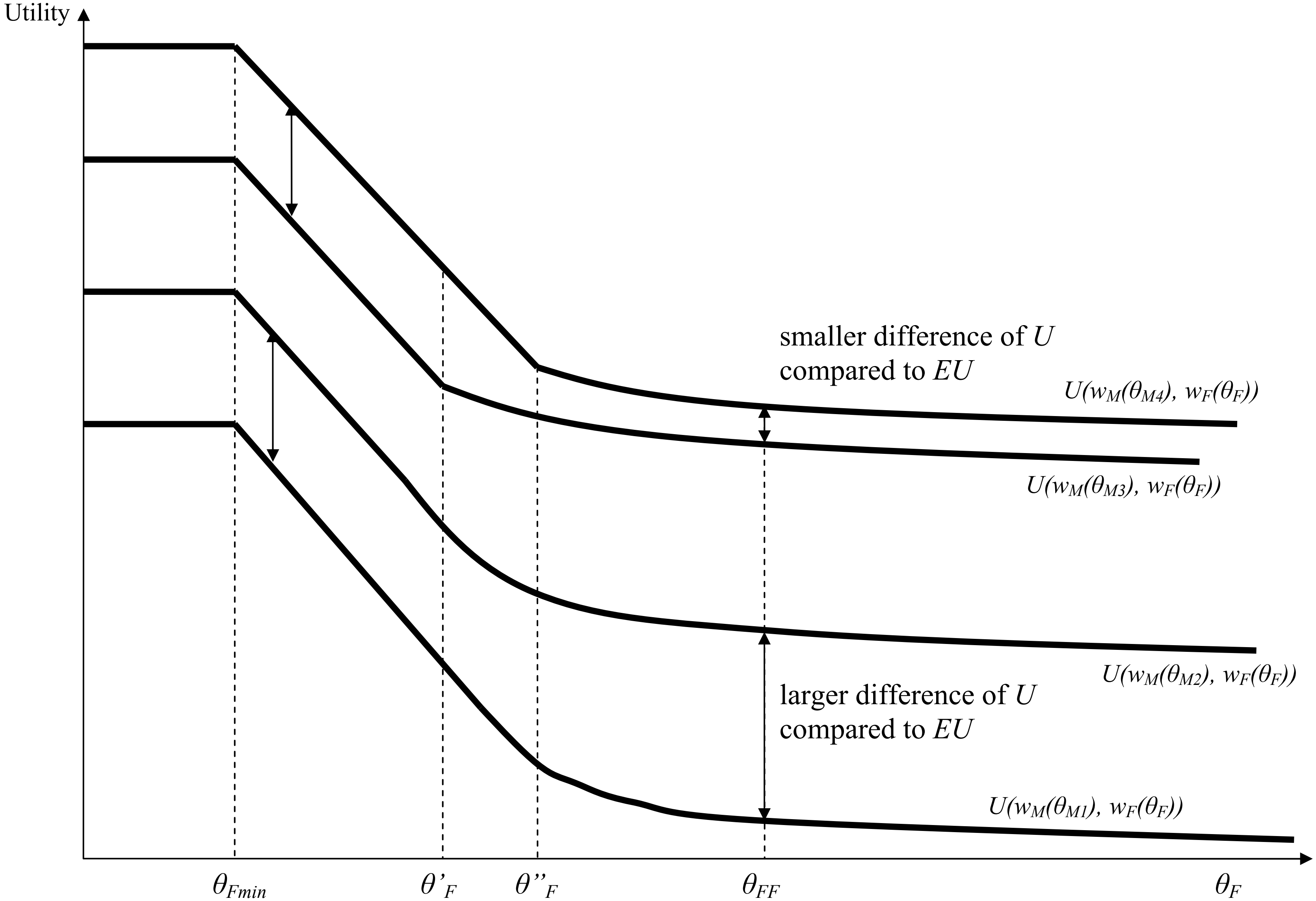


Figure 4 – Men's utility at different levels of θ_M and θ_F

Moreover, the distance between utility functions varies with θ_F. To take the example of θ_{FF}, the distance between $U\left(w_M(\theta_{M1}), w_F(\theta_{FF})\right)$ and $U\left(w_M(\theta_{M2}), w_F(\theta_{FF})\right)$ is greater than at any $\theta_F<\theta_{FF}$ while the distance between $U\left(w_M(\theta_{M3}), w_F(\theta_{FF})\right)$ and $U\left(w_M(\theta_{M4}), w_F(\theta_{FF})\right)$ is smaller than at most $\theta_F<\theta_{FF}$.

These differences have a direct effect on the values of the expected utility, EU, and of $U_W\left(w_M(\theta_M), w_F(\theta_F)\right)$. If $\theta_{FF} = \theta_F{}^*(\theta_{M1})$, then $U_W(w_M(\theta_{M1}), w_F(\theta_{FF})) = \delta EU\left(w_M(\theta_{M1}), w_F(\theta_{FF})\right)$. But this implies that $U_W(w_M(\theta_{M2}), w_F(\theta_{FF})) > \delta EU\left(w_M(\theta_{M2}), w_F(\theta_{FF})\right)$ because $U_W\left(w_M(\theta_{M2}), w_F(\theta_{FF})\right)$ shifts more than the expected utility as we move from θ_{M1} to θ_{M2}. This means that the θ_{M2} man will be able to tolerate higher level of productivity on the part of his spouse. On the other hand, the difference between $U_W\left(w_M(\theta_{M3}), w_F(\theta_{FF})\right)$ and $U_W\left(w_M(\theta_{M4}), w_F(\theta_{FF})\right)$ can potentially be quite small, so if we assume that $\theta_{FF} = \theta_F{}^*(\theta_{M3})$, then $U_W(w_M(\theta_{M3}), w_F(\theta_{FF})) = \delta EU\left(w_M(\theta_{M3}), w_F(\theta_{FF})\right)$, then it is possible that $U_W(w_M(\theta_{M4}), w_F(\theta_{FF})) < \delta EU\left(w_M(\theta_{M4}), w_F(\theta_{FF})\right)$ and so the cut-off point will be lower for the θ_{M4} man.

The size of the hump, however, depends on other parameters, such as δ, and it need not appear at all. However, it is not a product of the distribution of productivity among men and women (i.e. $F(\theta_M)$ or $F(\theta_F)$) and it is not specific to the particular functional form of the utility function, used in the model. As Figure 4 illustrates, the crucial point is the transition between regions and how it affects the derivatives of the utility function. The transition from Region 1 to Region 3 is one where all three choice variables – n, α and l – change continuously as does utility. In the transition from Region 2 to Region 3, however, only n changes continuously while l and α jump (l jumps from 0 to $1 - tn > 0$ which effects a discontinuous change in α). For that reason, the utility surface is not smooth (differentiable) along the line $w_F = \rho\theta_M = \frac{\rho}{A} w_M$. This, in turn, is a consequence of the relaxation of the women's time constraint (WTC) in Region 2: women have free time on their hands in Region 2 because their husbands do not let them work even though they have too few children to use up all their time endowment. Thus, a move from Region 2 to Region 3 entails a discontinuous reallocation of this unused time to labor which affects the slope of the utility function. It is the constraints and their binding or relaxed state what produces the unusual shape of the proposal boundary.

From a historical perspective, however, the hump is not as unusual as it may seem. The eventual increase in married women's labor supply comes, as the calibration exercise will show, precisely from those matches that occur below this inverted-U-shaped boundary which has its peak somewhere in the middle range of male wages. In this, the model reflects the fact that the arrival of married women into the office or even the factory in large numbers was to a great degree a middle-class phenomenon and that it involved breaking through a certain level of unease about wives' place in the labor market – an unease which in this model is described as the crossing from Region 2 to Region 3 where previously 'non-employed' middle class wives convert their free time into labor supply.

3.5. Labor market meets marriage market

The overall marriage rate (*MR*) equals

$$MR = \int_{\underline{\theta}}^{\bar{\theta}} F\big(\theta_F{}^*(\theta_M)\big) f(\theta_M) d\theta_M \qquad \text{(Eq. 12)}$$

Changes in the marriage rate will depend on how the matches that are formed as part of the random dating stand relative to the proposal boundary (see Figure 3). Both male and female wages are affected by technological change (parameters A and B) but so is the proposal boundary. Generally speaking, an increase in male productivity increases male wages and male utility from marriage, ceteris paribus, while an increase in female productivity raises female wages and single women's labor supply and has a negative effect on men's utility from marriage. More specifically, a rise in A increases θ_F* for every level of θ_M while a rise in B decreases θ_F* for every level of θ_M. For the marriage rate to exhibit the swing that was observed historically, we need to show that, prior to 1900, the technological effects working through women's labor market were stronger than the effects on the male labor market but that the situation changed after 1900. Note that prior to 1900, the increase in B has both an effect on the level of women' wages and a strong influence on the level of women's employment. After 1900, however, when the proportion of single women employed becomes large, the effect of B on women's employment runs into diminishing returns and thus becomes relatively less important.

4. Quantitative analysis

In this section I calibrate the model presented in section 3 to examine its plausibility in explaining the social and economic changes in women's lives at the turn of the 20th century. I focus on four series: (1) single women's labor supply, p, (2) marital fertility[29], n, (3) the marriage rate, MR, and (4) the behavior of married women's labor supply, l. Additionally, the variable α, the share of husband's income transferred to his wife, can gives some insight into (5) the manner in which household resources were divided and how this division changed through time. Moreover, given that households in the model differ in n, l and α depending on which region

[29] Strictly speaking, the variable n, being a subject to pre-marital bargaining, represents the desired number of children rather than marital fertility. For that reason, for each marriage cohort, the simulated n is compared with the number of children that survived to age 20 rather than with the actual number of births. However, I use the term "marital fertility" as a short hand for n in the following section.

they are formed in (see Figure 2), I analyze regions 1 or 2 or 3 separately. The households of Region 1 represent traditional families, poor but fertile. Region 2 families resemble the households of well-to-do husbands and stay-at-home wives. Region 3 comprises those in the middle – the "middle class" where wives work and the division of resources is more favorable to the wife. This is necessarily a crude, stylized split but, as Table 2 documents, the solutions to the optimization problems differ from region to region not only in actual values but also in functional form, so the portrayal of the three regions as giving rise to three distinct manners of household operation finds some support here.

4.1. Parameters and inputs

The parameter values are summarized in Table 4.

Table 4: Parameters and their values

Parameter	*Description*	*Value*
π	relative weight of children in the utility functions of men	195
σ	relative weight of children in the utility function of women	65
ρ	strength of husband's dislike of his wife's employment	0.462
β	fraction of income spent on children	0.065
t	time spent by a mother per child	0.25
δ	discount factor	0.96

They were selected with an eye to fitting the model with the observed marriage, fertility and labor market behaviors. The values of $\pi = 195$ and $\sigma = 65$ may seem high, but notice how they enter the utility function. These are the men's and women's weights on children relative to consumption. The high values for π and σ are not unrealistic: to convince a man to have only one child instead of four would require a compensation of $195 dollars of consumption which, depending on the year, could be anywhere between 20% and 50% of that man's average annual income. Women's valuation of children is lower than that of men, which reflects the fact that 19th century women were exposed to a number of sources of "disutility" associated with childbearing such as high risk of death or infection during pregnancy and birth, a disproportionate share of child care etc. Men, on the other hand, were more in the position of "pure consumers" when it came to the enjoyment of their children's company (Peiss, 1987: 103).

Parameters ρ and δ are important because they have a direct bearing on the marriage market and the married women's labor supply. Their specific values have been chosen to obtain the best possible fit between the simulation results and the actual historical developments. ρ is a measure of a man's disutility from wife's work and determines the slope of the border between Regions 2 and 3 in Figure 2. Setting it at 0.462 implies that for a man who earns, say, $500 a year in 1900 (approximate nominal annual income of a non-farm employee around 1900), the difference between having a non-working wife and one who works full-time is equivalent to about $150 worth of consumption. The subjective discount factor δ is crucial for determining the proposal boundary because it is instrumental in evaluating the alternative to marriage – the expected utility from future potential match. Annualized, δ usually takes values between 0.947 (Cooley and Prescott, 1995) to 0.98 (Greenwood et al. 2005b). Given that the wage rates entering the calibration are annual earnings when multiplied by each individual's labor supply, one period of time in my model is set at one year. I set the discount factor $\delta = 0.96$, which is in line with, for example, the value used in Kydland and Prescott (1982). It implies an annual interest rate of 4.1% which is close to the historical values for yields on US government bonds during the period (Historical Statistics of the United States: Millenial Edition, 2006: Table Cj 1192).

The productivity and technological parameters are set so that the resulting annual earnings correspond to those observed in the US economy from 1870 to 1930 in 1930 prices. I also seek to realistically capture the relationship between male and female earnings. Goldin (1990: Table 3.1) shows that throughout the period in question (1870 – 1930), the ratio of female-male wages moved between 0.55 and 0.58 and so the productivity and technological parameters – particularly regarding women's wages – are also set with a view to this fact. The wage trends from which these parameters are derived come from the Historical Statistics of the USA.

The child-rearing parameters are β, the fraction of a man's income spent per child, and t, the fraction of a woman's time spent per child. These are set at 0.065 and 0.25. This means that, on average, a child claims about 6.5% of a father's wages net of rent and about 25% of a mother's time.

The exact value of C, a non-working single woman's stipend, is hard to establish historically. It is likely that its size varied in proportion to the wealth of each woman's parental family. In the model, C is assumed constant for all women but growing over time. The value of C is important because a woman's premarital utility is decisive in determining α, the share of husband's income that must be transferred to her as consumption. In the premarital bargaining, if C were too low, then α could become negative, which would be unrealistic because all of a woman's utility would then derive from her children and she would have negative consumption. I also assume that the stipend grew at a slower rate than real wages: if it grew at the same (or higher) rate, then the proportion of single women in the labor force could never increase because the same (or higher) fraction of low productivity women would find it preferable to stay out of employment. In this way, C is allowed to grow from about \$125 in 1870 to about \$255 in 1930 in current prices.[30] Considering that *C* is defined as a stipend that a single woman can use purely for consumption ("pin money"), these values are equivalent to between $2 and $5 per week of personal consumption (in nominal value) between 1870 and 1930. For comparison, a dressmaker in 1870 would make about $12 per week and a seamstress about $9 at current prices.[31] By 1930, a woman clerk could earn about $22 per week and a manufacturing employee about $17 (Goldin, 1990: Table 3.2A). Based on these considerations, the values of *C* seem plausible.

Similarly, the value of *R*, "rent", is hard to pin down because the living arrangements of single women took many forms, from living in private families to sharing a room in an organized boarding house. Some information on rents is available from the Historical Statistics of the United States but a consistent series stretching the whole period from 1870 to 1930 is hard to reconstruct. In calibrating my model, I let the rent variable, *R*, grow at the same real rate as men's wages. This implies that the weekly housing costs faced by the single working women grew, in nominal terms, from $1.13 in 1870 to about $3.54 in 1930. These numbers are slightly on the low end but not too far from actual values. The 1910 Senate report states, for example, that the "average weekly cost of living" of women employed in department stores and factories ranged somewhere between $3.18 and $4.24, nominally (Senate Report 1910 (5): 53). These average weekly costs comprised food, shelter, heat, light and laundry and were calculated from data reported by relatively high-earning women (such as store assistants) in large cities. The overall average for all employed single women is therefore likely to have been somewhat lower. Moreover, if food and laundry is subtracted from these figures to arrive at actual costs of household operation (shelter, heat and light), we would probably get quite close to the $1.46 per week, implied by the calibration setup for 1910.

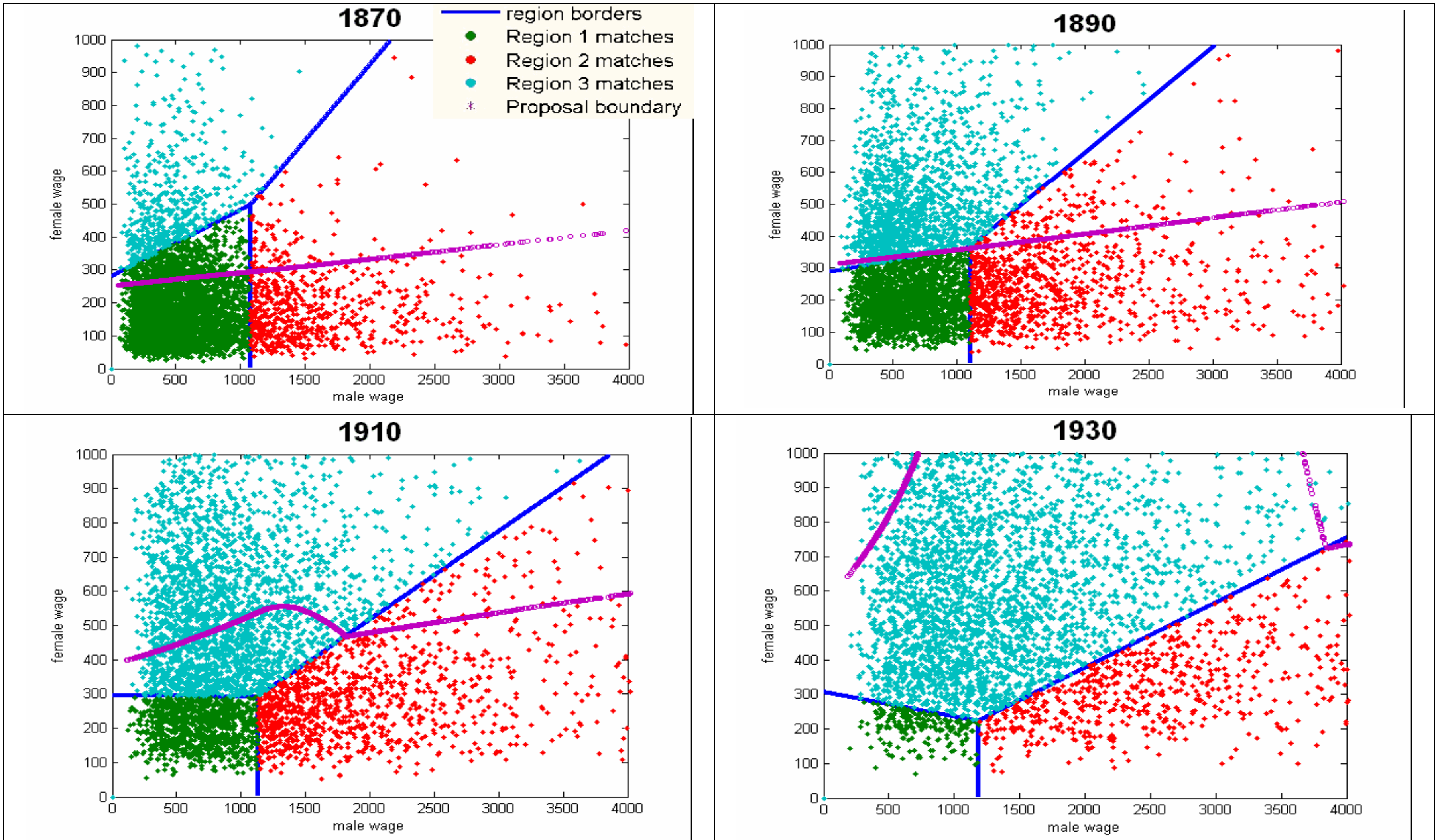
[30] In real 1930 dollars, it grows from $160 to about $255.

[31] Senate Report (1910, Vol. 9, Table F, p. 263

4.2. Simulation results and comparison

The simulation uses Matlab 7 to generate 5000 male and 5000 female productivity levels from the log-normal distribution. Men and women, indexed by θ_M and θ_F, are then randomly matched in each decade from 1870 to 1930. Figure 5 shows the successive matches for four selected years. The sequence of the graphs illustrates how the growth of wages slowly moves the bulk of the matches out of Region 1 and into Regions 2 and 3. At the same time, the proposal boundary shifts, separating those matches that end in marriage from relationships that end in a break-up. The hump in the proposal boundary is relatively slight at first but becomes eventually prominent. It is responsible for the swing in marriage rate: in the first three decades of the simulated history, the cloud of matches shifts faster than the proposal boundary and that is why the marriage rate declines.

Table 5 compares the model-generated series with the actual historical series. The single women's labor force participation is reproduced relatively well by the model. It is driven by the growth in women's wages, w_F, relative to the stipend C and rent R. Simulated marital fertility is close to its historical values in 1870 and 1920 although it falls somewhat more slowly than the historical series. The marriage rate shows a swing at a time when it historically occurred. The married women's labor force participation is overestimated but it replicates the historical experience in that it stays relatively low until about 1900 after which time it explodes.



Note: Graphs depict the gradual movement of the 'cloud of matches' out of Regions 1 and 2 and into Region 3. At first, the cloud shifts faster than the proposal boundary and the marriage rate falls but after 1900, this process is reversed and the marriage rate increases.

Figure 5 – Matches and proposal boundaries 1870 – 1930

Table 5: Simulation results versus Historical trends								
	Single women's labor force participation		Marriage rate		Desired number of children		Married women's labor force participation	
	historical	**model**	historical	**model**	historical	**model**	historical	**model**
1870	34.4%	**31.9%**	49.37%	**75.9%**	3.742	**3.718**	1.8%	**0.0%**
1880	39.0%	**32.2%**	46.41%	**75.5%**	3.257	**3.708**	2.0%	**0.0%**
1890		**47.5%**		**63.6%**	2.879	**3.374**		**0.1%**
1900	50.2%	**51.6%**	43.64%	**61.0%**	2.695	**3.176**	2.1%	**1.9%**
1910	60.8%	**58.2%**	45.62%	**62.9%**	2.599	**2.585**	5.5%	**15.0%**
1920	66.4%	**60.5%**	48.70%	**65.4%**	2.331	**2.247**	6.4%	**23.9%**
1930	69.0%	**69.5%**	47.86%	**87.7%**	2.131	**0.965**	11.5%	**62.7%**

Note: Results of simulation were obtained using parameters values as specified n Table 4. For historical values, the sources are: IPUMS for single and married women's labor force participation and for marriage rate. They pertain to white women aged 20-24. Desired number of children is derived from marital fertility in Hernandez (1996: 318) and the mortality statistics from Historical Statistics of United States and pertains to the number of children born to a given cohort of women that survived to age 20.

The biggest mismatch occurs in the year 1930 which produces very high marriage rate, an excessively high married women's labor supply and a very low number of children. The last two are closely connected, since married women in the model allocate their time between child care and labor supply. To see what kind of change in parameters would be required to bring the 1930 model-generated results more in line with historical reality, I ran another simulation using the same model and same parameter values as the benchmark results in Table 5 – except for a one-time change in β between 1920 and 1930 from 0.065 to 0.033. The results presented in Table 6 and the changed 1930 results are highlighted. In terms of marital fertility and marriage rate they represent a better fit than the 1930 values in Table 5. The married women's labor supply is significantly reduced, too – to 39.6% – which is considerably lower than 62% in Table 5.

The question is whether halving of β during the 1920s is defensible as historically realistic. The parameter β denotes the proportion of a husband's income (net of rent) claimed by each child. A move from 0.065 to 0.033 therefore implies that by 1930, the average child cost only 3.3% of the father's income whereas it cost 6.5% in 1920. Note that costs of household

Table 6: Simulation results versus Historical trends								
	Single women's labor force participation		Marriage rate		Desired number of children		Married women's labor force participation	
	historical	**model**	historical	**model**	historical	**model**	historical	**model**
1870	34.4%	**32.7%**	49.37%	**75.8%**	3.742	**3.707**	1.8%	**0.0%**
1880	39.0%	**33.1%**	46.41%	**75.3%**	3.257	**3.700**	2.0%	**0.0%**
1890		**47.3%**		**63.4%**	2.879	**3.400**		**0.1%**
1900	50.2%	**51.5%**	43.64%	**60.9%**	2.695	**3.195**	2.1%	**1.9%**
1910	60.8%	**57.4%**	45.62%	**62.7%**	2.599	**2.610**	5.5%	**14.2%**
1920	66.4%	**59.9%**	48.70%	**65.2%**	2.331	**2.291**	6.4%	**23.1%**
1930	69.0%	**69.8%**	47.86%	**68.6%**	2.131	**2.073**	11.5%	**39.6%**

Note: Results of simulation were obtained using parameters values as specified n Table 4 except for a one-time change in β from 0.065 in 1920 to 0.033 in 1930. For historical values, the sources are the same as in Table 5.

operation are already captured by the variable R, so the fraction of income consumed by a child should be viewed as expenditures tied directly to the child's needs, such as children's clothing etc. Sufficiently detailed data are hard to find but Lebergott (1993: 91, 148) shows that the fraction of American families' overall spending on clothing declined in the 1920s. Moreover, within this declining share a growing portion was spent on women's clothing. This implies that the fraction spent specifically on children's clothing was probably declining even faster. If Moehling (2005: 427) is correct in arguing that clothing expenditures usually represent "a sizeable fraction of a total private consumption", then there seems to be some evidence that a decline in β is not entirely unrealistic.

These aggregate results hide a considerable amount of variation between the three solution regions (see Figure 2). Results of calibration by region are displayed in Table 7. This table illustrates that most of the changes in the marriage behavior are taking place in Region 3. Although the marriage rate is consistently increasing in this region, it starts from zero. The three regions are distinct in terms of the desired number of children, n, as predicted by the model. Region 1 has the highest and maximum possible fertility, $1/t$, or 4 children. Marital fertility in

Region 2 starts at the lowest level of the three regions but falls most slowly. The greatest movement in marital fertility occurs in Region 3, where according to the solutions in Table 2 both male and female wage act to reduce it. In both Regions 2 and 3, the eventual level of childbearing is about 2 children per family, which corresponds well with historical trends.

Table 7 - Simulation results by regions

Region 1	Single women's labor force participation	Marriage rate	α	Marital fertility	Married women's labor force participation
1870	22.5%	85.0%	10.5%	4.000	0.0%
1880	22.9%	85.0%	10.5%	4.000	0.0%
1890	12.2%	98.6%	14.9%	4.000	0.0%
1900	3.2%	98.3%	15.6%	4.000	0.0%
1910	0.0%	97.9%	18.2%	4.000	0.0%
1920	0.0%	96.0%	20.0%	4.000	0.0%
1930	0.0%	95.0%	24.7%	4.000	0.0%
Region 2	Single women's labor force participation	Marriage rate	α	Marital fertility	Married women's labor force participation
1870	31.4%	83.6%	4.8%	2.218	0.0%
1880	28.1%	84.4%	4.7%	2.210	0.0%
1890	37.3%	85.5%	6.8%	1.966	0.0%
1900	37.3%	88.0%	7.4%	1.830	0.0%
1910	32.4%	91.4%	8.1%	1.595	0.0%
1920	29.0%	93.5%	8.3%	1.430	0.0%
1930	25.2%	96.6%	8.8%	0.913	0.0%
Region 3	Single women's labor force participation	Marriage rate	share	Marital fertility	Married women's labor force participation
1870	100.0%	0.0%	NA	NA	NA
1880	100.0%	0.0%	NA	NA	NA
1890	100.0%	3.5%	27.4%	3.848	3.8%
1900	99.6%	15.1%	19.2%	3.260	18.5%
1910	89.0%	39.0%	17.2%	2.296	42.6%
1920	86.2%	48.2%	17.2%	1.936	51.6%
1930	80.7%	85.7%	23.1%	0.844	78.9%

Note: Simulation results were obtained using parameter values as specified in Table 4. Variable *α* refers to the share of husband's income transferred to a non-working wife. Variable 'share' refers to the fraction of total financial resources of a family that are controlled by a working wife.

The third column of Table 7, denoted *α*, shows the average fraction of a family's income that is spent on wife's consumption. This fraction increases in Regions 1 and 2, reflecting the growing bargaining power of women on the marriage market. As more and more women work before marriage and as their wages grow, men must adjust their marriage proposals accordingly. So α increases. It is lower in absolute terms in Region 2 than in Region 1 because the men in the Region 2 couples are more productive. Thus, α is calculated from a higher (male) income. In Region 3, the situation is more complicated since wives work ($l > 0$). It can even become negative, if the wife is the more productive spouse ($\theta_F > \theta_M$). The variable 'share' therefore refers to the fraction of total financial resources of a family that are controlled by a working wife, including her own earnings ($w_F l$). The reason why the share declines before it increases is again is that the composition of couples with working wives changes from 1890 to 1930. In 1890, the working wives come from those couples in Region 3 where the husbands have a low productivity θ_M (see Figure 5, Graph "1890"). Their earnings therefore represent a large fraction of the family's income. As the pool of couples with working wives grows in size to include marriages with high-θ_M husbands, the average share declines. But the underlying growth in women's bargaining power operates even for Region 3 couples and ultimately the share of family budget controlled by the wife increases in Region 3 also.

4.3. Sensitivity analysis

To see how much my results depend on particular parameter values, I ran the same simulation exercise changing each of the relevant parameters by about ± 20% from the parameter value of the benchmark case (see Table 4). Such variation is large enough to produce changes in the simulation results, allowing for a sensitivity analysis. The results are summarized in Figures 6-9.

Figure 6 shows that single women's labor force participation is, for the most part, immune to changes in parameter values. This is because it depends exclusively on female wages, the value of stipend, C, and the value of rent, R. Married women's labor force participation in Figure 9 displays greater variance. The kink in married women's labor supply is robust with respect to variation in parameters although the overall level of labor supply is strongly affected by those parameters that influence marriage and fertility: δ, ρ, π and σ. This is not surprising. In the model, we solve for married women's labor supply as the residual of the time endowment after children are taken care of ($l = 1 - tn$). This is why a high π, for example, through its positive effect on the number of children, dampens the married women's labor supply. Higher δ means that fewer marriages occur in Region 3, ceteris paribus, because the prospect of waiting is more enticing compared to a specification where δ is lower. Fewer marriages in Region 3 means in turn that the working wives of Region 3 make up a smaller proportion of all wives which thus reduces aggregate married women's labor supply. Overall, however, whatever the parameter change, the change in married women's labor supply is decidedly higher after 1900 than before this date. The kink is robust in this respect although the actual values of married women's labor force participation are overestimated.

Figures 7 and 8 focus on marital behavior and fertility. The swing in marriage rate is heavily influenced by specific parameter values although it does not disappear even for very high levels of δ. Thus, the swing in marriage rate is a persistent feature of the calibrated model. The fact that δ has considerable influence is also documented in the fact that an increase from 0.9 to 0.99 makes the swing much deeper and shifts the minimum age at marriage into later years. The

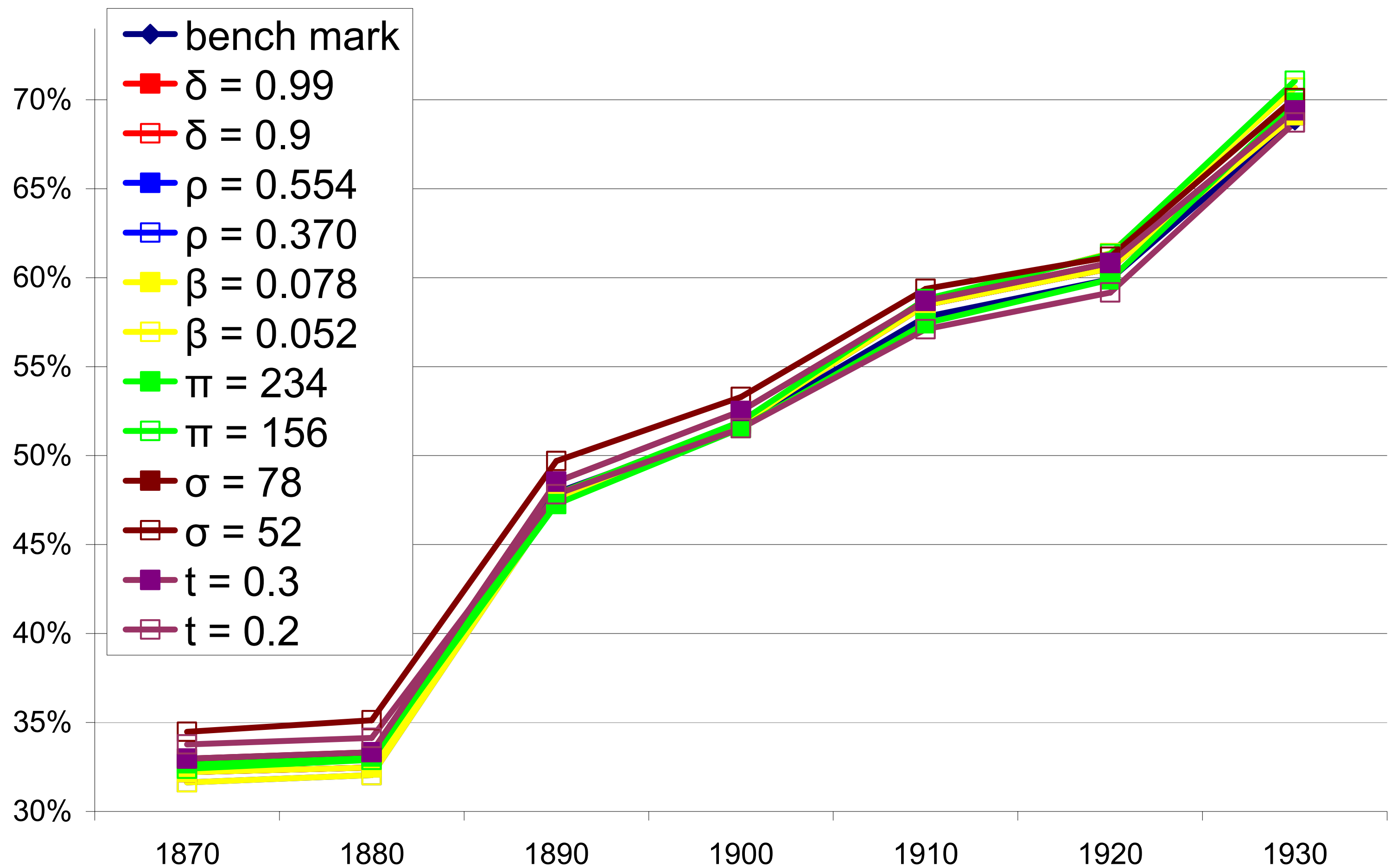


Figure 6 - Single women's labor supply and variation in parameters

Note: The readings for $\delta = 0.9$ and $\delta = 0.99$ fall within ± 0.6 percentage points of the bench mark readings and so are overlapped by the benchmark line. The same is true for the readings for $\rho = 0.554$ and $\rho = 0.370$.

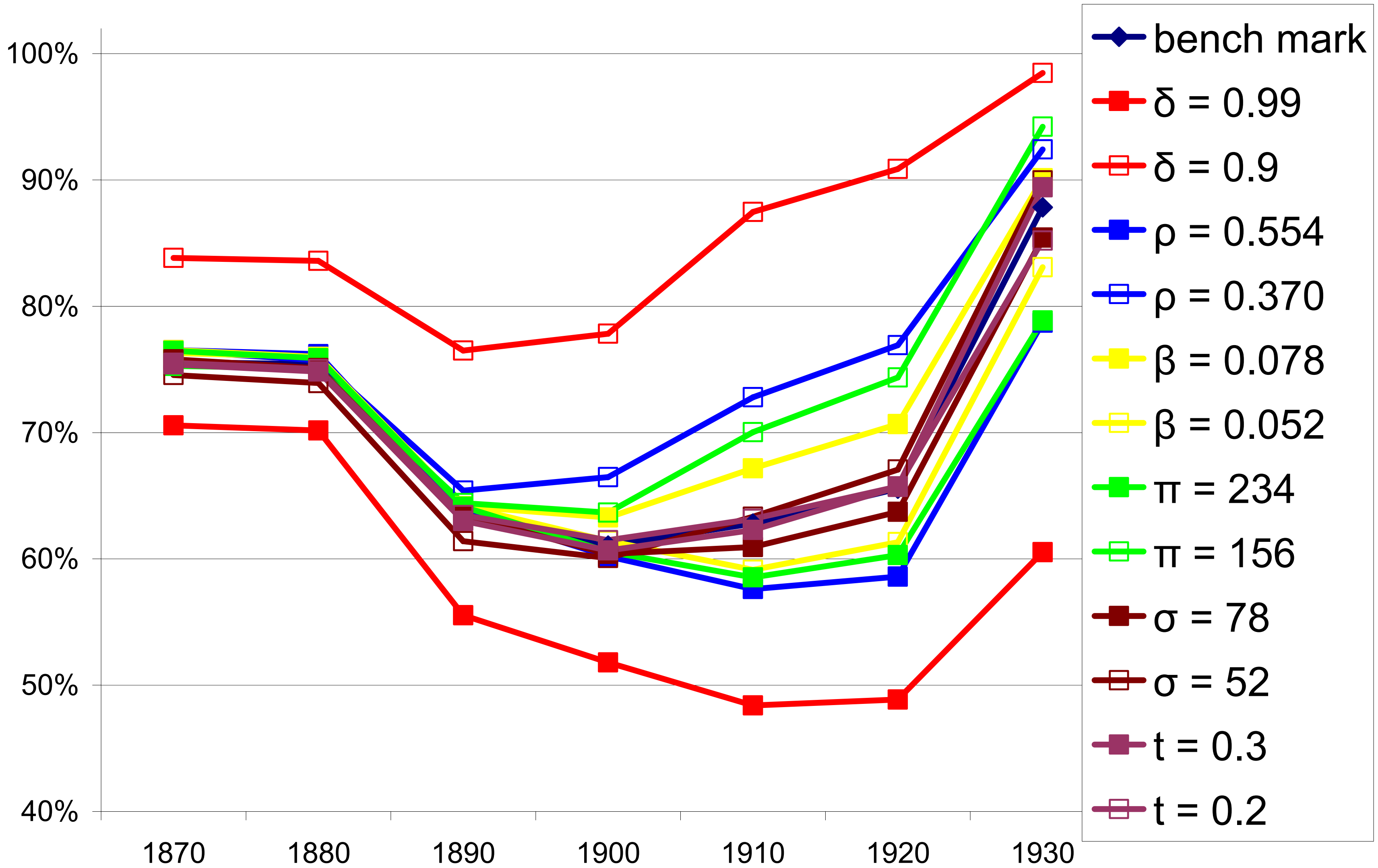


Figure 7 - Marriage rate and variation in parameters

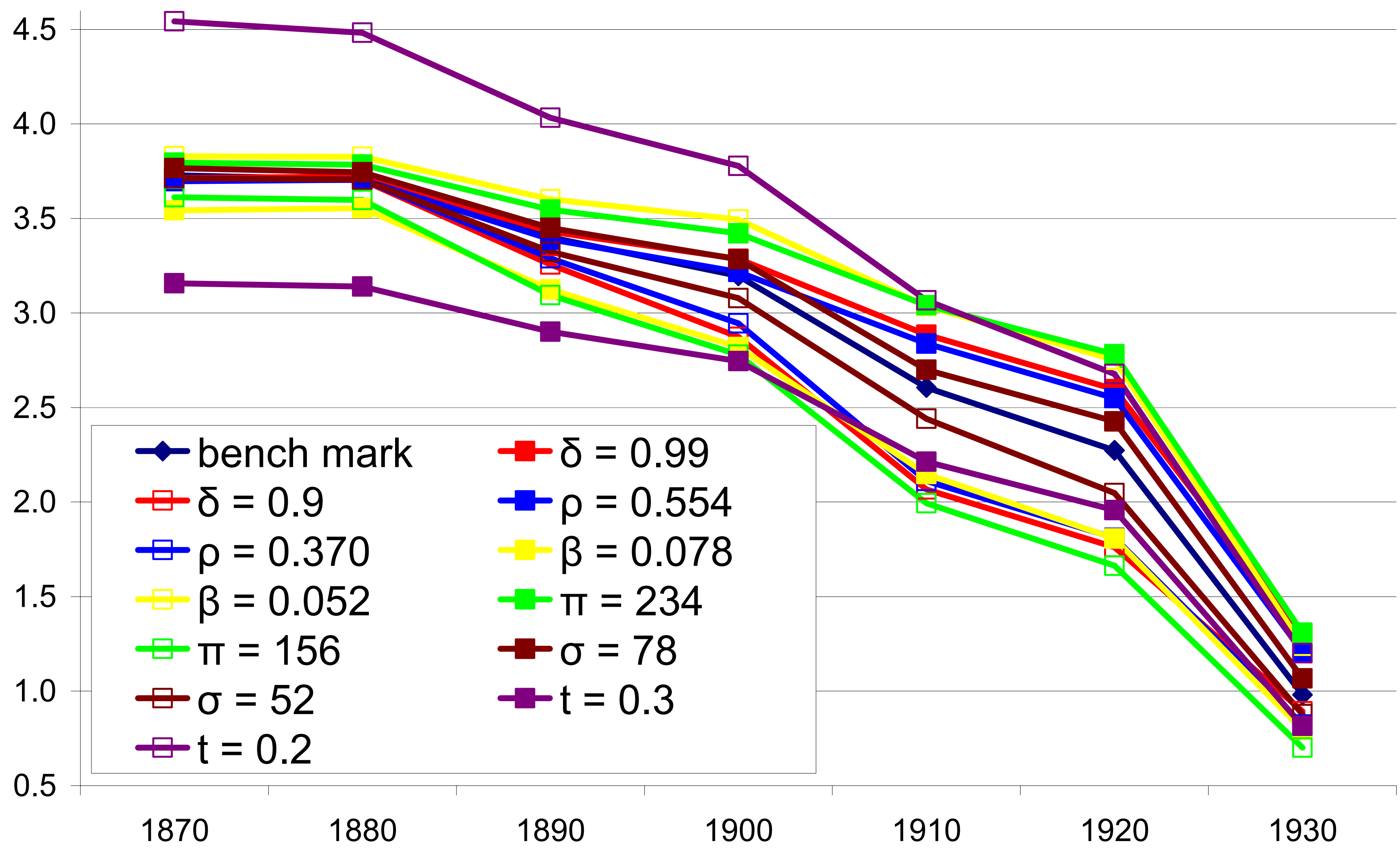


Figure 8 - Marital fertility and variation in parameters

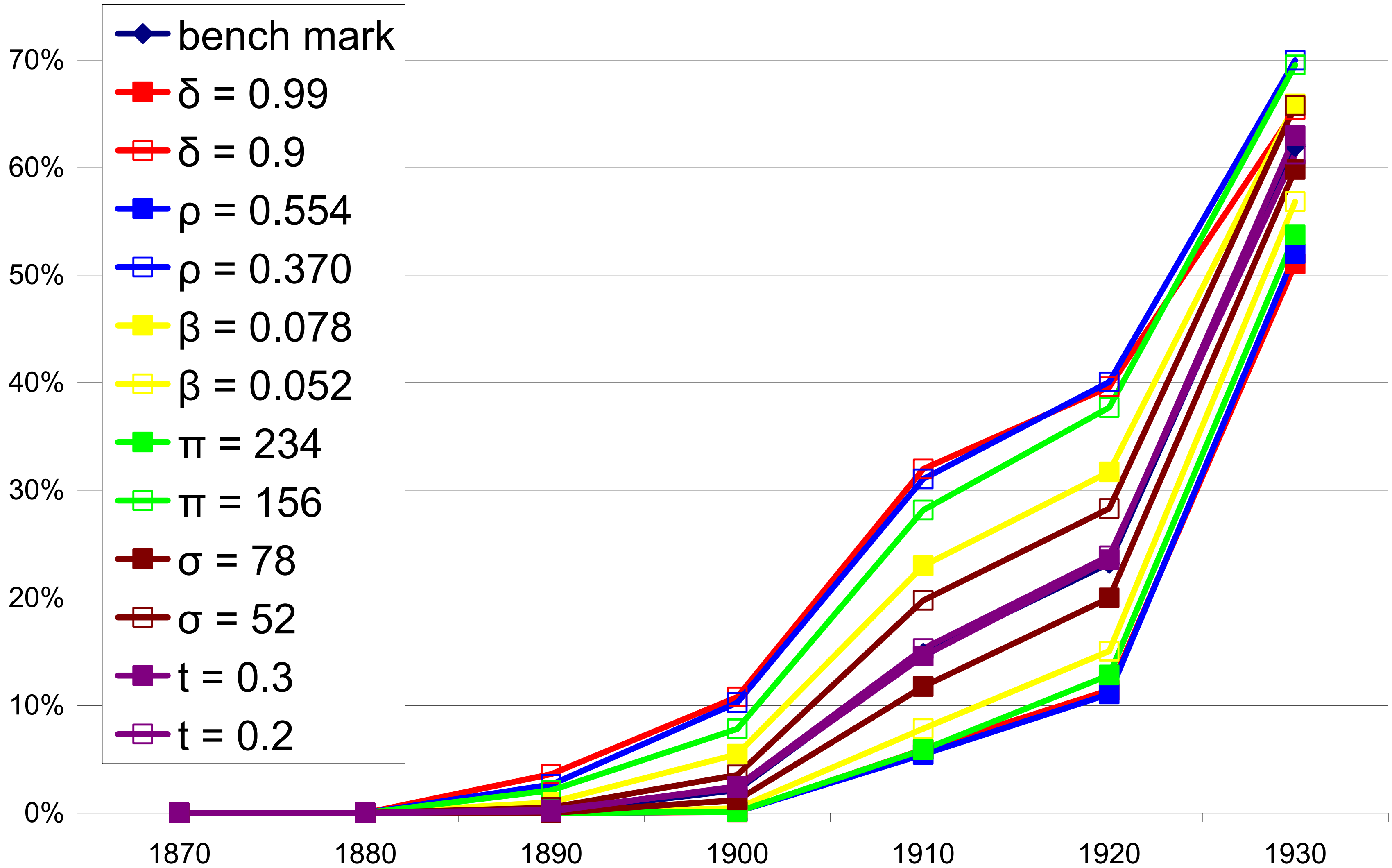


Figure 9 - Married women's labor supply and variation in parameters

parameter ρ has a similar effect, deepening the marriage swing when ρ is higher and dampening it when it is lower. That these two parameters are crucial should come as no surprise: one of them, δ, determines how valuable postponement of marriage is relative to marrying the present match; the other, ρ, affects a man's disutility from his potential wife's work which makes marriage to a working woman less likely and initial downturn of marriage steeper. At any rate, the swing in marriage rate seems quite robust with respect to parameter changes.

The number of children is mostly affected by the parameters that directly affect n (see Table 2): π, σ, β and t. The changes in overall marital fertility occur in the direction one would expect. The higher the utility weights of children, π and σ, the higher the marital fertility. The higher the real and temporal costs of children, β and t, the lower the marital fertility. Other parameters, such as ρ and δ, influence marital fertility primarily through their effect on marriage.

5. Conclusions

The life of American women changed considerably during the six or seven decades following the Civil War and young women's ability to earn independent income was an important cause of the changes. Although many families perceived their young daughter's employment as a temporary expedient intended only to improve the financial standing of the family, the labor market activity in fact had deep effects on the young women's expectations regarding their future professional and family life. Inevitably, such expectations began to have an impact on the workings of the marriage market. As the number of working single women increased, their new outlook on marriage and work ultimately reshaped many areas of life such as fertility, household management and married women's labor supply.

The theoretical model and the calibration show how interdependent the personal and professional decisions are in one's life. They also highlight that growing individual bargaining power of women, while crucial, is considerably more effective when reinforced by the strength in numbers. Individual power affects how resources are divided inside an individual family but it was the growing proportion of working single women that eventually led to a turnaround in the marriage rate. The scope of change is all the more impressive considering that the marriage market was structured (both historically and in the model) in such a way that it was men who decided when to propose marriage, to whom and on what terms.

This is not to deny that other forces were also at work. A revolution in household technology was getting under way after 1900, shortening the housewife's workday and reducing the workload. This strengthened the wives' case that outside employment was something to seriously consider (Greenwood et al., 2005). Technological change, however, only created an opportunity; it was up to women to seize it, sometimes in opposition not only to their husbands but also to various social critics who confused liberation with "too much independence" (Lebergott, 1993). It is also undeniable that some changes in women's standing in the economy and in the family were a result of the political movements of the day. But it is equally undeniable that these political changes were just as much an outgrowth of what was happening "on the ground" in individual families.

Viewed from a broader perspective, the changes of the 1870 – 1930 period set the stage for further reforms in the 20th century and therefore marked a crucial turning point in women's history. It was then that they began to present an ever stronger case for a right to vote, for legislative protection in the work place and for an equal access to education – which are all the hallmarks of full citizenship.[32]

[32] See Kessler-Harris (2001), particularly pp. 23-24 for the discussion of the relationship between wage work and the idea of citizenship and political participation.

Appendix A

Theorem 1. Assume that c.d.f. F(θ_F) is continuous and differentiable. The threshold function $\theta_F{}^* = \theta_F{}^*(\theta_M)$ *is continuous over* $\Theta = [\underline{\theta}, \overline{\theta}]$ *and differentiable at all points except where*

$$w_F(\theta_F{}^*) = \rho\theta_M = \frac{\rho}{A} w_M(\theta_M) \text{ and } w_M(\theta_M) \geq R + \frac{(\pi+\sigma)\sqrt{t}}{2\beta}.$$

Moreover, $\forall\, \theta_M; \theta_F{}^*(\theta_M) > \theta_{F\min} = \dfrac{R+C}{B}$.

Proof.

Continuity: Note that $U_W(\theta_M, \theta_F)$ is a continuous function as can be verified by plugging the solutions from Table 2 into the utility function. Similarly,

$$EU(\theta_M, \overline{\theta}_F) = \frac{1}{1-\delta+\delta F(\overline{\theta}_F)}\left[F\left(\frac{R+C}{B}\right)U_N(w_M(\theta_M), C) + \int_{\theta_{F\min}}^{\overline{\theta}_F} U_W(w_M(\theta_M), w_F(\theta_F))dF(\theta_F)\right] \text{ is}$$

continuous because it is a linear combination of continuous functions. By implication, $G(\theta_M, \overline{\theta}_F) = U_W(\theta_M, \overline{\theta}_F) - \delta EU(\theta_M, \overline{\theta}_F)$ is continuous. Note that the proposal boundary $\theta_F{}^*(\theta_M)$ is defined for such $(\theta_M, \theta_F{}^*)$ that $G(\theta_M, \theta_F{}^*) = 0$.

Now, suppose $\theta_F{}^*(\theta_M)$ is discontinuous at some point $\tilde{\theta}_M$. Specifically, without loss of generality, assume that the discontinuity is such that

$\exists \gamma > 0, \varepsilon > 0 \forall\, \theta_M \in [\tilde{\theta}_M - \varepsilon, \tilde{\theta}_M) \Rightarrow \left|\theta_F{}^*(\theta_M) - \theta_F{}^*(\tilde{\theta}_M)\right| > \gamma$ (see Figure A1).

The discontinuity of the proposal boundary at $\tilde{\theta}_M$ implies that $\forall \gamma > 0 \exists \theta'_F \neq \theta_F{}^*(\tilde{\theta}_M)$ such that $\left|\theta'_F - \theta_F{}^*(\theta_M)\right| < \gamma$ and $G(\tilde{\theta}_M, \theta'_F) \neq 0$ (which is just another way of stating that $(\tilde{\theta}_M, \theta'_F)$ does not lie on the proposal boundary). The value of the function *G* must either be strictly positive or strictly negative at $(\tilde{\theta}_M, \theta'_F)$.

Assume, without loss of generality, that $G(\tilde{\theta}_M, \theta'_F) < 0$. Now, notice that

$\forall \varepsilon > 0 \forall \theta'_M \in [\tilde{\theta}_M - \varepsilon, \tilde{\theta}_M] \Rightarrow G(\theta'_M, \theta'_F) > 0$ since all such points (θ'_M, θ'_F) lie below the proposal boundary. But in that case, $G(\theta_M, \overline{\theta}_F)$ is discontinuous at $(\tilde{\theta}_M, \theta'_F)$ because $\exists \eta > 0, \varepsilon > 0 \forall \theta'_M \in [\tilde{\theta}_M - \varepsilon, \tilde{\theta}_M) \Rightarrow \left| G(\theta'_M, \theta'_F) - G(\tilde{\theta}_M, \theta'_F) \right| > \eta$. That is a contradiction. QED.

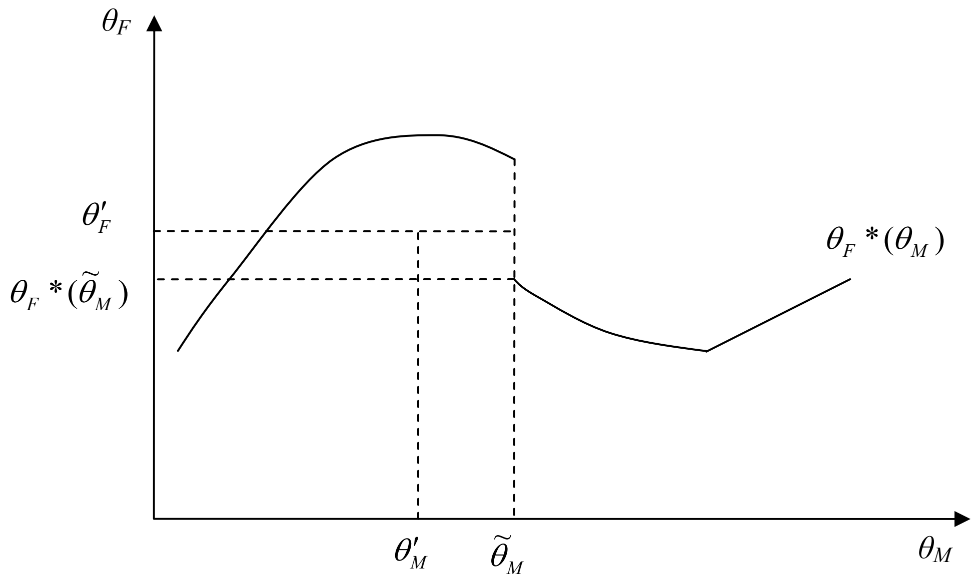


Figure A1 – Discontinuous proposal boundary in a $\theta_M - \theta_F$ space

Differentiability: Totally differentiate the condition $U_W(\theta_M, \theta_F*) - \delta EU(\theta_M, \theta_F*) = 0$ to obtain

$$\frac{d\theta_F*}{d\theta_M} = \frac{\delta \frac{\partial EU}{\partial \theta_M} - \frac{\partial U_W}{\partial \theta_M}}{\frac{\partial U_W}{\partial \theta_F*} - \delta \frac{\partial EU}{\partial \theta_F*}}$$

. It is easy to verify that, given the solutions in Table 2 to the optimization problem in section 3.2, all four of these partial derivatives exist and are finite at all points except that the derivatives $\frac{\partial EU}{\partial \theta_M}$, $\frac{\partial U_W}{\partial \theta_M}$ and $\frac{\partial U_W}{\partial \theta_F *}$ do not exist at (θ_M, θ_F) such that

$w_F(\theta_F *) = \rho\theta_M = \frac{\rho}{A} w_M(\theta_M)$ and $w_M(\theta_M) \geq R + \frac{(\pi+\sigma)\sqrt{t}}{2\beta}$. Consequently,

$$\frac{d\theta_F *}{d\theta_M} = \frac{A}{B} \frac{\delta F\left(\frac{R+C}{B}\right)\frac{\partial U_N}{\partial \theta_M} + \delta \int_{\frac{R+C}{B}}^{\theta_F *} \frac{\partial U_W(\theta_M, \theta_F)}{\partial \theta_M} f(\theta_F) d\theta_F - \left[1-\delta+\delta F(\theta_{F*})\right]\frac{\partial U_W(\theta_M, \theta_F *)}{\partial \theta_M}}{\left[1-\delta+\delta F(\theta_{F*})\right]\frac{1}{B}\frac{\partial U_W}{\partial \theta_F *}}$$

does not exist at such points either. QED.

*Lower bound on θ_F **: This part of the theorem states that every man, no matter how low his θ_M, will be willing to propose to at least some working women. No man will propose to non-working women only. This part is also proven by contradiction. Suppose $\theta_F *(\theta_M) \leq \theta_{F\min} = \frac{R+C}{B}$. Then

$EU(\theta_M, \theta_F) = F(\theta_F *)U_N(\theta_M, C) + \left[1 - F(\theta_F *)\right]\delta EU(\theta_M, \theta_F) = \frac{F(\theta_F *)}{1-\delta+\delta F(\theta_F *)} U_N(\theta_M, C)$. But

for $\theta_F *(\theta_M)$, it must also hold that $U_W(\theta_M, \theta_F *) - \delta EU(\theta_M, \theta_F *) = 0$ which, however, in this particular case simplifies to $U_N(\theta_M, C) - \frac{\delta F(\theta_F *)}{1-\delta+\delta F(\theta_F *)} U_N(\theta_M, C) \neq 0$. Thus

$\theta_F *(\theta_M) \leq \theta_{F\min} = \frac{R+C}{B}$ cannot be the proposal boundary. QED.

Theorem 2. Assume that c.d.f. $F(\theta_F)$ is continuous and differentiable.

Then, provided $t > \beta$ and $1 > \rho > 0$

(a) for θ_M such that $w_M(\theta_M) < R + \frac{(\pi+\sigma)\sqrt{t}}{2\beta}$, $\theta_F *(\theta_M)$ is increasing in θ_M;

(b) for $[\theta_M, \theta_F{}^*(\theta_M)]$ *such that* $[w_M(\theta_M), w_F(\theta_F{}^*)] \in$ *Region 2 and*

$w_F(\theta_F{}^*) \neq \rho\theta_M = \dfrac{\rho}{A} w_M(\theta_M)$*,* $\theta_F{}^*(\theta_M)$ *is increasing in* θ_M*.*

Proof. (a) By Theorem 1, $\theta_F{}^*(\theta_M)$ is differentiable for θ_M such that $w_M(\theta_M) < R + \dfrac{(\pi+\sigma)\sqrt{t}}{2\beta}$.

Using the formula for $\dfrac{d\theta_F{}^*}{d\theta_M}$ (see above) and plugging in the expressions for the individual

utility partial derivatives, one obtains $\dfrac{d\theta_F{}^*}{d\theta_M} > \dfrac{A}{B}\dfrac{(1-\delta)}{[1-\delta+\delta F(\theta_F{}^*)]}\dfrac{\left(1-\dfrac{\rho}{A}l^* - \beta n^*\right)}{(1-l^*)} > 0$. QED

(b) Again, by Theorem 1, $\theta_F{}^*(\theta_M)$ is differentiable for $[\theta_M, \theta_F{}^*(\theta_M)]$ such that

$[w_M(\theta_M), w_F(\theta_F{}^*)] \in$ Region 2 and $w_F(\theta_F{}^*) \neq \rho\theta_M = \dfrac{\rho}{A} w_M(\theta_M)$. Using the formula for $\dfrac{d\theta_F{}^*}{d\theta_M}$

(see above) and plugging in the expressions for the individual utility partials yields

$\dfrac{d\theta_F{}^*}{d\theta_M} = \dfrac{A}{B}\dfrac{1-\delta}{1-\delta+\delta F(\theta_F{}^*)}(1-\beta n^*) > 0$. QED

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CHAPTER II

SEASONAL ANTHROPOMETRIC CYCLES IN A COMMAND ECONOMY: THE CASE OF CZECHOSLOVAKIA, 1946 – 1966[33]

1. Introduction

Anthropometry has become a valuable tool for studying secular trends in welfare. Most studies (e.g. Margo and Steckel, 1983; Steckel, 1983; Komlos, 1985; Steckel, 1995; A'Hearn, 2003; Steckel and Rose, 2003; Brainerd, 2003) use measurements over relatively long intervals such as a several decades or even centuries but there has been a recent upsurge in research investigating shorter-term variations (Brabec, 2005; Tassenaar and Jacobs, 2004; Woitek, 2003; Sunder and Woitek, 2005). This paper analyzes seasonal height variations in Czechoslovakia using a new sample of anthropometric data for adolescent boys from the Bohemian city of Liberec. Between 1946 and 1966, local schools measured pupils three times a year (at the beginning of September, the beginning of February and at the end of June), enabling us to examine anthropometric evidence on short-term variations in the students' well-being.

There is a lengthy record of anthropometric measurement in the Czech lands beginning with the 18th century (Komlos 1986, 1989; Matiegka 1927). More recently, extensive surveys were administered on an aggregate level by the National Institute of Public Health (NIPH) in Prague between 1951 and 2001 with the aim of monitoring the health status of children and youth. These decadal surveys of boys and girls aged 0-19 have about 100,000 observations each (Prokopec, Suchy and Titlbachova, 1973; Vignerova and Blaha, 1998; VIgnerova, Brabec and

[33] This work has already appeared in Economics and Human Biology 4 (3), December 2006, pp. 317 – 341

Blaha, 2006).[34] They typically cover 3-5% of the country's relevant age cohorts using the standard methods of the International Children's Centre.

These studies report a fairly steady increase in average height during the last half a century (Vignerova, Brabec, and Blaha, 2006). My results corroborate this long-term trend. However, the present sample sheds light on the short-term variations in adolescent heights that are not captured by long-term trends. In sections II and III, the argument is advanced that the cyclical pattern of height and weight fluctuations in the sample is inconsistent with that exhibited by healthy, well-nourished populations. In contrast, it corresponds with periodic food shortages in the spring and relative abundance in the summer and autumn months (shortly after harvest).

In the immediate post-war years, Czechoslovakia dismantled its war economy and by 1948 had become a part of the Soviet bloc. The Communist government subsequently introduced policies that imposed central planning and state control. These included collectivization of agriculture (1948 – 1960), gradual nationalization of the retail sector (1948 – 1951), severe restrictions on import and currency convertibility and currency reform (1953). These policies affected agricultural production, delivery chains and with them the whole food supply, as described in section IV. Thus it is likely that the welfare of schoolchildren may have been negatively affected by the erratic and unbalanced food supply during the late 1940s and 1950s. While such juxtaposition in itself is insufficient to establish a firm causal link, it is suggestive, making it worthy of further research.

[34] Other local studies included Prokopec (1960), Kapalin, Kotaskova and Propokec (1969) and Blaha (1986).

2. Seasonal anthropometric cycles

With the improvement of measurement techniques over the last two decades, auxologists have been able to investigate changes in height over ever shorter periods and there is now an extensive new literature on short-term variation in human growth. Hermanussen (1998) notes that as measurement intervals decrease, incremental patterns appear more irregular. Lampl et al. (1992) formulated the saltation-stasis theory, whereby total stature is the product of an irregular series of very short growth bursts, spanned by weeks or months of stagnation.

While the ‘very short-term’ growth theories are a subject of debate, none of them contradicts the evidence of seasonal variations in growth, which has been confirmed by many studies (Marshall, 1971; Bogin, 1978; Lee, 1980; Neyzi et al., 1993; Thalange et al., 1996; Tillman et al., 1998). Consensus has not emerged, however, regarding the precise shape of the cycle (i.e. phase) and its strength at various ages (i.e. amplitude).

As for phase, height and weight have been shown to be countercyclical: height gain is greatest when weight gain is lowest and vice versa. Tanner (1962) suggests that the seasonal cycle is present at all ages of children and youth and that peak height velocity is achieved in the spring months of March, April and May, while a trough occurs in September, October and November. Rogol et al. (2002) and Marshall (1971) agree. Marshall finds that April is the month when most of the pre-pubescent boys in his sample complete their 3-month period of fastest growth, followed by July, May and June. January, followed by September and October are months when highest proportion of boys complete their slowest-growing 3 months. This is largely in line with Tanner (1962) although it suggests that the peak growth months may extend to early summer. Marshall and Swan (1971) conduct a trigonometric regression analysis and conclude that peak growth occurs in early April.[35] Tillman et al. (1998) and Thalange et al. (1996) place the peak of growth in July and the trough in February.

In search for a scientific explanation, Bogin (1978) connects the cycle to the amount of sunlight children receive. The ultraviolet component of sunlight encourages the production of vitamin D_3 which affects positively the absorption of nutrition and hence growth. He notes that while in temperate zones, the growth cycle shows some correspondence with length of day during various seasons: Guatemalan children grow faster in the dry season and slower in the rainy season (which occurs in August and September). Lee (1980) shows the cycle is independent of temperature variation.

All these studies were performed on pre-pubescent children, usually aged 5 – 8 years which raises the question of whether their conclusions are relevant for inferences about adolescents. Cycle phase does not seem to vary much with age but the case may be different for amplitude. Bogin (1978), Johnson et al. (1975) and Rudolf et al. (1991) provide some evidence that the cycle is either absent or much less pronounced in adolescents. Tanner (1962) notes that the half-year of high growth is responsible for circa 55% of annual increment in stature. That suggests a rather mild cycle. Reynolds and Sontag (1944) put the maximum share of the high-growth season at 54% and claim that the seasonal cycle is pronounced in weight, moderate in skeletal development (incidence of ossification centers) and slight in height. Marshall and Swan (1971) imply that 60% of annual increment is attained during the high-growth half-year.

The seasonal variation in height, examined in these studies, pertain to children and youth who are well-fed. Bogin (1978), for example, emphasizes that his sample of Guatemalan children

[35] They report the following result: $Height = 134.232 + 4.76t + 0.242\cos[2\pi(t - 0.521)]$ where the phase (0.521) is given in decimal time and denotes the time at which the seasonal cycle reaches its full amplitude (0.242). The peak velocity occurs one quarter of cycle before that, i.e. at 0.271 of the year which corresponds to 7th – 8th April. The regression was based on a sample of monthly measurements of 251 boys of average age 9.2 years.

was recruited from the top socioeconomic strata of the country, that they were fed a nutritionally adequate and balanced diet and that their health was monitored by a fully staffed school health office. In other words, their seasonal cycle is unlikely to be the result of nutritional deficiency of any kind.

Malcolm (1970) investigates the effects of nutrition on growth and the speed of physical reaction. In two experiments, he shows that in a nutritionally constrained population of (pre-pubescent) children, a supplementary protein intake results in a marked catch-up growth within 10 weeks. The treatment group (receiving extra protein) grew by 2.4 cm over the ten weeks, as opposed to 1.2 cm of the control group. Other studies did not produce such marked results, but Malcolm (1970) points out that the extra protein intake only takes effect if, first, the nutrition had previously been deficient and, second, the increase in protein (the treatment) is sufficiently large.

Despite differences regarding the exact shape of the cycle, there is no disagreement that the seasonal cycle is virtually identical across populations living in the temperate climate zone in the Northern hemisphere (Tanner, 1962; Bogin, 1978; Marshall, 1971); that weight displays the converse pattern of height (Reynolds and Sontag, 1944; Tanner, 1962; Rudolf, et al. 1991; Tillman, 1998; Rogol et al., 2002) and that recuperative powers of the human body are great and respond quickly to improvements in nutrition (Malcolm, 1970; Tanner, 1962; Rudolf et al., 1991). Also, boys are regarded as more sensitive to the seasons (Rudolf et al., 1991; Tanner, 1962). Garn and Rohman (1966) analyze height correlations between siblings and show that sister-sister correlation is by far the highest, indicating greater influence of genetics over environment in girls relative to boys.

Figure 1 depicts a stylized cycle in growth velocity of children, taking, by way of example, the phase description as presented in Tanner (1962), Marshall (1971), Marshall and

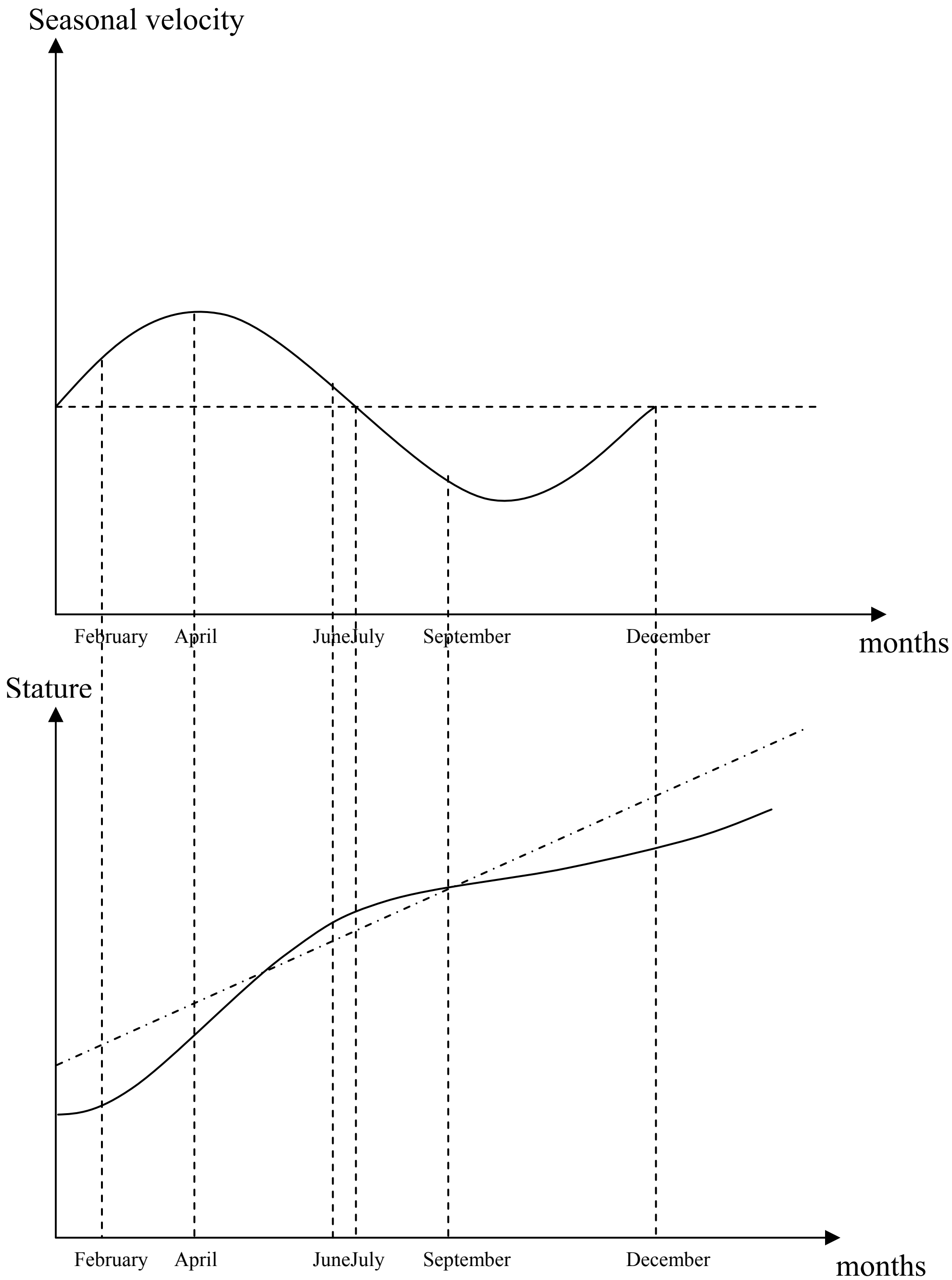

Figure 1 - Stylized seasonal cycle in height velocity

Swan (1971), Reynolds and Sontag (1944), and Rogol (2002). The cycle is characterized by the velocity curve in the top panel which is the first derivative of stature (in the bottom panel) and which shows the highest rate of change in stature in April and lowest in October. Such annual cycle in velocity, as depicted in the top panel, has obvious implications, in the bottom panel, for the relative position of stature measurements taken at three distinct dates in our dataset: February, June and September. The dotted line (in the bottom panel) depicts the long-term trend in stature as measured in September. [36] The cyclical variation in velocity, however, means that actual stature (solid curve in bottom panel) oscillates around this trend line. Given the phase of the velocity cycle, this oscillation puts June height measurement above the dotted September trend line and February measurement below it.

The hypothesis to be tested is whether the height and weight data for the Liberec boys are consistent with the pattern expected in a healthy, well-nourished population. The nature of the sample, however, is such that the hypotheses must be formulated in a sufficiently robust manner. This is done in two steps: by comparing a fluctuation in height with the fluctuation in weight, and by comparing the seasonal effect of February with seasonal effect of June.[37] In the first step, this formulation makes use of the countercyclical nature of the weight and height fluctuations. Specifically, if the June fixed effect on height proves to be positive, then the June fixed effect on weight should be negative (i.e. when one is currently above trend, the other must be below trend). An analogous argument applies to the February fixed effect: if it is negative for height it should be positive for weight. In the second step, I rely on the opposition of February

[36] This diagram relies on the assumption that the long term trend in stature can be inferred from annual observations of any given month. For example, if we measure all children every September we will end up with a trend line of the same gradient as if we measured them in, say, July (only shifted upwards by the height increment accrued from July to September).
[37] Note that, in the hypothesis formulation as in Figure 1, September is taken as the referential measurement, thus the seasonal effects of February and June are estimated against this backdrop.

and June measurements vis-à-vis the September trend (as depicted in Figure 1). The following table overview summarizes the null hypothesis.

Position of cyclical measurements relative to trend in a healthy well-nourished population		
Measurements of \ in	February	June
Height	Below trend (–)	Above trend (+)
Weight	Above trend (+)	Below trend (–)

To be sure, the three within-year observations in the data set are not enough to establish the definitive shape of the seasonal cycle (Marshall and Swan (1971) rely on 13 monthly observations) – but they do suffice to rule out certain classes of cycles as inconsistent with these data. For example, if June height were persistently below the trend line and February height above, one could not reasonably conclude that the data exhibit a cycle of spring growth spurt and fall slow-down as depicted in Figure 1. Analogous inferences can be made in case of weight.

Based on the medical literature reviewed above a growth pattern is consistent with a healthy development if (i) the height and weight in the sample display opposite cycles and (ii) if the height growth peak occurs during the third to seventh month, and weight gain in the second half of the year. As the rest of the paper documents, the current sample does not exhibit such a pattern found in healthy populations: growth peak seems to occur in the summer for both height and weight.

Testing such a hypothesis requires that the identification strategy be sufficiently robust. For that reason, I rely on fixed effects. Some individual characteristics such as age, month of measurement and certain family conditions (e.g. divorce) take the form of dummy variables, while genetic and family-specific influences are all modeled as part of an error-component model.[38] Allowance must also be made for the fact that adolescence is a time of dramatic changes in how a human body responds to external factors and so the estimation model must be able to capture the potentially variable effects of seasons at different ages.

3. Anthropometric evidence

The anthropometric evidence in this study stems from school records from the city of Liberec in northern Bohemia. Seven schools were approached regarding access to their records. Five agreed to open their archives (Table 1). Schools were selected which had records that dated back to the end of the Second World War. The schools differed in size: the large ones had 1000 or more pupils in all grades while the smaller ones had less than 500.[39]

Table 1 - Characteristics of data sources[40]

School	Location	Size (pupils)	Span	Individuals measured
ZS 5 kvetna	City centre	900 - 1200	1950 – 1966	1,594
ZS Husova	City centre	800 – 1000	1948 – 1966	1,378
ZS Na Perstyne	City centre	400 - 500	1952-53, 1961 – 1964	159
ZS Na Zizkove	Industrial suburb	600 - 800	1946 – 1966	606
ZS Vrchlickeho	Residential suburb	700 - 900	1948 – 1966	936
Total	City of Liberec		1946 - 1966	4,673

The data were collected from school registers. These had one page per student, recording place and date of birth, parents' occupation, the pupil's mid-year and final grades as well as the

[38] This approach is more robust than using a specific functional form (such as trigonometric for the annual cycle) because that would *a priori* impose such functional structure on the data and lead us to conclude that a pattern was present when in fact that might not be the case.
[39] They also differed in location. Three of them are located in the city centre and the remaining two in the suburbs. The abbreviation ZS stands for "zakladni skola", perhaps best translated as primary school. From 1953 onwards, these schools were designed for students aged 6 – 14 or 15 years. The second part of a school name consisted of the street where it was located.
[40] The author is a former pupil of ZS Husova.

record of his absence from school. [41] The register pages had specific cells for height and weight measures to be taken at the beginning, in the middle of, and at the end of each school year. [42]

I collected heights and weights of boys during their adolescent growth spurt because they are more sensitive to environmental and nutritional insults than girls (Tanner 1962, p. 127). Over 90% of observations are for pupils between 10 and 15 years of age. The youngest boys in the sample were those who skipped grades while the oldest students were those who repeated a grade or started school later. Since school attendance was universal, the sample is representative of the particular birth cohorts. The boys were measured between 1946 and 1966. The sample includes 29,315 observations of height and 30,753 of weight on 4,673 boys.

During the period under study, the population of Liberec grew from 60.000 to about 100,000 in the 1980's.[43] Assuming Liberec followed national trends with respect to birth rates, one can roughly estimate that the average birth cohort in Liberec comprised about 1200-1300 children in the 1950's of which about half would be boys. For most years and age groups, the sample contains more than 50 observations or about 6% of the relevant age cohort in the city. This percentage varies from year to year and in some years, as many as 30% of all the city's boys

[41] Initially, only father's occupation was recorded, mother's only if father was absent from the family.

[42] The school records provide no instructions as to how the measurements should be taken, nor do they say at which time in the day the children were measured. The teachers who did the measurements were not professional auxologists. Consequently, a certain level of random measurement error can be expected. With regards to reliability of data in general, Schwartz, Britten and Thompson (1928) (quoted in Boyd (1929)) performed measurements on 50 adolescent boys at 4-month intervals and concluded that proper measurement will result in high correlation between two consecutive points in time: "If any given measurement showed a correlation very much less than this [0.99], questions would be raised as to the value of the measurement as generally employed." (Boyd 1929, p. 393). For weight, the desirable lower bound on correlation was 0.98. Although this reference is dated, it is probable that the clinical standards of late 1920's were closer to the actual practice in the Liberec schools in 1950's than would be today's methods – primarily because the measurement tools used today were unavailable then.
Using this benchmark, I calculated the correlations between any two consecutive measurements for the period under study. For height, the correlations ranged from 0.977 to 0.995 with a median of 0.989; for weight, the range was 0.916 – 0.987 with a median of 0.970. There was one outlying weight correlation equal to 0.82 based on only 30 observations of 11-year-olds who were measured in both June and September of 1948. While the height numbers are in line with what Schwartz, Britten and Thompson (1928) view as reasonable, weight correlations show more variation. Still, a majority of correlations seem to meet the condition of not being 'very much' below 0.98.

[43] Until the Second World War, the city's population was 90% German. After the war, those of German descent were deported to Germany and the city was gradually repopulated by Czechs. Data on city population come from Statisticka Rocenka 1957, p. 53 – the statistical yearbook of Czechoslovakia.

are included in the sample. Thus, the sample contains a relatively large fraction of the city's male population at ages 10 – 15.

Table 2 provides a first look at the seasonal variation of height and weight in the present sample. The whole period of interest is divided in 1953 which not only marks an important economic turning point but also begins the period when the post war generation started attending school. The practice of measuring children started in the post-war years as a new phenomenon and it probably took several years before it became routine. In the early post-war years, teachers were probably more likely to shirk at the end of the school year. For that reason, the pre-1953 statistics are based on fewer observations.

The seasonal variation is captured here by z-scores for each month of measurement and age. Two observations stand out. First, for both height and weight, the June average tends to be the lowest of the three months throughout most of puberty in the post-1953 period while in the immediate post-war years, this pattern is not present. Second, height and weight display similar pattern, not opposite.

Table 2 - Z-scores for height and weight by month of measurement and age

Age	Height - early period (1946 - 1953)			Height - later period (1954 - 1966)		
	February	June	September	February	June	September
9.5 – 10.0	0.069	0.116	**-0.096**	**-0.237**	-0.086	0.047
10.0 – 10.5	0.022	0.032	**-0.028**	0.119	**-0.141**	-0.040
10.5 – 11.0	0.036	**-0.100**	0.009	**-0.045**	0.112	-0.007
11.0 – 11.5	0.103	**-0.109**	-0.033	0.009	**-0.043**	0.028
11.5 – 12.0	0.112	**-0.014**	-0.105	0.024	-0.010	**-0.021**
12.0 – 12.5	**-0.125**	0.062	0.056	-0.023	**-0.025**	0.053
12.5 – 13.0	0.061	0.033	**-0.085**	0.037	**-0.048**	0.002
13.0 – 13.5	**-0.063**	0.030	0.035	-0.008	**-0.056**	0.073
13.5 – 14.0	0.038	**-0.103**	0.026	0.044	**-0.039**	-0.019
14.0 – 14.5	**-0.086**	-0.017	0.073	-0.018	**-0.027**	0.089
14.5 – 15.0	0.091	**-0.118**	-0.066	0.043	**-0.038**	-0.010
15.0 – 15.5	**-0.017**	0.007	0.023	-0.020	0.018	**-0.156**
15.5 – 16.0	0.041	0.051	**-0.204**	-0.008	**-0.016**	0.219
16.0 – 16.5	**-0.360**	0.135	0.238	0.030	**-0.021**	0.306
16.5 – 17.0	0.692	-0.259	**-0.304**	**-0.707**	0.283	**-0.707**
Overall	0.020	-0.005	**-0.014**	0.010	**-0.025**	0.014

Age	Weight - early period (1946 - 1953)			Weight - later period (1954 - 1966)		
	February	June	September	February	June	September
9.5 – 10.0	0.206	-0.001	**-0.147**	**-0.214**	0.107	0.028
10.0 – 10.5	0.093	0.074	**-0.074**	0.128	**-0.201**	-0.040
10.5 – 11.0	0.344	-0.009	**-0.122**	0.028	0.015	**-0.034**
11.0 – 11.5	0.096	0.013	**-0.047**	0.054	**-0.052**	-0.006
11.5 – 12.0	0.114	0.012	**-0.113**	0.047	**-0.042**	-0.015
12.0 – 12.5	**-0.138**	0.107	0.029	0.042	**-0.079**	0.041
12.5 – 13.0	0.094	-0.039	**-0.066**	0.069	**-0.108**	0.026
13.0 – 13.5	**-0.036**	-0.032	0.055	0.033	**-0.098**	0.078
13.5 – 14.0	0.022	**-0.149**	0.072	0.074	**-0.098**	0.012
14.0 – 14.5	-0.063	**-0.100**	0.110	0.005	**-0.068**	0.139
14.5 – 15.0	0.036	-0.018	**-0.049**	0.117	**-0.096**	-0.030
15.0 – 15.5	-0.006	**-0.018**	0.175	-0.016	0.009	**-0.019**
15.5 – 16.0	0.104	**-0.009**	-0.144	0.118	**-0.059**	0.490
16.0 – 16.5	**-0.491**	0.260	-0.164	0.211	**-0.075**	0.191
16.5 – 17.0	0.691	**-0.278**	-0.274	0.191	0.029	**-0.365**
Overall	0.040	-0.015	**-0.023**	0.051	**-0.069**	0.015

Note: Z-scores are calculated as $z_i = \frac{x_i - \bar{x}}{\sigma}$ with the mean here representing the average height or weight across all measurements in a given year. The 'Overall' readings at the bottom of each panel represent the weighted average of each column (weighted by the number of observations). Minima in each row and period are highlighted. Reported are only those age intervals where observations exist for all three points of measurement.

4. Regression analysis

In analyzing panel data, a choice must often be made between a fixed effects model and a random effects model (Greene, 2000). A fixed effects model views differences between individuals as parametric shifts of the same regression function. On the other hand, random effects model sees these differences as randomly distributed across individual units. I use a random effects model which is usually applied to samples that are wide (i.e. include information on many individual units) but not very long (units are observed over relatively few periods), and which may be unbalanced (i.e. include unequal number of periods across observations). Such is the case with the present data.[44] In equation form, the random effects model leads to the following specification:

$$y_{it} = \alpha + \boldsymbol{\beta}'\boldsymbol{x}_{it} + u_i + \varepsilon_{it} \qquad \text{(Eq. 1)}$$

where y_{it} is height or weight, α is a constant and $\boldsymbol{x}_{it}$ is a vector of explanatory variables, as observed for individual i at measurement time t. In the present context, this vector includes the age of the child at the time of measurement, month-of-measurement dummies capturing the seasonal effects at various ages (February or June; September is the reference month), year-of-measurement dummies and other variables representing certain family characteristics. Age has not been entered as a continuous variable but rather in the form of a group of dummy variables.[45] The advantage of the approach is twofold: first, it allows us to sidestep the question of the precise functional relationship between age and height and weight. Instead of having to specify *a priori*, that height (weight) is, say, a cubic or a bi-quadratic function of age, the growth curve is

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[44] Between 1946 and 1966, 4673 individuals were measured, some only once, some as many as eighteen times. Over 82% of individuals were measured at least 3 times and about 36 % were measured 9 or more times during their middle school career.

[45] The age dummies were created by splitting the whole sample into several groups based on age: those younger than 10.5 years, the 11-year olds (10.5 – 11.5 years), 12-year olds and so on, up to the group of children older than 15.5 years. This is a relatively crude split, considering how dramatic development is during puberty, so in the extended specification (discussed in Table 4) the age differentiation is much finer.

simply traced out by the coefficients on individual age dummies. Second, this allows us a similar freedom from the constraints on functional form in analyzing the seasonal effects at various ages. The seasonal effects (February and June) are interacted with the age dummies.

The term u_i in the equation captures the differences between individuals in the form of an individual-specific component of the overall error term ($u_i + \varepsilon_{it}$).[46] For the random-effects model to be consistent and efficient, it is necessary that the u_i-component be uncorrelated with the explanatory variables included in the vector $\boldsymbol{x_{it}}$. Since this error component captures an individual-specific effect, it can be viewed as a proxy for (individual-specific) genetic factors influencing height and weight, personal medical history etc. The explanatory variables in $\boldsymbol{x_{it}}$, however, are age, age-season effects and other family and environmental variables which are unrelated to individual genetic or medical traits. Consequently, there is a strong *a priori* case of such zero correlation.[47]

The empirical strategy is such that the behavior of height and weight will be decomposed, through consecutive regressions, so that the seasonal effects can be evaluated at a progressively finer level (see note 12). Table 3 reports regression results for an ordinary least squares regression and for the random effects model in order to demonstrate the importance of the individual-specific error component, u_i.[48] The seasonal effects are interacted with the age dummies in order to show how the seasons affected different age groups. Standard errors in the OLS regressions are estimated using the Huber-White estimator of variance (because variance of height and weight can be expected to differ with age) and allow for clustering at the individual level. The random effects model uses a feasible generalized least squares estimator.

[46] For that reason, it is sometimes referred to as error-component model. See Hayashi (2000), Ch. 5
[47] *Ex post* correlation between a retrieved $\hat{u}_i$ and explanatory variables ranges in (-0.08; 0.03).
[48] All the regressions also included year-of-measurement dummies in order to control for idiosyncratic shocks of a given year, but they are not reported in any of the tables as they are not of prime interest.

The results are summarized in Table 3 and the coefficients that are statistically significant at a 5% level are highlighted.[49] Note that since the explanatory variables are all dummies, the regression coefficients represent the net effect, in centimeters or in kilograms, of a given characteristic on overall height or weight, compared to the reference case.[50] For the analysis of the seasonal behavior of height and weight, the important result is that both height and weight are affected in the same way: compared to the September reference, both February and June effects are mostly negative and mostly significant. This is counter to what one would expect in a normal population where not only seasonal effects on height should have opposite signs to those on weight but also February and June should have effects opposite to each other. Moreover, seasonal effects also show marked differences across age groups. In February the strongest negative effect is apparent for the 12.5-13.5 year olds (e.g. 1.10 cm below trend height and 0.43 kg below trend weight, see columns iia. and iib.); in June it is mostly 13-year olds, especially in the post-1953 period (columns iva. and ivb.), when the boys are 1.01 cm below trend height and 1.33 kg below trend weight. Thus February and June deviations from trend growth seem to be most intense during periods of most rapid pubertal development. The F-tests and Wald-tests in the bottom section of Table 3 show that both age-February and age-June variables are jointly significant. The Breusch-Pagan LM test also shows that the individual effects are an important addition to the model: the test rejects the null hypothesis that u_i have zero variance (i.e. that a classical regression with a single constant term is appropriate for this panel). The move from

[49] I also estimated a log-linear form, for both height and weight, but the regression results were in line with the linear specification reported here. Compared with the linear model, some marginally significant coefficients (at 5%) turned insignificant and vice versa in the log-linear model but structurally and qualitatively the results for the two models were the same. Full regression reports are available from the author.

[50] The exception here are the seasonal effects at each age which are the sum of the overall seasonal effects (i.e. the coefficient on February and June, respectively) and the age-season interactions. These summed total effects are reported in Table 3.

Table 3 - Regression results: Dependent variables: Height (cm) and Weight (kg)

	OLS regression Whole period		Random-effects model: Whole period		Random-effects model: Pre-1953 period		Random-effects model: Post-1953 period	
	ia. Height	ib. Weight	iia. Height	iib. Weight	iiia. Height	iib. Weight	iva. Height	ivb. Weight
$\beta_{11.5 > age \geq 10.5}$	**4.42**	**2.63**	**4.04**	**2.64**	**3.22**	**2.15**	**3.44**	**2.28**
$\beta_{12.5 > age \geq 11.5}$	**9.26**	**5.87**	**8.22**	**5.73**	**5.73**	**4.64**	**7.28**	**5.14**
$\beta_{13.5 > age \geq 12.5}$	**15.11**	**10.55**	**13.33**	**9.99**	**9.10**	**7.72**	**12.08**	**9.29**
$\beta_{14.5 > age \geq 13.5}$	**21.66**	**16.22**	**18.89**	**15.05**	**13.55**	**12.80**	**17.14**	**13.90**
$\beta_{15.5 > age \geq 14.5}$	**26.36**	**20.19**	**23.29**	**18.93**	**16.66**	**16.23**	**21.44**	**17.64**
$\beta_{age \geq 15.5}$	**30.23**	**24.48**	**27.36**	**23.78**	**19.67**	**19.85**	**24.76**	**22.31**
$\beta_{February}$	**0.92**	**1.15**	0.20	**0.86**	**-0.75**	**0.50**	0.08	**0.68**
β_{June}	**1.15**	**1.15**	**0.61**	**0.76**	0.21	**0.63**	**1.09**	**1.12**
$\beta_{February} + \beta_{(11.5 > age \geq 10.5)*feb}$	**-0.27**	**0.42**	**-0.90**	0.15	**-1.53**	0.27	**-1.13**	-0.06
$\beta_{February} + \beta_{(12.5 > age \geq 11.5)*feb}$	**-0.31**	0.06	**-1.00**	**-0.29**	**-1.98**	**-0.94**	**-1.16**	**-0.36**
$\beta_{February} + \beta_{(13.5 > age \geq 12.5)*feb}$	**-0.46**	-0.16	**-1.10**	**-0.43**	**-1.94**	**-0.65**	**-1.33**	**-0.65**
$\beta_{February} + \beta_{(14.5 > age \geq 13.5)*feb}$	**-0.40**	**-0.44**	**-0.99**	**-0.64**	**-2.32**	**-1.63**	**-1.04**	**-0.55**
$\beta_{February} + \beta_{(15.5 > age \geq 14.5)*feb}$	**0.84**	**1.23**	**-0.44**	0.26	**-1.56**	**-0.85**	**-0.70**	**0.38**
$\beta_{February} + \beta_{(age > 15.5)*feb}$	0.27	0.39	-0.13	-0.30	**-1.64**	-0.82	-0.21	-0.54
$\beta_{June} + \beta_{(11.5 > age \geq 10.5)*june}$	0.03	0.11	**-0.49**	-0.14	**-0.87**	**0.70**	**-0.48**	**-0.28**
$\beta_{June} + \beta_{(12.5 > age \geq 11.5)*june}$	-0.21	**-0.33**	**-0.70**	**-0.75**	**-0.79**	-0.26	**-0.76**	**-0.85**
$\beta_{June} + \beta_{(13.5 > age \geq 12.5)*june}$	**-0.54**	**-0.97**	**-0.91**	**-1.14**	**-1.07**	**-0.54**	**-1.01**	**-1.33**
$\beta_{June} + \beta_{(14.5 > age \geq 13.5)*june}$	-0.21	**-1.03**	**-0.47**	**-1.09**	**-1.25**	**-1.43**	**-0.46**	**-1.01**
$\beta_{June} + \beta_{(15.5 > age \geq 14.5)*june}$	**0.93**	**0.77**	0.28	0.23	-0.43	0.01	0.08	0.20
$\beta_{June} + \beta_{(age \geq 15.5)*june}$	0.79	0.03	-0.31	-1.17	-0.32	-0.18	-0.29	-1.41
Currency reform (June 1953)	-0.43	**-0.67**	-0.13	**-0.34**	-0.16	**-0.92**		
Homemaking mother	-0.23	**-0.63**	0.00	**-0.27**	**0.30**	**-0.31**	**-0.21**	**-0.32**
Deceased father	**-1.54**	**-1.33**	0.29	0.48	**-0.91**	**-0.98**	0.46	**0.64**
Parents separated	**-3.70**	**-3.34**	**-1.30**	**-1.54**	-0.57	-0.94	**-1.24**	**-1.39**
Parent a farmer	**-6.64**	**-5.50**	-0.05	-0.32	-0.49	**-1.67**	-0.20	1.12
Parent in a food-process job	0.04	-0.25	-0.32	**-0.77**	-0.35	-0.63	-0.32	**-0.80**
Parent in armed forces, police	0.76	0.24	0.09	-0.13	0.72	-0.14	0.20	0.11
Constant	**137.60**	**32.78**	**135.53**	**31.43**	**146.25**	**36.59**	**148.86**	**40.10**

Observations	29315	30753	29315	30753	6306	6573	23009	24180
Number of individuals	4673	4672	4673	4672	1670	1672	3546	3544
R-squared	0.55	0.42						
Adjusted R2	0.55	0.42						
F-test of joint significance of age-Feb interactions	6.42	10.21						
Prob > F	0.00	0.00						
F-test of joint significance of age-June interactions	4.23	12.26						
Prob > F	0.00	0.00						
Overall R2			0.44	0.39	0.43	0.44	0.40	0.35
R2 - within variation			0.89	0.79	0.89	0.75	0.90	0.79
R2 - between variation			0.25	0.31	0.31	0.44	0.16	0.25
Breusch-Pagan LM test			81051.68	94274.25	10675.22	9832.48	66050.28	77948.49
Prob > chi2(1)			0.00	0.00	0.00	0.00	0.00	0.00
Wald test of joint significance of age-Feb interactions			89.65	104.11	41.78	71.95	69.12	69.12
Prob > chi2			0.00	0.00	0.00	0.00	0.00	0.00
Wald test of joint significance of age-June interactions			83.32	143.44	27.74	55.11	60.62	107.74
Prob > chi2			0.00	0.00	0.00	0.00	0.00	0.00

Height and weight were regressed on age dummies, age dummies interacted with seasons (Feb/June – September is the omitted season), year-of-measurement dummies, ‘reform’ and family characteristics. Reported are coefficients on interaction dummies of age and Feb/June for ages above 10.5 and family characteristics. Default values are September for month of measurement; age 7.5 - 10.5 years and year 1953 in whole period and pre-1953 regressions; year 1966 in the post-1953 regression. Coefficients significant at 5% are highlighted.

OLS to random effects pushes most age-season coefficients further away from zero which seems to indicate that OLS tends to average out the seasonal variation.

Yet, these results have a disadvantage insofar as the age categories are too wide.[51] To correct for that, in Table 4, the age dummies represent much finer division of the whole age range in the sample. In this specification each age dummy represents an interval of 0.1 years, from age 7.7 years to 17.4 years.[52] Interaction terms of season and age are included again. The shortest span between any two measurements is two months (June to September), while each age dummy represents an interval of only about 36 days. Thus with the finer age disaggregation, for any individual, the regression analysis of the difference in height or weight between two consecutive observations separates the trend growth, due to ageing, from the seasonal effects, as different children reach a given age at a different moment during the calendar year.[53] This extended specification confirms the impression from Table 3, that the seasonal effects are stronger negative for boys aged 12 – 14, who are currently undergoing or about to undergo their adolescent growth spurt. Most pronounced June deviation from the long term trend occurs roughly during the 14th year of life (12.8 – 14.5 years) when the adolescent can be as much as 1.3 cm and 2 kg below the trend.[54] February has a much milder impact on the children and generally does not seem to be statistically different from September (the default season) although in

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[51] For example, a person born in April 1945 would be in the 13-year-old cohort in 1958 both for the February measurement (when he was 12.8 years old) and for the June measurement (when he was 13.2 years old). Hence, the age-season dummies would be picking up some trend growth, as well as the seasonal effects.
[52] Note that while 90% of the sample pertains to children aged 10 – 15, some outliers are present also. Some boys repeated grades, some skipped grades. Thus, the lowest age in the whole sample is 7.73, the highest 17.36. Dissecting this age range into intervals of 0.1 years creates 95 groups. See Table A2 for descriptive statistics.
[53] Since each regression includes about 250 or more variables, I do not report the whole regression results but only coefficients of interest. The complete regression reports are available from the author.
[54] See the June column for Height and Weight for the post-1953 period in Table 4. Note that instead of reporting the actual coefficients which would render the table intractable, I substitute arrows of different sizes for those coefficients which turned out to be significant.

Table 4 – Overall seasonal effects and coefficients on family characteristics

	Whole period				Pre-1953 period				Post-1953 period			
	ia. Height		ib. Weight		iia. Height		iib. Weight		iiia. Height		iiib. Weight	
Age	Feb	June	Feb	June	Feb	June	Feb	June	Feb	June	Feb	June
10												
10.1												
10.2												
10.3												
10.4												
10.5												
10.6			Λ				▲					
10.7		V					▲					
10.8							▲					
10.9			Λ							V		
11								▲			Λ	
11.1	V	V			▼				V	V		
11.2	V	V			▼					V		
11.3	V	V								V		
11.4	V	V								V		
11.5												
11.6		V								V		
11.7												
11.8		V		V						V		▼
11.9	V	V		V	▼					V		▼
12	V				▼					V		V
12.1	V	V		V		▼				V		
12.2		V		V		▼						V
12.3		V		V						V		V
12.4	V	V		▼				▼	V	V		▼
12.5		V		V			▲			V		▼
12.6		V								V		V
12.7				V								V
12.8		V		▼						V		▼
12.9	V	V		▼					V	V		▼

13	V	V		▼	▼		▼	▼	V	V		▼
13.1	V	V		▼						V		▼
13.2	▼	▼		▼	▼	▼			▼	V		V
13.3		▼		▼						▼		▼
13.4		▼		▼		▼		▼		▼		▼
13.5		V		▼		▼		▼		V		▼
13.6		▼		▼						▼		▼
13.7		V		▼			▼					V
13.8	V	V		▼	▼		▼	▼		V		▼
13.9	V	V		▼					V	V		▼
14	▼	▼		▼			▼	▼	▼	▼		▼
14.1	V	V	V	▼	▼		▼	▼		V		▼
14.2		V		▼		▼						▼
14.3		▼		▼				▼		▼		▼
14.4		V		▼						V		▼
14.5		▼		▼		▼		▼		▼		▼
14.6				▼								▼
14.7	V	V							V			
14.8					▼	▼	▼	▼			▲	
14.9					▼	▼						
Currency reform (6/1953)	-0.26		**-0.44**		**-0.33**		**-1.09**		not included		not included	
Homemaking mother	0.01		**-0.28**		**0.34**		-0.26		-0.12		**-0.26**	
Deceased father	-0.23		0.05		**-1.19**		**-1.25**		-0.04		0.20	
Parents separated	**-1.17**		**-1.48**		0.31		-0.02		**-1.26**		**-1.42**	
Parent a farmer	-0.75		-0.75		-0.69		**-1.85**		-0.64		0.93	
Parent in a food-process job	-0.21		**-0.65**		-0.36		-0.55		-0.22		**-0.62**	
Parent in armed forces, police	0.29		0.02		**1.09**		0.21		0.26		0.08	
Constant	**166.59**		**56.23**		**167.97**		**57.89**		**167.59**		**59.83**	
Observations	29315		30753		6306		6573		23009		24180	
Number of individuals	4673		4672		1670		1672		3546		3544	
Overall R^2	0.567		0.440		0.572		0.499		0.568		0.425	
R^2 - within variation	0.929		0.828		0.920		0.799		0.930		0.829	
R^2 - between variation	0.483		0.396		0.554		0.509		0.492		0.390	

Breusch-Pagan LM test Prob > $chi^2(1)$	88687.20 0	100010.57 0	11092.15 0	10253.01 0	72697.74 0	82680.27 0
Wald test of joint significance of age-Feb interactions Prob > chi^2	99.15 0.01	148.20 0	104.22 0.29	160.62 0	68.78 0.03	82.83 0.14
Wald test of joint significance of age-June interactions Prob > chi^2	98.46 0.02	261.34 0	72.02 0.01	144.09 0	88.64 0.52	167.84 0

Height and weight were regressed on age dummies, age dummies interacted with seasons (Feb/June – September is the omitted season), year-of-measurement dummies, currency reform and family characteristics. Reported are coefficients on interaction dummies of age and Feb/June for ages 10 to 14.9 and family characteristics. Omitted are: interaction dummies for age between 7.7 and 9.9 and between 15 and 17.4; all age dummies (representing the trend line). Coding: V – coefficient in interval [-1,0]; ▼ – coefficient in [-2, -1); ▼- coefficient in (-∞, -2); Λ – coefficient in (0, 1]; ▲ – coefficient in (1, 2]; ▲- coefficient in (2, ∞); blank cell – coefficient was not significant at 5%. Bolded numbers in the bottom half of the table are coefficients significant at 5%.

absolute terms, the February effects are lower (more negative) for children aged 13 than for other age groups.[55] These results indicate that most of the February effect from Table 3 can be explained away by the growth trend which is why the February effects in Table 4 are not nearly as significant as in Table 3. The most important result, however, is that weight is affected as much as height and the effect seems to have a similar pattern: strong negative June effect and a mildly negative, mostly insignificant February effect – particularly for the teenage cohorts.

This is an important finding. We do not see opposite cycles of height and weight but rather a below-trend June reading for both height and weight. If this is the case, then the seasonal development of the anthropometric indicators of the boys in the sample is inconsistent with the one in a healthy population.[56]

5. Government policy and the food supply

A natural place to look for an explanation of the above pattern is the nutritional status of the children. Nutritional inadequacy can vary from family to family depending on income or social status. However, it can also be an "across-the-board" phenomenon, if a country experiences, as Myant (1989) notes in the case of post-war Czechoslovakia, "periodic supply breakdowns even for basic foods" (p.61).

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[55] Since the measurements were not performed by professionals, there is the possibility that weight data may be biased if the boys were weighed with their clothes on. The regression results indicate, however, that this does not ultimately constitute a problem. September, which is the reference month in the regression, is not very different from end of June in terms of temperature. February, on the other hand, is a cold month when a heavy clothing effect could be expected. Thus, clothes should not significantly affect the June-September comparison but should bias February coefficients in relation to September. Thus, while the negative June effect cannot be viewed as a product of clothing, the mostly insignificant coefficients on February may in fact be an underestimate of a true negative seasonal effect.

[56] The implications that the regression results would have for the phase of the height and weight annual cycle are that the boys' height and weight increments would both have to peak in summer, perhaps in late July, early August. For height, this is not entirely unrealistic although it would be untypical. But weight does not exhibit such a phase. Healthy populations gain more weight late in the fall and over the winter, not over the summer vacations. In the case of weight, the results are not consistent with a fall/winter weight gain and spring and summer weight loss or stagnation. (See section II for more detail on growth cycle phase.)

To address this question, the regressions also include dummy variables for several occupational groups that may have had a noticeable effect on a child's nutritional status: one is for either parent working in a food-processing job, such as cook, supplies supervisor, butcher etc. They had direct access to food. This may have given them opportunity to supplement their diets. Another is for farmers who also had a direct access to food production but their political situation was so disadvantageous that it may have cancelled out the advantage of direct access.[57] Yet another was for fathers employed in the armed forces and the police, the mainstays of the (oppressive) regime who may have been offered preferential treatment in return for their loyalty. Other variables represent certain specific income-related family circumstances: absence of a father due to death or divorce; single-income families where mother was a homemaker.

Some of these variables show significant coefficients. In Table 4, death of a father had a detrimental effect throughout the period, especially prior to 1953 (such boys being on average 1.2 cm shorter and 1.25 kg lighter – cols. iia. and iib.). Absence of a father through divorce became important after 1953 (the effect being – 1.25 cm and – 1.4 kg). A homemaking mother was less of a disadvantage although that, too, must have meant the family lived on a single income. Presumably, families with a homemaking mother were those who could afford it, and the mother could take better care of the child. The coefficients on occupational variables exhibit signs that are in line with expectations but generally are not very significant. For farmers, the economic implications of political oppression probably outweighed the advantage of direct access to food but farmers' sons do not suffer significantly, except in terms of weight in the post war period (pre-1953) when they were about 1.8 kg lighter on average then their counterparts

[57] Farmers were one of the most persecuted groups and output requisitioning was frequent. However, even cooperatives members were allowed to own small plots of land (up to 0.5 ha) which was usually reserved for non-marketable production (International Bank for Reconstruction and Development, 1991). Stevens (1985) notes that "much of the rural household's personal consumption, a supplement to its typical low wage income, originated there – and less than half of private-plot output was marketed" (p. 36 – 37)

from non-farming families. For boys with parents in non-farming food-related industries, the effects are slightly negative but close to zero and mostly insignificant. Sons of policemen and military personnel, too, did not seem to be consistently advantaged over others, although the coefficients show positive signs and height has a significantly positive coefficient in the pre-1953 period.

Apart from these family-specific circumstances, let us consider nutritional insults connected with substandard food supply due to systematic deficiencies throughout the whole economy. Czechoslovakia became fully integrated into the Eastern bloc of Soviet satellites in 1948 but the Communist party had a firm grip on power beginning with the last free elections in 1946. Soon after their rise to power, they began implementing their policies of nationalization and collectivization. Some of these policies affected negatively the food supply (Myant, 1989). Meat consumption fell between 1950 and 1953, while milk consumption fell throughout the period and fruit consumption fluctuated excessively. Figures 2a and 2b depict the consumption of the basic staples of the diet, with 1948 as the base year (Statistical Yearbook of Czechoslovakia, 1975, p. 36).[58] While there is a consistent increase in meat consumption, other foodstuffs, such as fruits and – to a lesser degree – vegetables showed a negative trend and considerable volatility during the period.

Sik (1972) argues that as late as 1963, the average Czechoslovak citizen ate about 5 kg less meat annually than his West German, and 6 kg less than his Austrian, counterpart. On the other hand, Czechoslovak per capita wheat consumption was 102 kg, compared to 75 kg in Germany. Throughout the period considered only meat and egg consumption increased meaningfully

[58] Year 1948 is selected as the base year because it marks the beginning of Communist rule and central planning. Stevens (1985) makes an interesting point in contrasting official Czechoslovak output figures with alternative calculations by Western researchers. He shows that while industrial production was usually grossly inflated (p. 21 - 23), agricultural data were much more realistic (p. 33 – 35). Figures 2a and 2b are based on aggregate data divided by population.

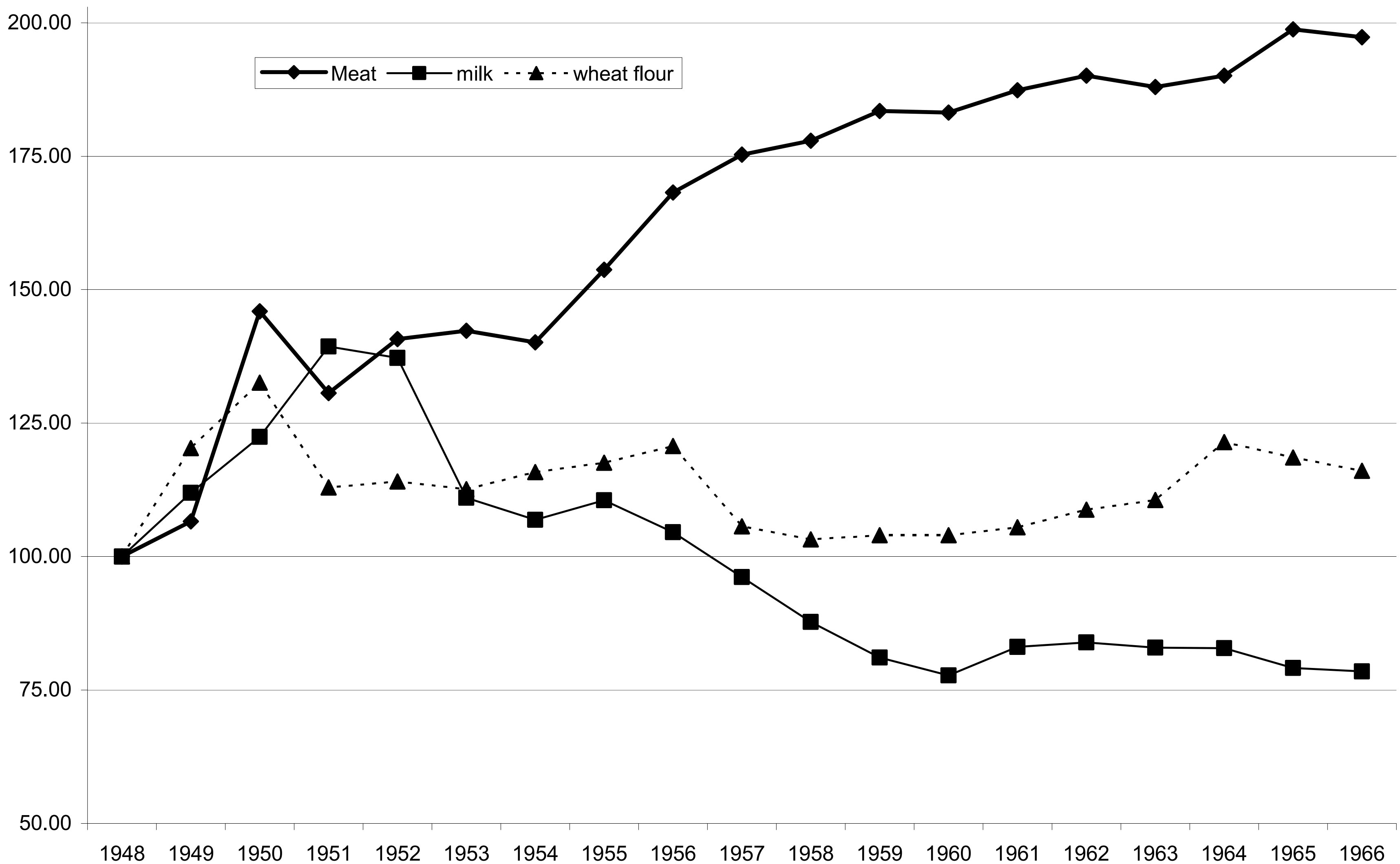

Figure 2a - Index of per capita consumption of selected foodstuffs, 1948 = 100

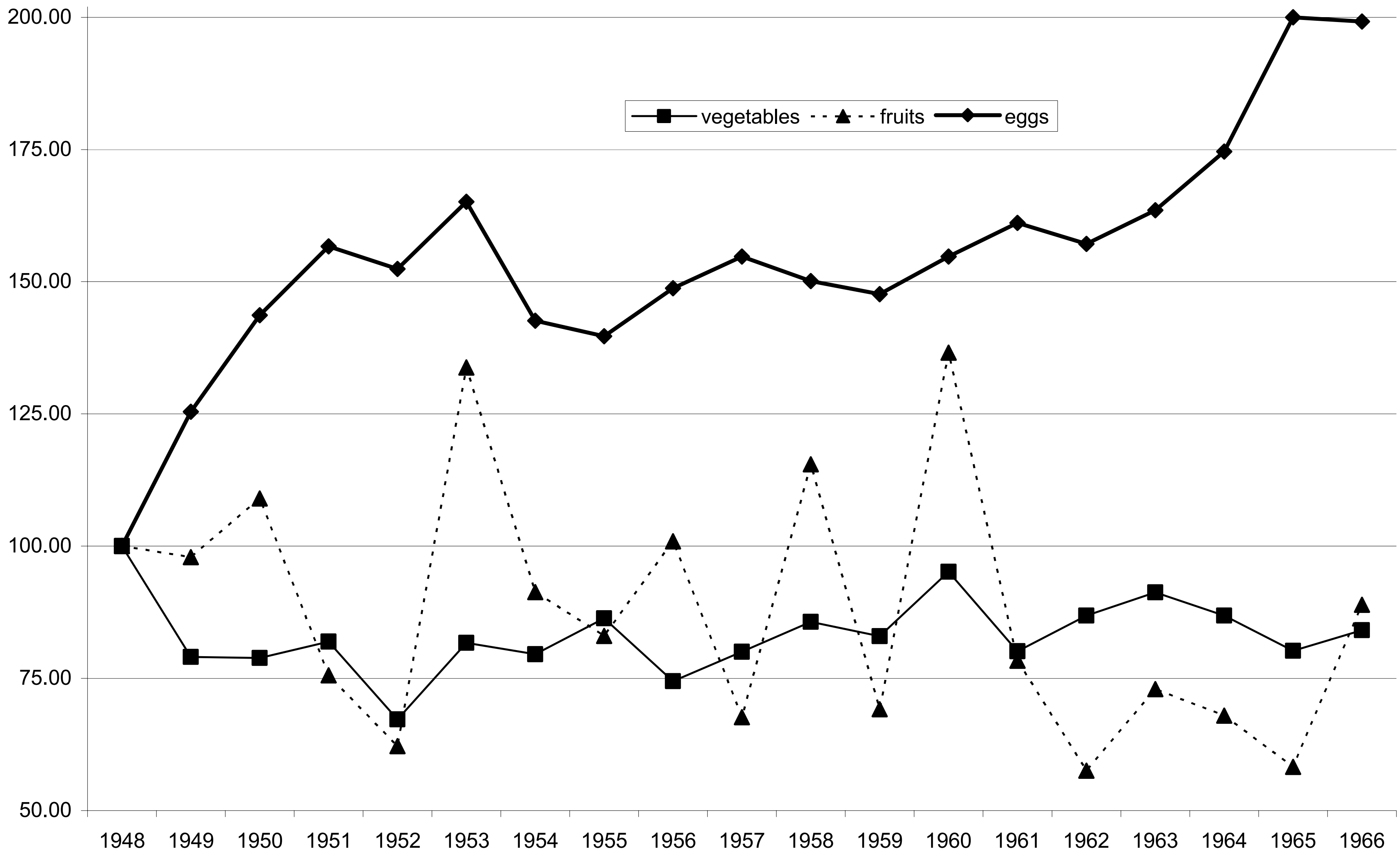

Figure 2b - Index of per capita consumption of selected foodstuffs, 1948 = 100

while the intake of milk, wheat, flour, fruits and vegetables tended to remain unchanged. There was also considerable fluctuation in supply. This was a reflection of two aspects: the instability of agriculture and the deterioration of the supply chain – the wholesale and retail network.

Between 1946 and 1966, agriculture repeatedly fell short of the production goals set by the central planners (Stevens, 1985). Collectivization met with fierce resistance and was a source of production disruptions well into late 1950's. Post-war Czech agriculture also wrestled with a large labor shortage, most acute during harvest time.[59] Hence, harvests were late on collective farms. Yet, Czechoslovakia was unable to resort to agricultural imports as trading links were dictated by political considerations from Moscow (Myant, 1989).

The food produced domestically was distributed inefficiently. An unencumbered retail market existed alongside a system of rationing, a holdover from of the war years.[60] This dual arrangement provided ample opportunity for corruption. The government fought back with a policy of extensive nationalization. Rationing was eventually eliminated by the currency reform of 1953. Over the weekend of 30th – 31st May 1953, rations were abolished; prices scaled down at a ratio of 1:5 but all currency holdings were scaled down at progressively higher ratios. Overall, prices rose relative to incomes forcing families to severely reduce their demand of virtually all retail goods (Stevens, 1985; Myant, 1989).

Urban dwellers had to resort to alternative channels of supply. Industrial workers could gain preferential treatment in access to supplies by working hard and exceeding their assigned

[59] The forced removal of the German minority, some 3 million strong, from the Czechoslovak borderland after the war had an immense impact on local labor supply. Agricultural employment fell from 3.3 million in 1937 to 2.2 in 1949, a decline of 36%. Tables 2-1 and 2-8 in Stevens (1985) imply that the removal of the German population did not affect the sectoral composition of output. The shares of employment in the German minority thus likely reflected the shares in the whole population. Since the German population accounted for about 20% of the country's overall population, it seems that about half of the 1.1 million decrease in agricultural employment was due to the German exodus.

[60] The retail market was unencumbered in the sense that retail prices were not yet set centrally. Ownership of outlets was occasionally private at first but complete nationalization came quickly after 1953.

production quota. Many helped with the harvest, and took part of the harvest home with them (Myant, 1989). In short, the government policies introduced disruption into agriculture and the supply networks which impacted the availability of food.

These policies had measurable effects. The variable ‘reform’ which captures the idiosyncratic effects of June 1953, when the currency reform had its most immediate impact, over and above the seasonal June effect is negative and significant for both height and weight even if the coefficients are small absolutely.

Periodic disruption of food supplies could be a possible explanation for the pattern in height and weight, namely the below-trend readings among adolescents in June. With most of the harvest being carried out in the summer, children’s weight and weight-for-height measures were relatively high for the September measurements. The supply problems were not too great throughout the autumn as there was a fresh stock of recently harvested foodstuffs. However, by spring, the supplies were slowly depleted which affected the welfare of school children. The unhealthy cycle is absent in the youngest cohort (11 years) since prior to the adolescent growth spurt, the body is not so sensitive to nutritional insults.

Table 4 indicates that the cycle is present more strongly in the post-1953 period: June effects are stronger and frequently significant in columns iiia. and iiib. At the same time, Figure 3 shows that in the post-1953 period, the boys were taller on average at each age. It plots the imputed growth trend in height as implied by the pre-1953 and post-1953 regressions in Table 4. The two trend curves clearly diverge throughout most of the age range with the pre-1953 trend being lower – at certain ages by more than 2 cm.

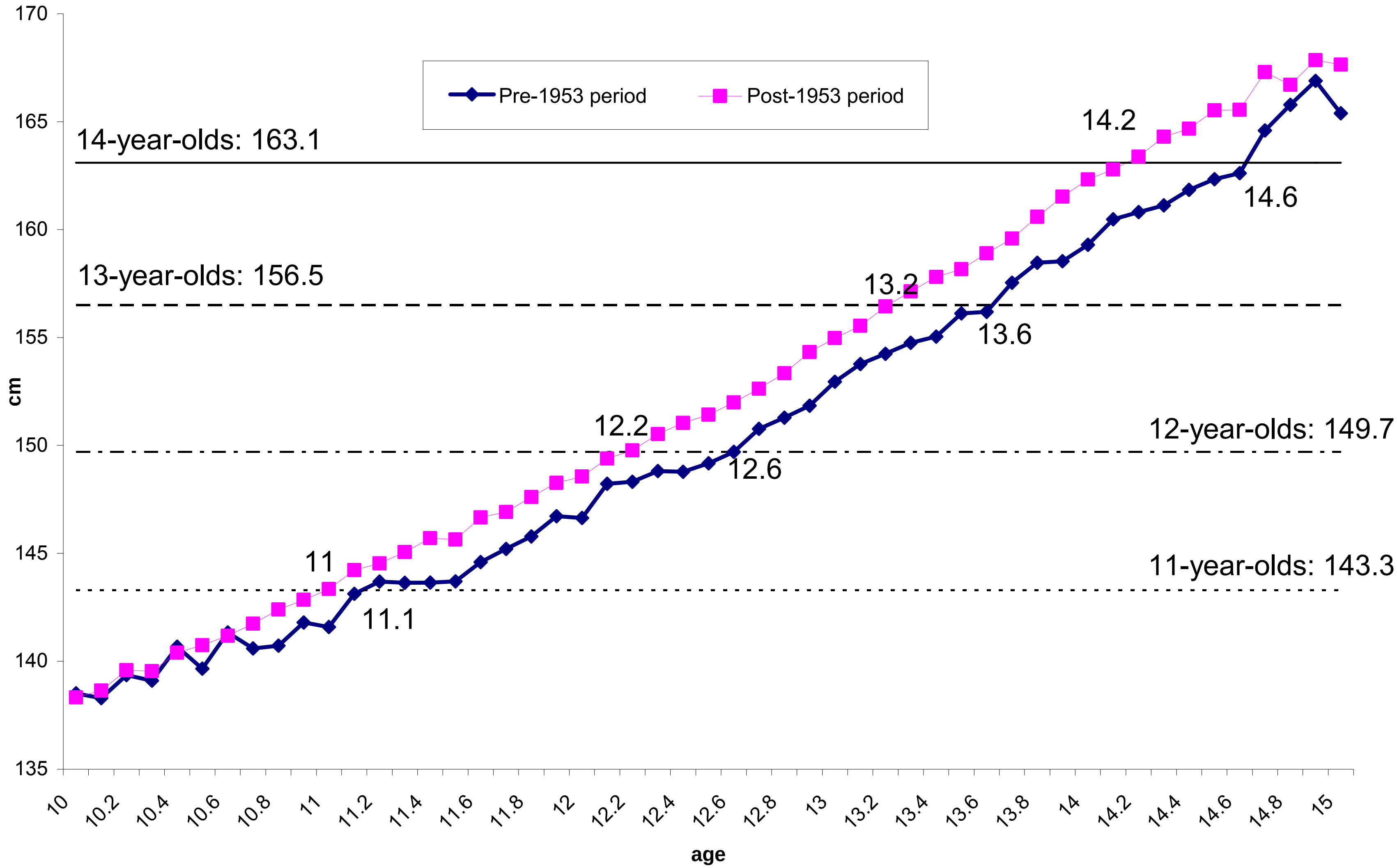

Figure 3 - Growth trends in height and 50th percentile of standard growth

Considered together, the evidence points to a substandard food supply throughout the year in the immediate post-war period (before 1953), which then gradually improved, but still fell short of providing adequate nutrition all year long. The immediate, postwar situation, being bad all year round, led to the relatively low pre-1953 heights of Figure 3. In later years, however, agriculture was able to provide sufficient supplies for at least a part of the year. Given the strong recuperative powers of human body during adolescence, it seems that the boys could catch up, during the plentiful months, on whatever growth deficit they acquired during the deficient months – which is why, in Figure 3, the overall trend line shifts up after 1953 but also why we see a strong negative June effect in Table 4. The two pieces of evidence are basically two different manifestations of the same effect: the mid-summer, post-harvest catch-up. Thus, the gradual, yet uneven improvement in food supply is a straightforward (if hypothetical) explanation of why, prior to 1953, the boys were relatively short but the annual cycle was absent while post 1953, the average height shot up but the annual cycle was relatively prominent.

By way of international comparison, in Figure 3, the 50th height percentiles of western standard (Steckel, 1996) are depicted for each age as the horizontal lines.[61] It is clear that the Liberec boys were behind their modern western counterparts (by about 0.6 years before 1953 and by about 0.2 years in the post-1953 period) but at the same time it is obvious that they were catching up.

6. Conclusion

The anthropometric evidence shows that the Liberec schoolboys exhibited an unusual cycle of growth, with a flat growth over the spring but fast catch-up growth over the summer.

[61] The western standards used here, taken from Steckel (1996), are based on studies of the National Center for Health Statistics which were conducted, for the age group relevant here, in year 1966 – 1970 and 1971 – 1974. They pertain to males at their nearest birthday.

For example, the regression results imply that an average boy who turned 13 in early September would be about 152.7 cm tall. By early February following year, he would grow another 2.3 cm. By late June, another five months, he would grow another 2.4 cm, making the two seasons almost indistinguishable in terms of growth velocity. But then by early September he would grow about 2.5 cm in a span of mere two months, reaching 159.9 cm on his 14th birthday. Similarly, a fall/winter weight gain which is characteristic for a healthy annual cycle seems to be smaller than the significant weight gain is observed in the summer, in spite of the fact that vacation is a period of time when adolescent boys are physically more active. To continue with the example of an average 13-year old boy, he would weigh 43.3 kg on his 13th birthday in September. Then he would gain 2.1 kg by February and another 1 kg from February to June. From late June to early September, however, there would be a weight gain of 2.7 kg to a total of 49.1 kg. The pattern is prominent particularly after 1953 when the Communist government was already fully in charge of the economy, both in terms of planning and management.

If human growth reflects a person's diet and health, anthropometric data must contain at least some valuable information about certain aspects of welfare. Together, these facts point to a possible strain in nutrition in the spring months which was then made up during the summer months. Anthropometric observations presented in this paper have the advantage of being available throughout the period three times a year. Moreover, these data were not politically sensitive (unlike, for example, infant mortality) and since they were not aggregated at the national level, they would not have been manipulated for political purposes. In contrast, soon after the currency reform of 1953, prices were fixed as part of the central plan and thus lost all informational value, and month-to-month price data were not published.

This means that anthropometric evidence may well be the only extant indicator of welfare strain in Czechoslovakia under early communism. Indirect evidence in the form of petitions and letters to party leaders do exist, as Myant (1989) documents, although their relevance and numbers also declined as the regime continually reduced political freedoms. In sum, the cyclical pattern of height and weight of these Czech boys is not one expected in a healthy, well-nourished population and the inference is warranted that periodic food supply breakdowns were responsible for that pattern. The workers' state was evidently unable to provide a steady flow of nutrients to the workers' children.

Appendix B – Sample characteristics

The advantage of longitudinal data is that they offer some self-corroborative evidence on each measurement. For example, children should not shrink over summer vacation; similarly they are unlikely to grow by 10 centimeters over those same two months (Tanner, Whitehouse and Takaishi, 1965), so it is easy to spot the unreliable observations and delete them from the sample. As a rule, I have excluded all measurements which indicated any decline over the summer ($S_{JUNE} > S_{SEPT}$) but kept measurements indicating no growth over the two months ($S_{JUNE} = S_{SEPT}$), recognizing the possibility of what is called 'stair step' fashion of human growth. On the upper end, there were not many observations which required attention. I excluded all measurements indicating a vacation stature increase of more than 6 cm. I applied similar rules for height data within a school year, except that the tolerance on the upper end was higher (9 cm) since the time span between measurements was 5 months.

In this manner, I eliminated about 4.5% of observations, leaving a total of 29,315 height observations. The attrition rate was highest for the late 1940's, when the practice of school measurement was new, but it somewhat increased again in the late 1950's, since the incoming post-war baby boom meant that more measurements had to be taken and quality of measurement probably suffered. The February measurements proved most reliable in this respect while the school-year end-points (June and September) obviously had a higher probability of falling outside the set range: the teacher who measured the boys in September usually could not see the previous June measurement as it was recorded in a different class register. The opportunity for corroboration was smaller, the probability of error larger.

I rely on measurements taken between 1946 and 1966 because schools were fairly disciplined regarding collecting the data until the mid-1960's. After that, the practice was stopped and did not resume until the early 1970's with only one annual measurement in September.

Table B1 reports the distribution of height and weight by percentiles. Note, however, that these percentiles are calculated on the basis of observations pooled across all years. Yet they nonetheless present a familiar pattern of roughly symmetric normal distribution.

Table B1 - Summary of distribution of height and weight by ages

Percentile	1%	5%	10%	25%	50%	75%	90%	95%	99%	N
Age	Height									
10.5 >	123	127	129.5	133	137	141.5	145.5	149	153	2294
11	128	132	134	137.5	142	146	150	153	158	5450
12	131	135	138	142	146.5	151	156	158.5	164	6722
13	135	140	142	147	152	158	163	166	172	6534
14	140	145	148	153	159	165	170	173	178	5408
15	144	150.5	154	159	165	171	175.5	178	184	2626
>15.5	145	152	158	163	169	174	179	181	186.5	317
	Weight									
10.5>	23	26	27	29	32	36	40	43	50	2330
11	26	28.5	29.5	32	35	39	43	47.5	55	5665
12	27.5	30	31.5	34	38	42.5	48	52	60	7129
13	30	33	34.5	38	42	48	54	58	66.3	6962
14	32.5	36	38.4	42	48	54	60.5	65	73	5660
15	35.5	40	43	48	53	60	66	70	79	2719
>15.5	36.5	42	47	51	57	63	69	74	78.4	324

Note: Age is as of the nearest birthday.

Table B2 provides summary information about other variables that enter the regressions such as the distribution of measurements across months (February, June and September). They are roughly one third each. The year dummies show that the bulk of the sample was measured in the 1950's and early 1960's and that the late 1940's are not very heavily represented.

Table B2 - Descriptive statistics of variables entering regressions					
Variable	N	Mean	Std. Dev.	Min	Max
Age	30878	12.561	1.440	7.737	17.362
Homemaking mother	30878	0.201	0.401	0	1
Deceased father	30878	0.027	0.161	0	1
Parents separated	30878	0.008	0.086	0	1
Parent a farmer	30878	0.007	0.083	0	1
Parent in a food-process job	30878	0.020	0.141	0	1
Parent in armed forces, police	30878	0.028	0.165	0	1
February	30878	0.340	0.474	0	1
June	30878	0.308	0.462	0	1
Year 1946	30878	0.001	0.036	0	1
Year 1947	30878	0.002	0.038	0	1
Year 1948	30878	0.008	0.090	0	1
Year 1949	30878	0.014	0.117	0	1
Year 1950	30878	0.029	0.167	0	1
Year 1951	30878	0.050	0.219	0	1
Year 1952	30878	0.060	0.238	0	1
Year 1954	30878	0.051	0.221	0	1
Year 1955	30878	0.058	0.234	0	1
Year 1956	30878	0.062	0.240	0	1
Year 1957	30878	0.063	0.243	0	1
Year 1958	30878	0.070	0.256	0	1
Year 1959	30878	0.076	0.265	0	1
Year 1960	30878	0.083	0.275	0	1
Year 1961	30878	0.084	0.277	0	1
Year 1962	30878	0.095	0.294	0	1
Year 1963	30878	0.084	0.277	0	1
Year 1964	30878	0.044	0.206	0	1
Year 1965	30878	0.013	0.113	0	1
Year 1966	30878	0.003	0.051	0	1
Variables February and June denote observations taken in those months, their mean reading therefore represents the proportion of all observations, taken in that given month.					

Table B3 compares the average heights in this sample and the national average heights reported by the National Institute of Public Health (NIPH) (Vignerova and Blaha, 1998). The NIPH studies relied on a representative sample of the Czech population. These observations were conducted by professionals or by thoroughly instructed non-professionals. The NIPH surveys were conducted in decadal intervals beginning in 1951. The Liberec sample is similar to the national averages in the relevant years. It overestimates heights by no more than about 2 cm which is likely a result of the fact that Liberec is a city – the present sample does not include any rural population (Vignerova, Blaha, and Brabec, 2006). Since children in the countryside tended to be smaller than urban ones, the present sample which is slightly upwardly biased. The comparison for later years (after the 1960's), however, is less reliable since the number of observations in the Liberec sample decline.

Table B3 – Comparison of present sample with height statistics of National Institute of Public Health, Prague

Age		NIPH 1951	Sample Sep-51	Difference in average	NIPH 1961	Sample Sep-61	Difference in average	NIPH 1971	Sample Sep-73	Difference in average	NIPH 1981	Sample Sep-81	Difference in average
11	Mean	140.7	141.9	1.2	142.68	141.8	-0.88	143.65	145.2	1.55	144.99	144.5	-0.49
	S. D.	6.9	6.1		6.8	6.8		6.7	6.6		6.9	6	
	N	5863	139		2788	159		2989	60		2225	72	
12	Mean	144.7	145.8	1.1	147.7	148.3	0.6	148.39	150.4	2.01	150.5	149.9	-0.6
	S. D.	6.9	7.2		7.2	6.9		7.1	6.8		7.3	7.2	
	N	6894	143		3369	141		2357	33		2289	39	
13	Mean	150.1	151.8	1.7	154	153.5	-0.5	154.61	156.9	2.29	157.17	159.8	2.63
	S. D.	8	8.2		7.9	8		8.4	7.4		8.6	7.7	
	N	6769	143		4083	154		2461	28		2435	28	
14	Mean	156.7	157.9	1.2	160.4	161.3	0.9	161.59	162.3	0.71	164.6	166.3	1.7
	S. D.	8.9	9.5		8.7	8.6		9	10.2		8.8	6.5	
	N	6795	129		5242	201		2508	23		2243	21	
15	Mean	163	161.7	-1.3	167.2	165.8	-1.4	168.19	173	4.81	171.28	174	2.72
	S. D.	8.8	9.2		8.4	7.9		8.5	6.4		7.9	11.5	
	N	4641	36		5027	72		2338	4		2301	4	

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CHAPTER III

INEQUALITY AND LIVING STANDARDS UNDER COMMUNISM: ANTHROPOMETRIC EVIDENCE FROM CZECHOSLOVAKIA: 1946 - 1966

1. Introduction

Communism, both in its ideology and political practice, represented one of the most ambitious attempts to create a society living in abundance while maintaining radical equality. This political program stood in opposition to the record of modern industrial economies in which economic growth and rising living standards were accompanied by considerable inequality. This paper is a case study in which these radical ideals and policy goals are compared, by means of anthropometric evidence, with the actual effects of Communist policies on welfare and inequality in the Czechoslovak city of Liberec during the first two decades of Communist rule. Anthropometric characteristics of populations, such as first and second moments of height and weight, have the advantage of conveying information both about the overall standard of living of a given population and about the level of inequality in a community. That makes them ideally suited to address such questions.

It would seem much easier, rather than analyzing height and weight, to simply look up the relevant data in the available sources of reference that any modern government usually publishes. Yet, standard economic indicators need not be entirely reliable as measures of overall welfare, as Costa and Steckel (1997) have shown. The human body responds not only to, say, the amount of nutrition but also to its quality, to the quality of environment and other factors. Height and weight provide a more holistic picture than GNP per capita or real wage and even a fast economic growth need not prevent their sizeable decline, if production increase is accompanied by a deteriorating environment.

Moreover, there are reasonable doubts about the quality of official statistics from the former Soviet bloc. Brainerd (2006), for example, states that incentives for misreporting, differences in methodology and selective publishing all created fundamental problems in evaluating statistics from the Soviet Union. Czechoslovak data present a similar problem because the local political regime, in close resemblance to the Soviet one, reproduced the incentives for misreporting and selective reporting.[62] The height and weight data in this paper should not be subject to these perverse incentives: they were never intended for public consumption, little value was placed on them outside of the schools where they were collected and no particular incentives existed for their manipulation.

The overarching theme here is the comparison between the story implicit in the published official statistics and that painted by the "unofficial" information such as the anthropometric evidence. Following a review of the available literature in the next section, section III then describes the economic development using official sources. More information on the sample is presented in section IV and the results of the statistical analysis of height sand weight are summarized in section V. The conclusions from the confrontation appear in section VI.

2. Personal wealth, inequality and anthropometric evidence

Anthropometric evidence has been used to address similar questions in many influential publications (Tanner, 1962; Bassino, 2006; Steckel, 1995). They usually rely on the non-linear relationship between height (weight) and income. While extraordinary poverty can and does lead

[62] A typical example of secrecy in reporting is military financing. Kaplan and Kosatik (2004) describe how military matters were rarely discussed at cabinet meetings (p.145). If any data pertaining to the military were published, they were aggregate and usually incomplete (p. 149).

to privation, loss of weight and subsequent stunting, extraordinary wealth does not inevitably lead to obesity or even gigantism in stature. Wealth generates a certain advantage in stature but it tends to be small in population where general living standards provide adequate resources for healthy physical growth. For height and weight, there are diminishing returns to income. Steckel (1983) argues that this relationship is robust enough to carry over to aggregate statistics, i.e. to comparisons between average height in a population and average standard of living as measured, for example, by GDP per capita but he also cautions that anthropometric averages should not be used to estimate economic statistics.

Czech children have been measured and re-measured for over two centuries now. Data for the earliest periods come from Komlos (1986, 1989) and Matiegka (1927). Moreover, during the period under consideration, extensive measurements were administered on an aggregate official basis by the National Institute of Public Health (NIPH) in Prague with the aim of monitoring health status of children and youth (Vignerova et al, 2006). Starting in 1951, close to 100.000 boys and girls aged 2.5 – 18 years were measured every decade until 2001. The conclusion from these studies is one of consistently increasing average height over the last half a century. By 1980's, Eveleth and Tanner (1990) considered Czech boys to be slightly taller than European average.[63]

The present sample size is much smaller in terms of individuals included but it provides important information on the family background of the measured children. Actual parental earnings are not available which makes the occupational information the next best available alternative. However, in a command economy, where personal welfare may be heavily influenced by factors other than earning power (e.g. by political connections, preferential

[63] See Appendix B for an analysis of the similarities and differences between the NIPH sample and the present high-school sample.

treatment for certain groups of population), it is likely that earnings will not tell the whole story even if they were available. The regression analysis investigates the functional relationship between the children's anthropometric characteristics and their parents' occupation.

3. Living standards under early Communism – Official statistics

The Communist government of Czechoslovakia published official data on many aspects of the country's life in the annual statistical yearbook (Statisticka rocenka CSR). The construction and compilation of certain economic statistics reflected the prevailing Marxist economic theory but most indicators, especially those measuring gross production (e.g. tons of steel produced), were similar in their construction to those in western statistical summaries.[64] What was the economic situation as presented in the official sources that were available to the general public?

Throughout the two post-war decades, economic policies of the Communist government had a profound impact on living standards. Nationalization, central planning and immense investment in heavy industry (particularly arms industry) led to a doubling of industrial production between 1948 and 1954 (Statisticka rocenka CSR, 1966: 28). Production and supply of consumer goods suffered, however, and by 1953, negative effects on living standards were evident (Myant, 1989: 27). In agriculture, collectivization met with fierce resistance leading to disruptions in food supply (Stevens, 1985). Faced with these problems, and in line with Khrushchev's push to de-emphasize military spending, the government redirected more resources to consumer durables and allowed a limited scope of autonomous decision-making in the lower tiers of the party hierarchy. Growth picked up again in the late 1950's. Inefficiencies

[64] For example, according to Marxist theory, certain sectors (industry, construction, agriculture) were considered productive while most services were viewed as "non-productive" sectors.

inherent in central planning persisted, however, and corruption reached new highs in early 1960's (Kaplan and Kosatik, 2004). The production targets of the 1961 – 1965 five-year plan had to be scaled down as the economy suffered a recession which lasted until 1964 (Kaplan and Kosatik, 2004: 282). Further reforms had to be introduced before some growth returned.

The official sources reflect in basic contours these swings in economic fortunes. In the long-run, they document an overall upward trend in most crucial indicators. National income per capita grew in most years, declining only in 1963 (see Figure 1). Real wages display a similar pattern of general growth with pauses in 1953 and early 1960's. The overall increase in real wage was over 60% from 1948 to 1966 which implies an average annual growth rate of 2.7%. Personal consumption per capita tells a similar story. Note that these official statistics indicate that the economic problems of early 1960's did not affect living standards as measured by consumption even while the purchasing power (real wages) and supply of goods (national income) both dipped.

In sum, one cannot miss the underlying upward trend in most important areas of welfare. High rates of long-run growth are only briefly interrupted by mild, temporary declines which are quickly reversed. Although some food supply problems tarnish an otherwise impressive picture of steady improvement, it is clear that, with per capita national income nearly tripling, personal consumption more than doubling and real wages almost doubling between 1948 and 1966, the official statistics describe a clear and strong movement towards ever higher living standards.

Much less official information is available on inequality. The statistical yearbooks say little about the earning power of individual occupations and carry no aggregate statistics measuring inequality (e.g. Gini coefficient). The most widely used decomposition was into

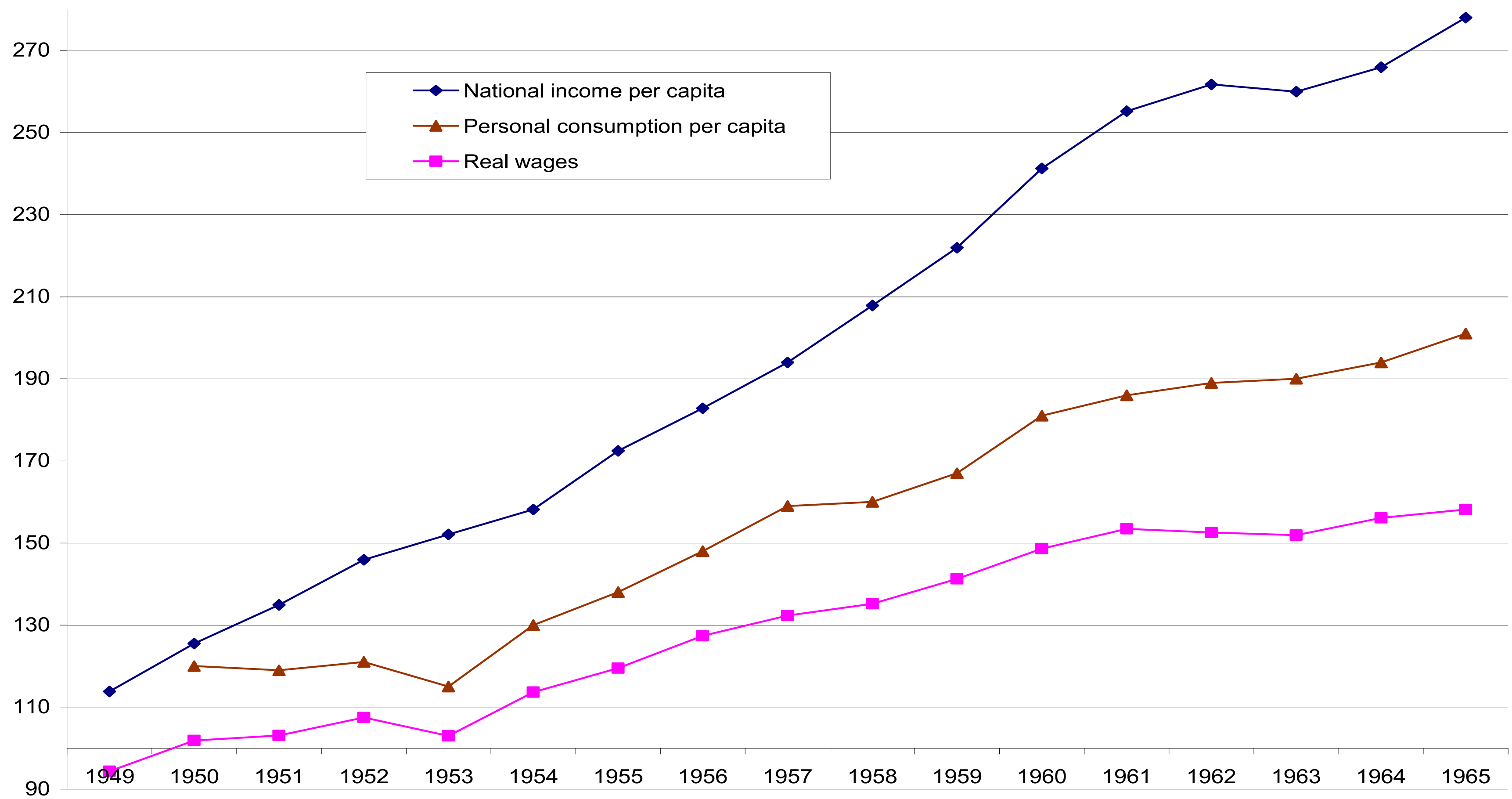

Figure 1 - Indices of economic condition (1948=100)

Note: The series are in constant prices. Per capita variables (national income and personal consumption) have been calculated by dividing aggregate values by total population.
Source: Statistical Yearbook of Czechoslovakia, 1966, pp. 22 – 25

broadly defined occupational categories of workers, technical staff and clerks. Workers employed in agriculture also had a separate category (but no data seem to be available).

In terms of sectoral inequalities, Figure 2 illustrates the point, made earlier, about the Marxist distinction between productive and non-productive sectors. The average monthly wages in construction, industry and transportation were by a quarter to a third higher than the wages in other sectors. The underlying logic was that those sectors that actually produce (or aid in production of) value in terms of physical goods should obviously remunerate their workers better. Agriculture was exempted from this thinking, largely for political reasons. It was a clear pariah throughout the 1950's although by mid-1960's, the situation improved radically.

Within sectors, too, there were differences in earnings. Figure 3 casts some light on the level of inequality in industry. The average monthly nominal wage for each of the aforementioned job categories is represented by the bars; the values are reported along the left-hand axis. In the long-run, wages grew in all occupations. Moreover, workers did not suffer any significant wage decrease during the recession of 1962-64, while the technical staff did. Clerks also saw a slight decline but it was milder than that for the engineers.

A crude measure of wage inequality is represented by the curve in Figure 3. It is calculated as the span between the highest and lowest average wage in the sector divided by the average worker wage.[65] It shows that inequality increased during times of overall growth and declined during periods of relative economic hardships. This corresponds with the earlier observation that workers' wages seem to be inert to economic downturns.

Figure 4 depicts a similar situation in the construction sector. The additional interesting observation is that here the clerical wages started out above the workers' wages but by 1953 their

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[65] Given the actual numbers, it can be mathematically expressed as $\frac{w_{engineers} - w_{clerks}}{w_{workers}}$.

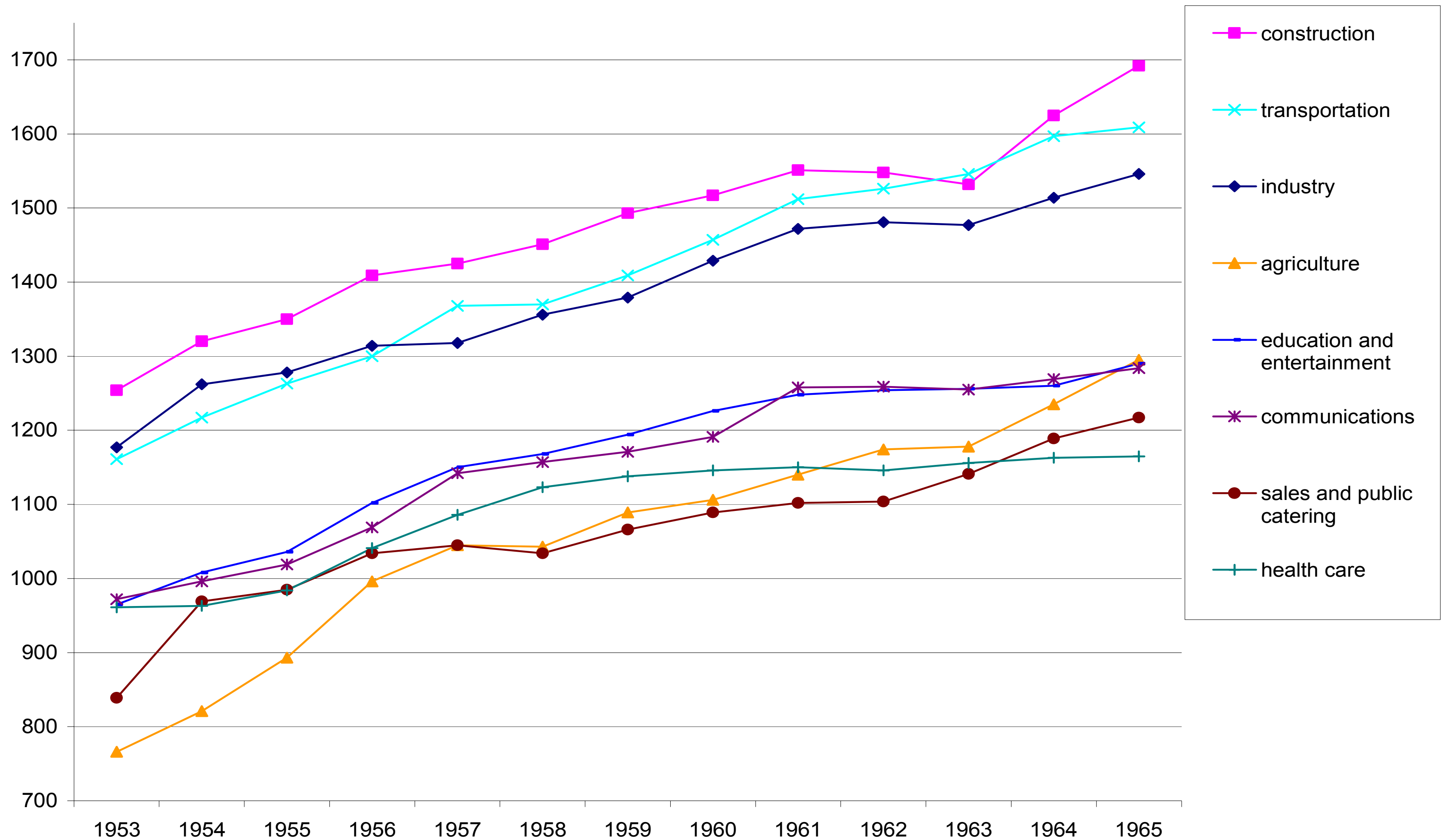

Figure 2 - Monthly wage by sector (CSK, current prices)

Note: Cited data are in current prices but this in an environment where prices were fixed by central planners.
Source: Statistical Yearbook of Czechoslovakia, 1966, pp.22 - 23

Figure 3 - Average monthly wages in industry by type of occupation (CSK, current prices)

Note: Cited data are in current prices but this in an environment where prices were fixed by central planners. Span/Workers' wage is equal to the difference between the highest cited average wage and lowest cited average wage, divided by the workers' wage.
Source: Statistical Yearbook of Czechoslovakia, 1966, pp.28 - 29

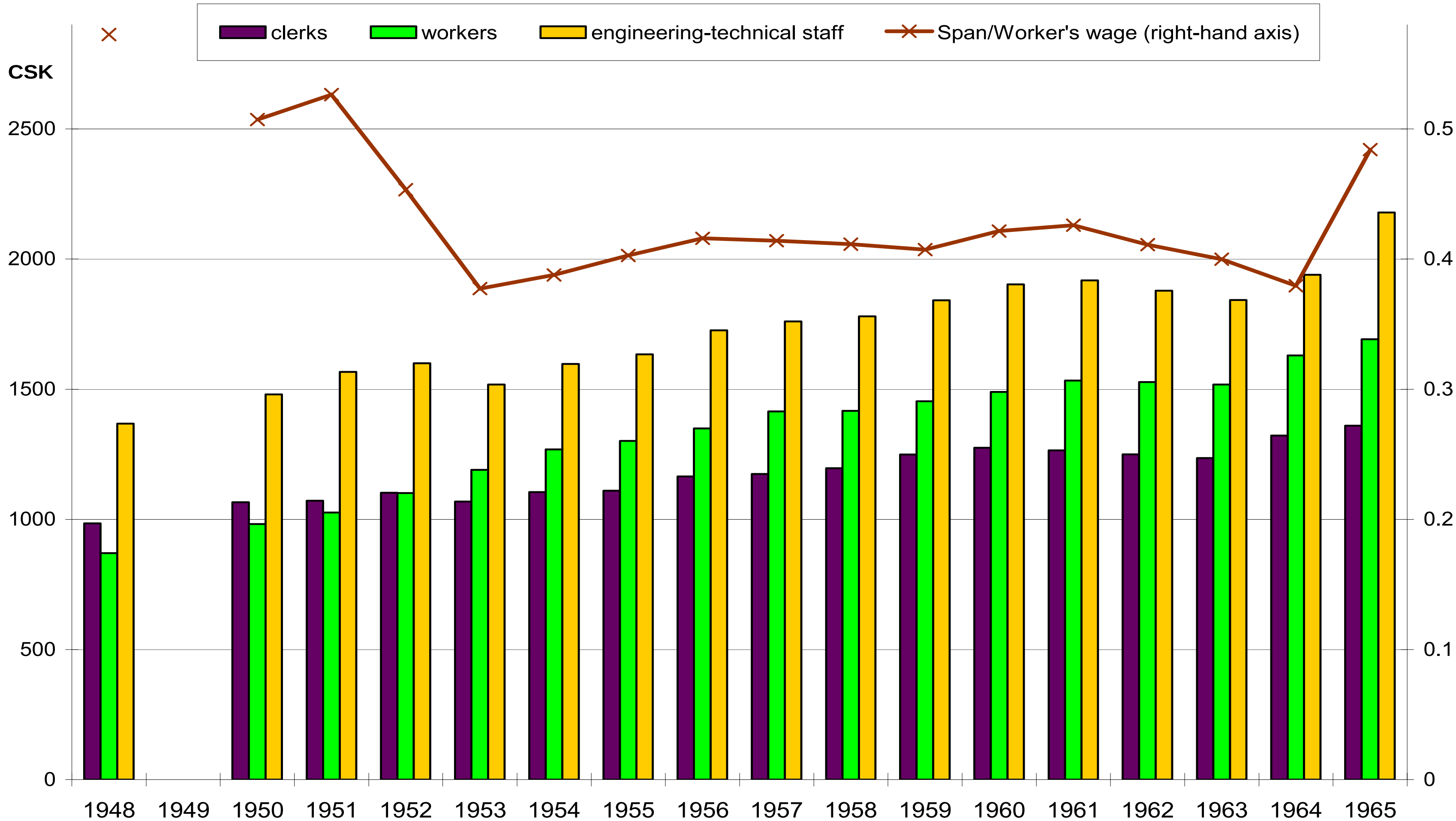

Figure 4 - Average monthly wages in construction by type of occupation (CSK, current prices)

Note: Cited data are in current prices but this in an environment where prices were fixed by central planners. Span/Workers' wage is equal to the difference between the highest cited average wage and lowest cited average wage, divided by the workers' wage.
Source: Statistical Yearbook of Czechoslovakia, 1966, pp.32 - 33

relative position was reversed. The strong growth of worker's wages is the main factor behind the steep fall of the measure of inequality between 1948 and 1953. It is possible that something similar occurred in industry during those years but relevant numbers for the 1948 – 1953 period are unavailable.

The data on wage inequality should be treated with caution, however. As Table 1 documents, these numbers were subject to revision in later statistical yearbooks. While revisions are routine in official statistics in most countries, the direction of change in all of these cases is one leading to an improvement in the relative position of workers vis-à-vis other kind of employees and of industrial workers in particular. Figures 3 and 4 rely on the revised, 1966 numbers but if the earlier, 1957 numbers were used, the measure of inequality would be higher by about 5%.

The Communist party prided itself on being a party of equality, a party that defends primarily the workers' interest. These ideals comprised a great part of its political rhetoric. According to official records, workers' living standards were mostly immune to the ups and downs of the national economy and their relative living standards were improving. This means either that the party was broadly successful in its main goals or that, no matter the reality, the numbers were sometimes "adjusted" to suit the propaganda. In the following sections, the anthropometric evidence will be brought in to confront the official statistics.

Table 1 - Wages by occupation: original and revised figures												
		Industry				Construction						
CSK, current prices	*edition*	1953	1954	1955	1956	1950	1951	1952	1953	1954	1955	1956
Workers	*1957*	1138	1235	1252	1285	998	1043	1119	1210	1290	1325	1372
Engineering-technical staff	*1957*	1522	1591	1637	1694	1518	1600	1638	1551	1633	1668	1766
Clerks	*1957*	1046	1093	1109	1133	1115	1126	1159	1120	1155	1159	1196
Workers	*1966*	1155	1255	1272	1305	982	1026	1101	1190	1269	1301	1349
Engineering-technical staff	*1966*	1481	1549	1594	1648	1480	1566	1600	1518	1597	1634	1726
Clerks	*1966*	1020	1065	1082	1105	1066	1071	1102	1069	1105	1110	1165
% size of revision (1957 - 1966)												
Workers		1.5%	1.6%	1.6%	1.6%	-1.6%	-1.6%	-1.6%	-1.7%	-1.6%	-1.8%	-1.7%
Engineering-technical staff		-2.7%	-2.6%	-2.6%	-2.7%	-2.5%	-2.1%	-2.3%	-2.1%	-2.2%	-2.0%	-2.3%
Clerks		-2.5%	-2.6%	-2.4%	-2.5%	-4.4%	-4.9%	-4.9%	-4.6%	-4.3%	-4.2%	-2.6%
Source: Statistical Yearbook of Czechoslovakia 1957, p.90; 1966, pp. 28-29												

4. Sources of anthropometric evidence

The height and weight data employed in this paper come from the school records of the Czechoslovak city of Liberec (North Bohemia). Between 1946 and 1966, local schools measured their pupils up to three times a year (in early September, in early February and in late June) and recorded the anthropometric information in school registers together with other information on pupils. Each pupil had one page in a register which noted not only the pupil's name, date and place of birth, grades, height and weight but also the pupil's parents' occupations. This information allows us to analyze the children's height and weight as functions of socioeconomic characteristics of their families' background. The children were measured every year they went to school. Therefore, most of the 4,673 individuals included appear in the sample more than once.

The sample consists of boys because their growth is more sensitive to environmental insults than growth of girls (Tanner, 1962; Garn and Rohman, 1966) and their anthropometric variables are therefore better suited to serve as a gauge of the changes in the overall living standard. The focus is on adolescent boys, specifically ages 10 to 14, when the male body undergoes the adolescent growth spurt and is therefore doubly sensitive to the environment. If the body is strained during these important years, the spurt may be delayed or may result in a much smaller gain in stature than would result from healthy conditions.

Parental occupation was recorded only once each school year – presumably in September when school started and school registers for each class were created. For that reason, September measurements are most likely to provide the anthropometric information for which the recorded occupational data are most current. They will be used in the subsequent analysis. With pupils who joined a class half-way through the school year, the parental occupation was recorded at the time of their joining the class (so such records would not be current as of September of each year) but since such pupils missed the September measurements, they are not included in the analysis. The height and weight measurements were carried out by the teachers themselves. They were not professional auxologists, so certain level of measurement error can be expected but it should not be systematic.[66]

Two problems arise in how parental occupation was recorded. First, early on, the mothers' occupation was not generally recorded – probably under the assumption that they were mostly home makers. Even after 1951, when records for both parents become regular, the proportion of mothers who are reported as being "at home" is high, reaching almost 38% in 1952. By 1964, this proportion fell to under 10%. It is likely that many, perhaps most, of the mothers whose occupation was not recorded at all prior to, say, 1950 were also homemakers but for the regression analysis, such a sweeping assumption would perhaps be too bold and so these observations are not used in the calculations.

Second, in some cases, teachers recorded the nature of a parent's occupation but failed to note the sector of employment (e.g. 'bookkeeper'). In other cases, they recorded the sector or the name of employer but not the nature of work (e.g. 'Textilana' – the local textile plant). In yet other cases, they wrote down an ambiguous description (e.g. 'employee').

In short, the records show a great diversity of both occupations and sectors for both mothers and fathers. In dealing with this diversity of information, I adopted the occupational and sectoral coding of IPUMS (Ruggles et al, 2004). This is a detailed three-digit coding but given the size of the sample most occupations were ultimately grouped under relatively general headings. Table 2 reflects these broad occupational and sectoral categories and also shows how severe was the problem of misreporting for mother and for fathers: of 10,889 individual

[66] See Appendix B for further description of the nature of the sample.

Table 2 - Occupational and sectoral composition of the sample: number of observations

Fathers	**Occupation**						
Sector	Professionals	Officials	White collar workers	Blue collar workers	Single income family	Unknown	Total
Agriculture	15	8	19	117	0	8	167
Mining	10	2	10	86	0	5	113
Construction	9	13	45	464	0	14	545
Manufacturing	77	69	353	2,256	0	50	2,805
Transportation	37	80	185	826	0	150	1,278
Services	611	257	297	424	0	68	1,657
Public administration	38	120	636	316	0	124	1,234
Not working	0	0	0	0	566	0	566
Unknown	446	137	1,214	265	0	462	2,524
Total	1,243	686	2,759	4,754	566	881	10,889
Mothers	**Occupation**						
Sector	Professionals	Officials	White collar workers	Blue collar workers	Single income family	Unknown	Total
Agriculture	0	0	6	71	0	15	92
Mining	0	0	1	12	0	1	14
Construction	0	0	7	10	0	2	19
Manufacturing	25	8	170	2,524	0	69	2,796
Transportation	0	1	125	63	0	31	220
Services	588	128	531	286	0	107	1,640
Public administration	4	7	152	9	0	19	191
Not working	0	0	0	0	2,277	0	2,277
Unknown	59	16	1,440	617	0	1,508	3,640
Total	676	160	2,432	3,592	2,277	1,752	10,889

observations, about one quarter (2,524) provide no information about the sector of father's employment and over a third (3,640) gave no indication about the mother's sector. With occupational characteristics, the situation is somewhat better. Since the occupational information is more frequently recorded than the sectoral one and since it seems, judging by the available official statistics, that occupations were more important in determining one's living standards than sectors, I exclude from the regression analysis those observations where occupation information is missing but not those where only sectoral information is missing. Ultimately, this leaves 7,857 observations for the analysis of height and 8,552 for the analysis of weight to work with.[67]

5. Analysis of height, weight and parental occupations

The advantage of anthropometric evidence is that it is an unofficial and independent source of information on welfare. The school records were never used for any official purposes other than the most cursory monitoring of the health status of the children in the classroom. Moreover, human body responds to both qualitative and quantitative changes in the environment.

Average height and weight are shown in Figures 5 and 6 for those years and ages where at least 30 observations were available. These are the crudest indicators of the overall changes in welfare because they do not control for changes in the composition of parents' occupations.

Some broad results emerge, however. There is a clear robust increase in both average height and weight in the late 1940's, culminating around 1951/1952. Only the oldest cohort fails to share in this trend. Stagnation in height from 1953 to 1957 is then followed by mild growth for the rest of the decade while weight is mostly stable throughout the 1950s among the younger

[67] In a few cases, the parental occupations are recorded properly but the relevant anthropometric information is missing.

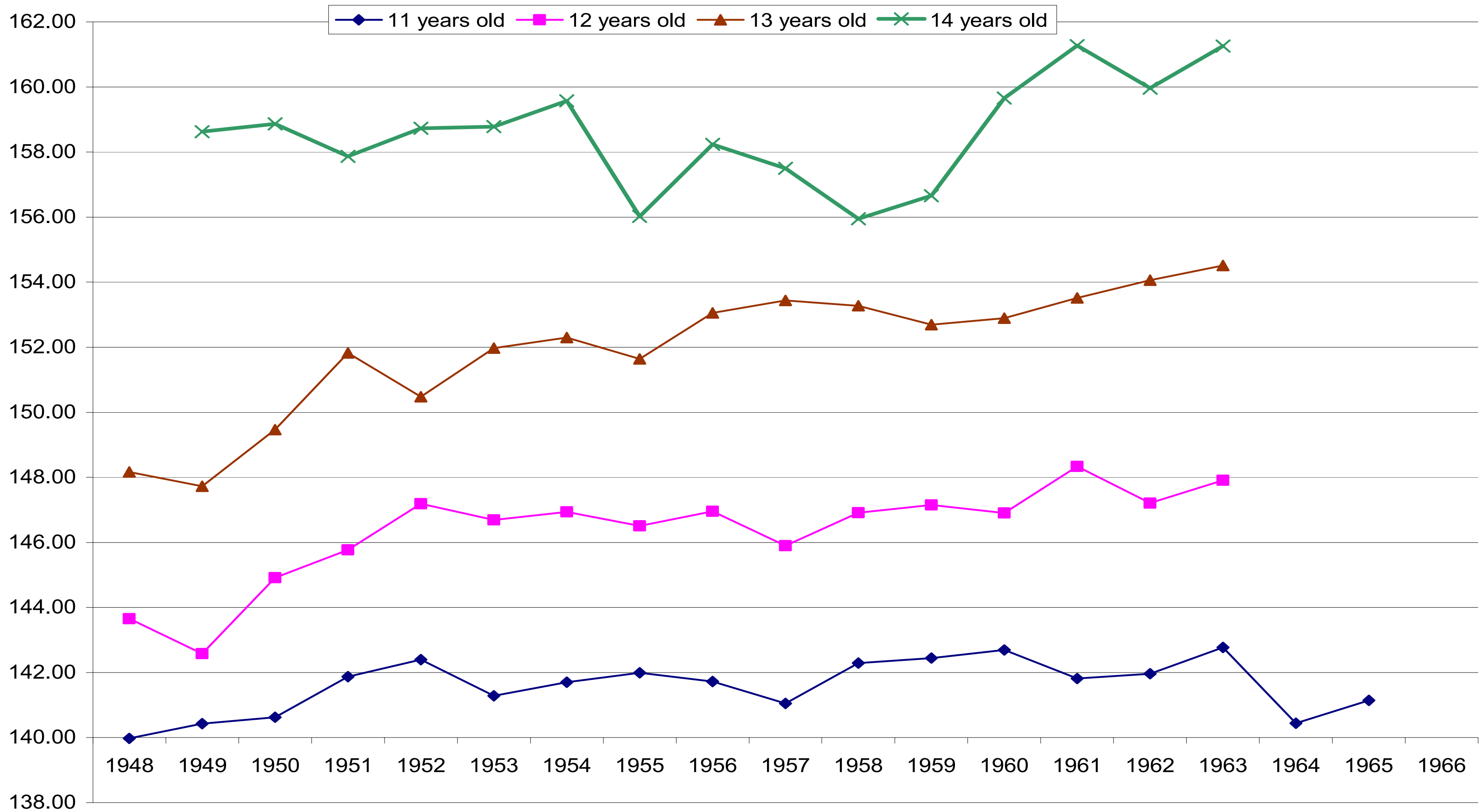

Figure 5 - Average height by age

Note: Averages are calculated from the sample data for those age-year cells where at least 30 observations were available. Age is at nearest birthday, so for example, 11-year-olds includes all boys aged 10.5 to 11.5 years as of the date of measurement.

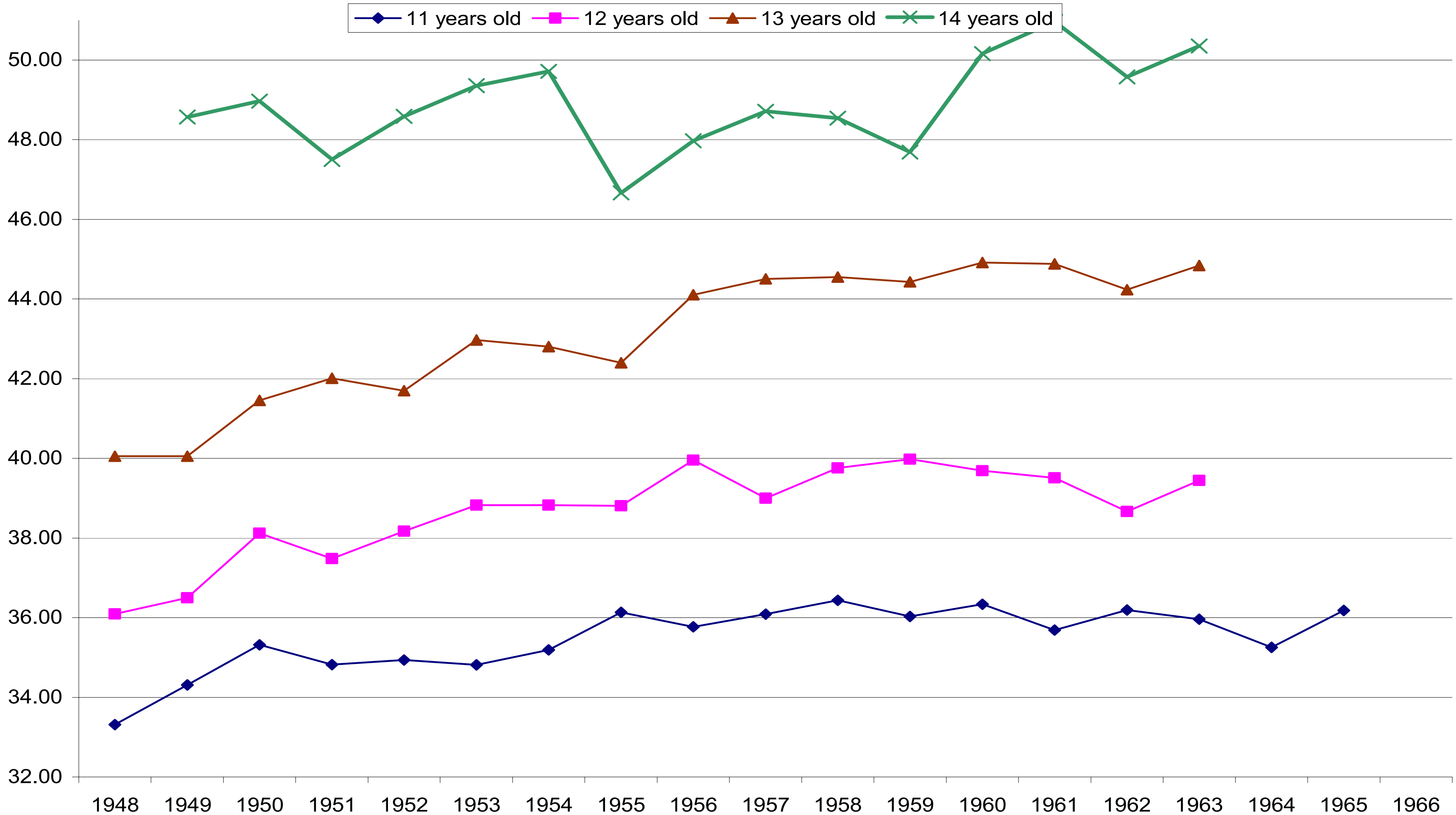

Figure 6 - Average weight by age

Note: Averages are calculated from the sample data for those age-year cells where at least 30 observations were available. Age is at nearest birthday, so for example, 11-year-olds includes all boys aged 10.5 to 11.5 years as of the date of measurement.

cohorts and fluctuates wildly among the older cohorts. It is doubtful that these developments provide a definitive corroboration for the strong show of growth, after 1953, in real wage and personal consumption as displayed in Figure 1. But it is undeniable that at the end of the 1950's the average height and weight (and so perhaps the living standards) were at least somewhat higher than they had been a decade earlier.[68] Thereafter, if we can judge by the experience of the 11-year olds, the recession of the early 1960's did leave a mark on the averages; the previous peak in growth may have even come as early as 1959/60.

To provide a more detailed analysis that makes use of the occupational information, I rely on regression. The data on parents' occupations enter in the form of dummy variables. One set of dummies describes the occupation categories, another is a set of sectoral dummies; yet another is a set of year dummies which control for the idiosyncratic effects of each year spanned by the sample. Age of the boys is also captured by a set of dummy variables. The logic behind this specification is that each of the sets captures a different aspect of the analysis: the year dummies capture the underlying trend in height and weight; the sectoral dummies capture differences between sectors and the occupational dummies similar differences between occupations. The age dummies control for age as a factor of growth (but they are not of primary interest here). The adolescent growth spurt is likely to introduce heteroscedasticity to the regressions, since variance in height or weight is likely to be higher during adolescent years. For that reason, I rely on the Huber-White covariance estimator in constructing the confidence intervals. At the same time, since some individuals appear more than once in the sample and the measurements of a person's

[68] The overall trends in published health data, such as infant mortality, seem to corroborate this mildly upward trend (Statisticka rocenka, 1966).

height or weight can be correlated across years, I allow for clustering on the level of the individual.[69]

The resulting coefficients for the year dummies are shown in Figure 7. Height and weight regressions tell the same story which is mostly consistent with what is known about the economic development of the country from the official data: strong post-war growth, a collapse in 1951-1953, then robust growth until 1960. What is particularly interesting is the visible downturn in the early 1960's which correspond nicely with the recession of those years. Recall that in Figure 1, the official claim was that personal consumption was virtually unaffected by the slump. The year fixed effects cast some doubt on that claim, however: the coefficients from the weight regression go from +1.66 for the 1961 dummy to -0.64 in 1964; the coefficients from the height regression move from +1.40 to -1.65. These numbers imply that, from peak to trough, the economic decline cost the boys 3.05 cm in (potential) stature and 2.3 kg in weight. If it was not for the slight rebound in 1963, one could argue that the recession already started in 1961 and lasted till 1965.

The relative size of the idiosyncratic effects of parental employment by sector and occupation are shown in Table 3. Both in terms of statistical significance and actual impact, fathers' job was clearly a stronger determinant of a child's stature and weight than the mother's job. In a society that had only began to fully integrate women in the workplace, this is not surprising. As with the year dummies, here, too, height and weight regressions provide similar results: being a farmer's or a co-op member's son was apparently detrimental to one's stature (a negative effect of 1.69 cm relative to sons of industrial fathers) and weight (-1.29 kg). Shorter and lighter students also came from families where father's income was missing from the family

[69] Given the number of variables employed, I do not cite the full regression report in the paper but the results are available upon request from the author.

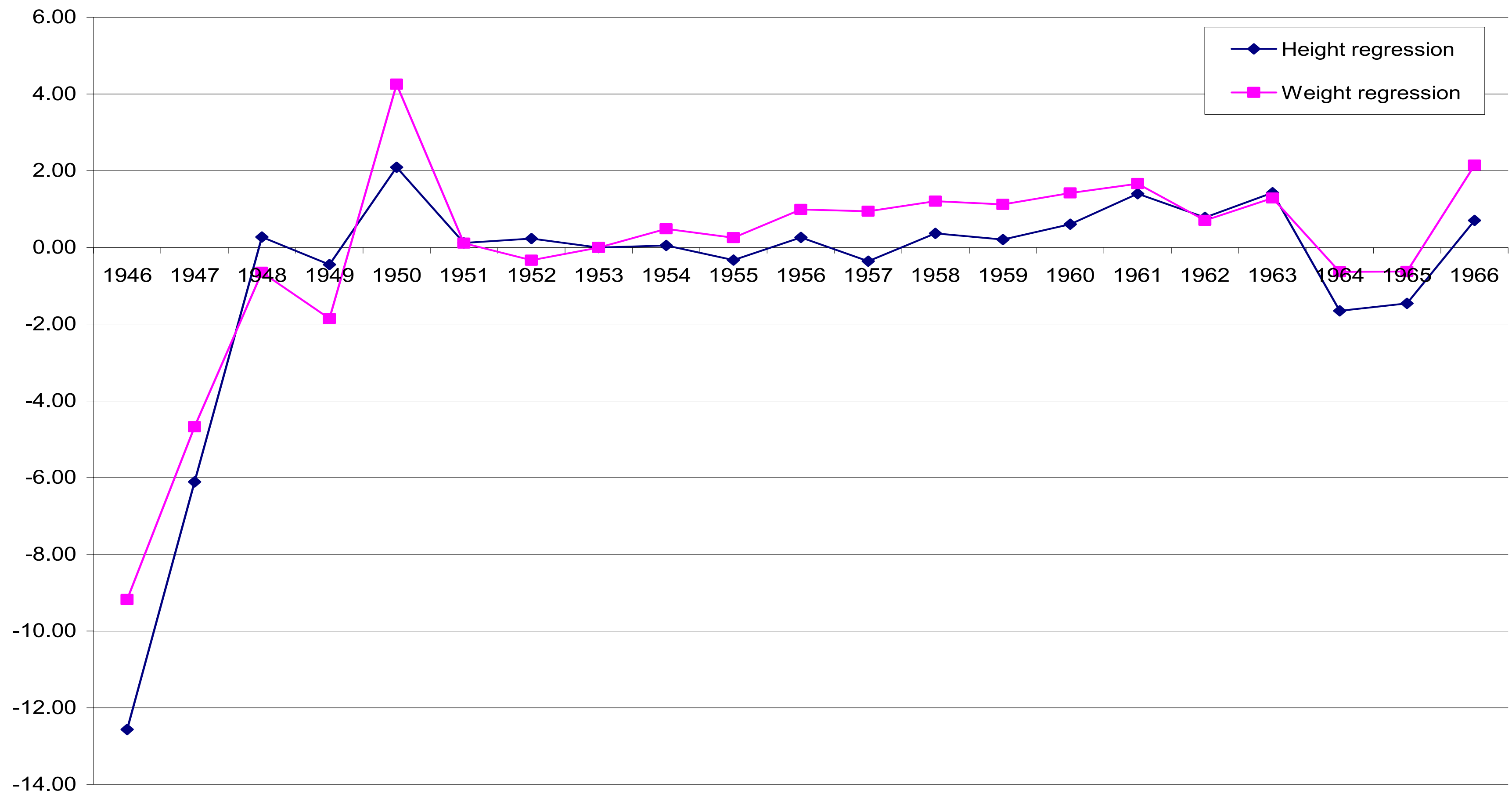

Figure 7 - Coefficients on year dummies

Note: Reported are coefficients on year dummies from regressing height and weight on occupation dummies, sectoral dummies and year dummies. The year dummy variables capture the idiosyncratic effects of each year on height and weight, measured in cm and kg, compared to the benchmark default year of 1953. Statistical significance is not shown.

Table 3 - Panel A: Coefficients on occupational dummies

Fathers				Mothers			
Height regression		Weight regression		Height regression		Weight regression	
Salesmen	2.08	Public safety	1.44	Clerical	0.87	Managerial	1.61
Army	2.07	Factory foremen	1.10	Managerial	0.75	Saleswomen	0.16
Clerical	**1.99**	Army	1.01	Operative	0.41	Operatives	0.07
Professional	**1.95**	Clerical	0.97	Professional	0.28	Factory forewomen	0.05
Official	**1.67**	Professional	0.84	Single income family	0.16	Industrial workers	0.00
Managerial	**1.61**	Salesmen	0.81	Industrial workers	0.00	Clerical	-0.03
Factory foremen	1.26	Official	0.73	Factory forewomen	-0.09	Professional	-0.08
Public safety	1.17	Managerial	0.55	Saleswomen	-0.21	Agricultural workers	-0.18
Operatives	0.53	Operatives	0.45	Public safety	-0.31	Single income family	-0.25
Service workers	0.24	Industrial workers	0.00	Service worker	-0.61	Officials	-0.36
Industrial workers	0.00	Service workers	-0.95	Official	-0.67	Public safety	-1.09
Single income family	**-1.38**	Single income family	-0.97	Agricultural worker	-1.20	Service workers	-1.35
Agricultural workers	-1.69	Agricultural workers	-1.29				
Panel B: Coefficients on sectoral dummies							
Manufacturing	0.00	Manufacturing	0.00	**Construction**	**6.88**	**Construction**	**4.75**
Construction	-0.67	Construction	-0.19	Mining	1.93	Mining	1.39
Mining	-0.68	Transportation	-0.33	Service sector	0.96	Sector unknown	1.08
Service sector	-0.81	Service sector	-0.43	Sector unknown	0.35	Service sector	0.97
Sector unknown	**-0.99**	Sector unknown	-0.60	Transportation	0.12	Manufacturing	0.00
Transportation	**-1.16**	Mining	-0.86	Manufacturing	0.00	Transportation	-0.23
Agriculture	-1.66	**Public administration**	**-1.39**	Public administration	-0.75	Public administration	-0.32
Public administration	**-1.75**	**Agriculture**	**-1.85**	Agriculture	-4.26	Agriculture	-3.62

Note: Coefficients significant at 5% are in bold; default category for each set of dummies is highlighted in red.

budget (‘single income family’). Note that, for a farmer’s son, the negative effect of agricultural occupation combined with the negative effect of employment in agriculture as a sector to produce an overall deficit of 3.35 cm and 3.14 kg vis-à-vis a son of an industrial worker employed in manufacturing (the reference category). This may seem surprising at first considering that farmers should have a relatively good and direct access to food supply but it is also true that as a social group, farmers belonged to the most persecuted and most expropriated.

On the other side, a positive effect on stature, anywhere from 1.61 to 1.99 cm, accrued to those whose fathers worked as managers, officials, professionals or clerks. The sector of employment mattered, however: a managerial position in manufacturing was apparently better rewarded than the same job transportation; a bank clerk seems to have lived better than a local government bureaucrat. The strong and persistent negative effect of public administration is somewhat puzzling since, in a centrally planned economy, bureaucrats were seen as having more than enough power to extract surplus from other sectors. However, this sector includes the post office employees and a large number of low-level local government clerks who may have been too far down the chain of command to be able to take advantage of their bureaucratic clout (if they had any).

The coefficients on sectoral dummies also indicate that manufacturing and construction were, in fact, favored somewhat. Father’s employment in manufacturing carries the best possible influence on both height and weight. In contrast to Figure 2, the odd one out is transportation. The significant negative effect on height (-1.16 cm) does not correspond with its alleged ‘productive’ status evident in Figure 2.

The employment of mothers, both in its occupational and sectoral aspect, has mostly the shape one would expect. When they worked, most mothers worked in blue collar occupations.

Manufacturing employment was particularly encouraged – hence the relatively good standing of industrial employment among occupations. White collar job was even better than that but relatively small proportions of women were thus employed. As with the fathers, farming employment carried a penalty.

To further assess the changes in inequality between various occupations through time, a further specification was analysed in which the occupational categories were interacted with the year of measurement. In such model, the year 1953 and the category of blue collar workers were taken as the reference cases. Such specification allows for the idiosyncratic occupational effects to vary year to year. Their overall size, as imputed from the height regression, is reported in Figure 8. What is clear from the figure is that the advantage of professional and clerical workers, as well as of party and administration officials, over the blue collar workers persisted throughout the period. Very few and far in between are the years when this was not the case. Second, it is clear that the level of inequality was not uniform throughout the period. In particular, there is a rapid convergence of fortunes (or rather misfortunes) during the recession in the early 1960's. Third, this downturn is evident for all categories of employment (with the bizarre exception of single-income families), including the blue-collar workers, which means that they were not immune to economic slumps.[70] The weight regression yields similar results (see Figure 9): professionals, officials and white collar workers generally carry a more positive effect than do blue collar workers and, as with height, the recession of early 1960's seems to affect almost everybody, including the workers. The differences between occupations are not great.

[70] Why the children from single income families should see such a sharp increase in 1964 is unclear. Considering that the overall shape of the 'single income family' curve in Figure 9 is quite out of line with the rest of the occupations, it is possible that the economic situation of single-parent families was influenced by some other, primarily non-economic factors. These could include the stipulations of the divorce law or changes in the causes of single parenthood (widowhood was much more frequent in the immediate post-war years; divorce became significantly more important later on in the period). Detailed research into this questions is currently under way.

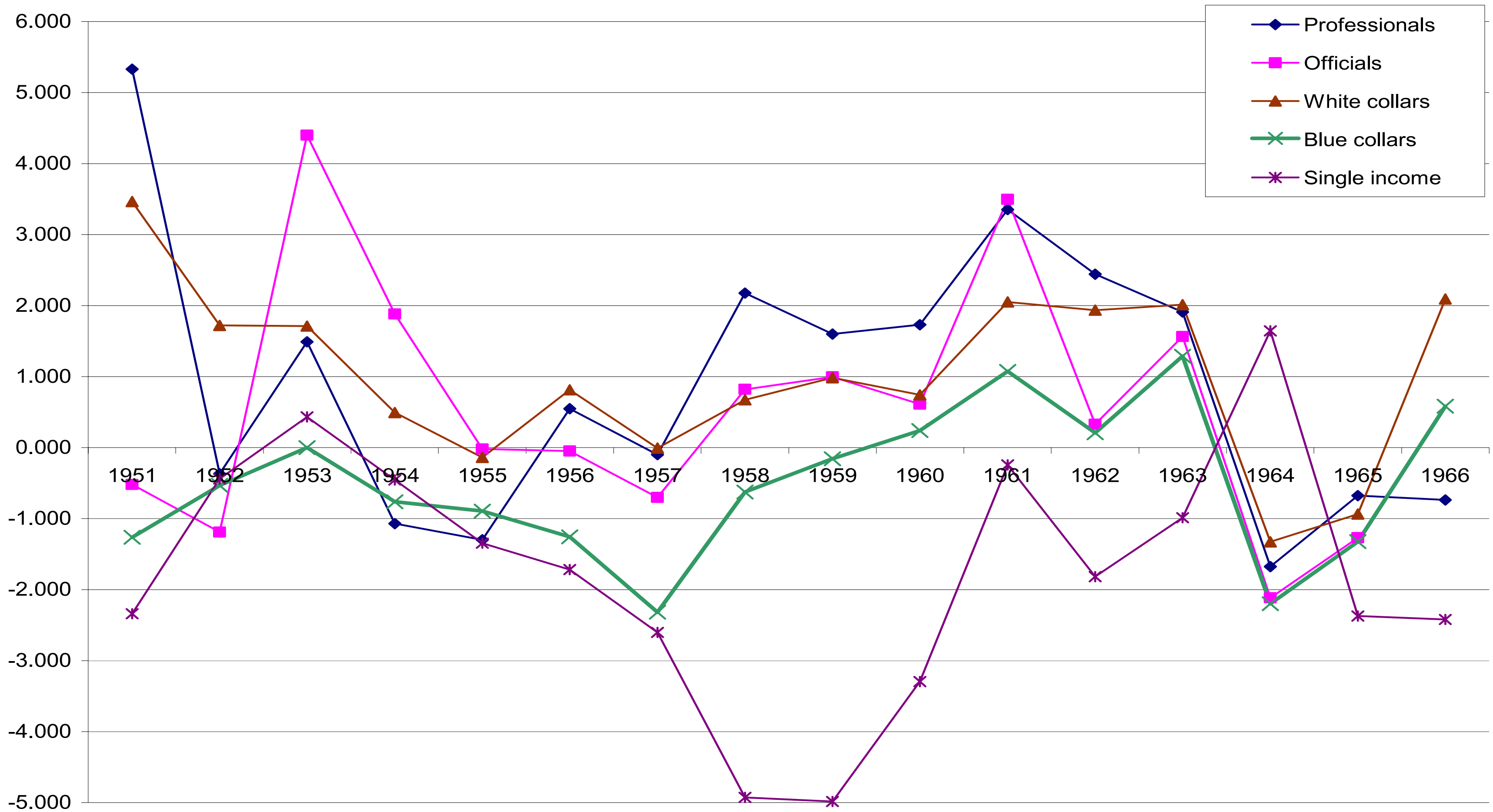

Figure 8 - Changing effects of father's occupation on height

Note: The y-axis shows the regression coefficients on interaction dummies of father' occupation and year. They measure, in cm, the idiosyncratic effects of a particular type of paternal occupation on height in a given year, as compared to the default of blue-collar workers in 1953.

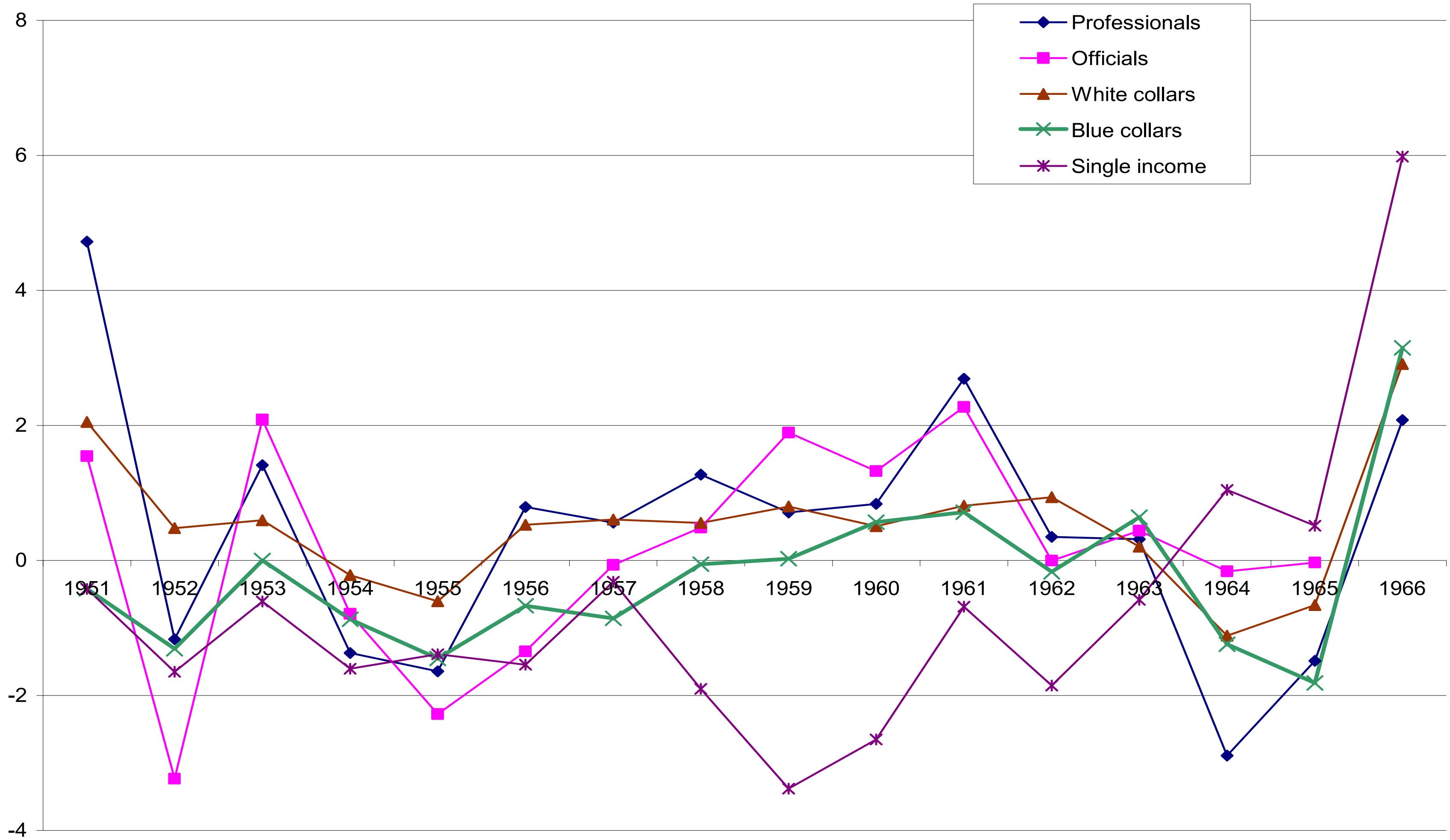

Figure 9 - Changing effects of father's occupation on weight

Note: The y-axis shows regression coefficients on interaction dummies of father' occupation and year. They measure, in kg, the idiosyncratic effects of a particular type of paternal occupation on weight in a given year, as compared to the default of blue-collar workers in 1953.

6. Conclusions

Greater equality and rising living standards – particularly for the working class: such was the political program of the Czechoslovak Communist party when it seized power in 1948. Reading the official statistics, one would conclude that the party was mostly successful in achieving these goals: all crucial economic indicators were on the rise; wages of workers grew most steadily and were admirably immune to economic fluctuations. Moreover, workers were earning higher wages than clerks and were slowly caching up with the professional employees.

The purpose of our analysis was to compare these official statistics with an independent indicator of welfare, one that was not produced – whether for internal or for public use – by the party hierarchy and that did not explicitly rely on quantitative measures of consumption or production. Height and weight of school children meet such criteria. These anthropometric variables depend on how well (or badly) the children are fed and taken care of which in turn depends on their parents' access to the relevant resources. Thus, the functional relationship between the parents' occupations and the children's height and weight can tell us a great deal about how reliable the official statistics are.

Putting the published official statistics and the unofficial anthropometric evidence side by side, we can see broad areas of agreement as well as telling instances of divergence. The basic contours of Czechoslovak economic development, namely the downturn in the early 1950's, growth in the second half of the decade and the recession in 1962-64, are visible in the anthropometric evidence. But economic growth is usually much stronger in the official numbers while slumps are much more pronounced in the height and weight data. The regime's sectoral preferences for industry and construction do find an adequate counterpart in the anthropometric analysis. But, in view of the biological welfare of their sons, clerks did not seem to fare worse than workers, in fact, throughout the period, they did consistently and significantly better. The workers' families were not shielded from the negative effects of economic downturn. The recession of 1962-64 seems to show an effect on heights and weights of workers' sons equal to a similar effect on sons from other families.

The devil, as is often the case, is in the details. Western analysts and experts have always had doubts about the reliability of published data from the Soviet bloc. This analysis provides an illustration of why this skepticism may have been legitimate. But the doubts that the anthropometric analysis raises do not necessarily imply that the officially published statistics were 'cooked' numbers; rather, all this highlights the gap that – in any economy – separates aggregate production and consumption from personal welfare. Many Communist leaders prided themselves on being able to increase their country's steel or coal production and many such increases were real and impressive in terms of sheer volume. They certainly made the aggregate statistics look impressive. But the welfare effect on people's lives was, it seems, negligible or sometimes outright negative. Thus, ultimately, the conclusions emerging from the anthropometric evidence on personal welfare raise to the long-standing question of what kind of production system best responds to the personal needs of individuals in a society. In view of the results presented here, central planning of the Communist variety does not necessarily emerge as adequate in meeting such needs and seems to fall short in achieving the ambitious socio-economic ideals of the Communism.

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