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Three essays in health and social participation

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The undersigned Elena Fumagalli, in her quality of doctoral candidate for a Ph.D degree in economics granted by the "Universita' Ca' Foscari di Venezia" and the "Scuola superiore di economia" attests that the research exposed in her dissertation is original and it has not been and it will not be used to pursue or attain any other academic degree of any level at any other academic institution, be it foreign or Italian.

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Introduction

In the last 50 years economics has lost the appearance of "dismal science", which has characterized its beginning as an independent discipline, and it has started tackling problems different from the ones the classical economists were originally trying to solve. *"Economics is what economists do"* is written in an article published on *"The Economist*[1]" at the end of 2008, and the choice of the 2009 Nobel price winners seems to confirm such a feeling.

In this thesis no much of the usual economic issues can be found; the three papers explain neither unemployment, nor economic growth nor financial crisis, but they are related to two areas that economists are now exploring with an increased interest: nutrition (and health in general) and social interactions and social participation. If one wanted to find in the thesis a strong link with the past, it would be in Keynes' idea of economists being like dentists,[2] who are called to fix the most challenging problems affecting the countries, rather than predicting future events. In fact, all the topics addressed in this thesis are on the top of the political agenda in many parts of the world: obesity, which is now an important concern also in low and middle income countries, the folic acid fortification, discussed in most part of Europe and, finally, social participation and the need to find some new paths of integration of ethnic minorities in the UK.

Even if the topics contained in the three papers of the thesis and the data used are quite different, they show many methodological similarities. In fact, in each chapter econometric tools and economic concepts are used to support findings coming from other disciplines, such as public health, nutrition and sociology. On the contrary, some historical facts and institutional characteristics of the countries analyzed are used to explain the causal effects that the simple analysis of correlations and the economic modeling can not capture.

The first chapter of the thesis, *"Like oil and water or chocolate and peanut butter? Ethnic diversity and social participation for young people in England",* is a joint work with Laura Fumagalli and it investigates the relationship between ethnic diversity and social participation of young people. We describe the effect of both ethnic fragmentation and segregation using a simple game theoretical model in which young people have to decide whether to be involved in spontaneous and unstructured social participation or to take part in a more structured activity, such as joining a sport or a youth club. In contrast with part of the literature on the topic, we find a significant effect both of ethnic fragmentation and ethnic segregation. Namely, both our model and our estimates suggest that ethnic fragmentation affects spontaneous *`hanging around'* much more than structured activities. In addition, segregation makes young people shift from spontaneous participation to social activities. We finally address the problem of endogenous sorting into districts mainly by using an instrumental variable strategy, which uses geographical data and exploits the English institutional and historical characteristics.

The second chapter, *'Average and distributional effects of the American Folic Acid fortification: an evaluation in a quasi-experimental framework'*, introduces new econometric tools in the public health debate. It addresses the problem of the food

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[1] Emerging Economists. "International bright young things". *The Economist.* Dec 30th 2008.

[2] "If economists could manage to get themselves thought of as humble, competent people on a level with dentists, that would be splendid" "The Future" Ch. 5, *Essays in Persuasion* (1931).

fortification, focusing in particular on the folic acid fortification of ready-to-eat cereals in the US and using the rich and complex source of information contained in different waves of the *National Health and Nutrition Examination Survey (NHANES)*. The chapter analyzes the aggregate trends in serum folate concentration between 1989 and 2003 and it investigates the distributional effects of the policy intervention considering its impact on different quantiles of the serum folate distribution. We cuse a new estimator of the 'quantile treatment effect', claiming that a lot is missed when just the average treatment effect is taken into account, in particular when folic acid overconsumption could be harmful.
In addition, we identify the changes in dietary habits due to the fortification in a new way, i.e. by proxing them using the concentration of vitamin C and beta-carotene in blood instead of self reported measures of folic acid intake.

Finally, the third chapter, *'Obesity in Egypt: trends, socioeconomic inequalities and determinants'* is a joint paper with Marc Suhrcke. It analyzes the prevalence of overweight and obesity in Egypt, an area in which the share of obese women is even higher than the one in more developed countries, such as US and UK. The paper helps covering the lack of information about women's health status in Middle East and North African countries, given that there is an extensive medical literature about issues of fertility and sexually transmittable diseases (STDs), while relatively little attention has been paid on not communicable diseases, such as obesity and cardiovascular diseases. The paper has mainly a descriptive nature and it aims at describing, and in part at predicting, the future evolution of adiposity in Egypt. The analysis has been carried out by putting together several waves of the Egyptian Demographic and Health Survey (DHS), almost the only source of health information in the region. The chapter covers the time span between 1992 and 2008. In spite of its descriptive quality, the paper addresses the problem by using different econometric techniques. In fact, the determinants of obesity are studied by means of an Age-period-cohort (APC) model and by considering the effect of the covariates on different parts of the body mass index distribution using a quantile regression approach.

Like oil and water or chocolate and peanut butter? Ethnic diversity and social participation of young people in England

with Laura Fumagalli*

Abstract

The paper studies the impact of ethnic diversity on social participation of young people. We first propose a theoretical model in which the agents choose between structured and unstructured social activities given the ethnic composition of the groups they join. Our model predicts that segregation should have non negative effect on social participation, while fractionalization should have a non positive effect. Moreover, we argue that the latter results should be stronger where spontaneous participation is taken into account. We test our predictions using English census data together with the 'Longitudinal Survey of Young People in England' (LSYPE) and we confirm the predictions of our model. Finally, we use an IV strategy based on both historical and geographical data to correct for endogenous sorting into neighborhoods. The results we get are even stronger than those obtained where the ethnic composition of the neighborhood is taken as exogenous.

Keywords: social participation, fractionalization, segregation
JEL classification: C25, D71, J15

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1 Chapter 1

1.1 Introduction

Due to the increase in the geographical mobility across the world, a growing number of economists and policy makers is getting interested in the link between ethnic diversity and social participation. Not only is social participation important *per se*, but it is also crucial because it is likely to be correlated with a broad set of labor market outcomes including productivity and wages. A recent article (Borghans, Weel, and Weinberg, 2008) shows that indicators at age 16 of non-cognitive skills like sociability[1] are good predictors of people's future performance in the labor market, thus claiming the need of studying the pattern of sociability for adolescents. In this respect, Cunha and Heckman (2008) show that, while parental investment for children's cognitive skills should take place between age 6 and age 9, the sensible period for investing in non-cognitive skills occurs between age 8 and age 13.

In the last decade very influent papers have been written with the purpose of explaining the impact of ethnic diversity on different outcomes including social participation, but very few attempts have been done to analyze the behavior of young people and to distinguish different forms of social participation. We believe that both extensions are potentially very promising. In this respect, in our analysis of social participation, we distinguish between 'structured' and 'unstructured' activities where the former require a more developed capacity of planning ahead, while the latter are more spontaneous and they do not require any planning. The reason why we think that such a distinction must be of interest for social scientists and especially for economists is that, according to the well known theory of the big-five personality traits (see Goldberg, 1971), the preference for planned rather than spontaneous behavior is one of the main features characterizing the trait of conscientiousness[2] which has been shown to be closely related with leadership, longevity, college grades (Borghans, Duckworth, and Heckman, 2008) and job performance (Borghans, Duckworth, and Heckman, 2008; Salgado, 1997; Avis, Kudisch, and Fortunato, 2002; Fallon, Avis, Kudisch, Gornet, and A., 2000).

Understanding the dynamics of social interaction has also direct policy implications in the debate on community cohesion. Granovetter's distinction between 'weak ties' and 'strong ties' and, even better, Putnam's dichotomy between 'bounding' and 'bridging' social capital (Putnam, 2000)[3] suggest that alternative forms of participation are not all equally effective in improving the integration of ethnic minorities. We believe that, while spontaneous aggregation is strongly driven by 'bounding social capital', forms of socialization where people share a common aim lead to the creation of 'bridging social capital' and they imply a higher level of interaction among different ethnic groups.[4]

[1] These indicators include 'going to the cinema or disco', 'going to youth clubs', 'do community work', 'go to political clubs', 'going out with friends without a particular reason'

[2] The remaining four factors are Openness, Extraversion, Agreeableness, and Neuroticism

[3] where the former type of capital indicates 'ties to people who are like you in some important way', while the latter defines 'ties to people who are unlike you in some important way'

[4] In this respect, Putnam (2007) observes that in the USA 'Community centers, athletic fields, and schools were among the most efficacious instruments for incorporating new immigrants a century ago, and we need to reinvest in such places and activities once again, enabling us all to become comfortable with diversity'

We follow Alesina and La Ferrara (2000), in arguing that young people's social participation might be influenced by the ethnic composition of the neighborhood in which they live, however, we focus on the case of England since very few pieces of work are available in the economic literature for this country in spite of a growing interest among the policy makers. In fact, it is generally thought that 'the high levels of residential segregation found in many English towns would make it difficult to achieve community cohesion' (H.O., 2001) and that there is little interaction between people with different ethnic background, especially when spontaneous socialization is taken into account (CIC, 2007).

The model we propose is based on the idea that more spontaneous and less spontaneous forms of social participation differ in two respects. On the one hand they are different in the level of importance the agents attach to the interaction with other people belonging to the same ethnic group, on the other hand they take place at different geographical levels. In fact, while spontaneous social interaction is likely to occur in the neighborhood in which the adolescents live, the majority of the structured social activities are located in a broader area e.g. the district. Therefore, a changes in the ethnic composition of the area could lead to changes in the rate of participation in social activities as well as a a shift from one type of activity to the other.

We test our predictions by using different data sources including the Longitudinal Study of Young People in England (LSYPE): a large sample of young people at grade nine at school which contains detailed information on the pattern of socialization of the respondents. In particular, to the authors' best knowledge, LSYPE is the only survey which both permits to distinguish between spontaneous and non spontaneous forms of social participation and which contains some indication of the geographical level where the activities take place. The empirical analysis confirms the predictions derived from our theoretical model and it suggests that ethnic diversity, in all its different aspects, has a strong impact on spontaneous interaction, while it has a much weaker effect on more structured activities.

In the last part of the paper we carry out an instrumental variable analysis to correct for attenuation bias and to address the problem of potential endogenous Tiebout type (Tiebout, 1956) sorting into areas. The results we got are even stronger than our previous findings.

The paper is organized as follows. Section 2 presents the related literature both in sociology and in economics and it identifies our contribution in both disciplines. In section 3 we set up a model in which agents have to choose among alternative forms of social participation (including no participation at all). In section 4 we present the empirical application and we provide the instrumental variable analysis. Section 5 concludes.

1.2 Background

1.2.1 Ethnic minorities and social participation

The investigation of the causal link between ethnicity and social participation is relatively new in economics, while in sociology the topic has been studied since the first half of the twentieth century. However, most of this literature analyzes the case of the USA and it is based on evidence showing that black Americans seem to participate more than their white counterpart also when social status is controlled for. The contributions trying to explain such a stylized fact refer to two competing theories. The first one, labeled as *'compensation hypothesis'* and proposed by Myrdal, Steiner, and Rose (1944) argues that black people use social participation as a mean of getting involved in social life when whites tend to exclude them from it. The alternative theory: Olsen's (Olsen, 1966) *'ethnic community hypothesis'* states that high participation among minorities is a consequence of their internal cultural solidity and of their ethnic community consciousness.

The results provided for the USA in most of the literature seem to be robust when blacks and whites are compared. However, allowing for different ethnic groups within these broad categories and for different forms of participation raises some additional problems. Antunes and Gaitz (1975) argue that, while black people show a greater willingness to participate, the level of social participation among Mexican Americans seem to be lower than the one among whites. Moreover, they suggest that the different forms of participation should be divided into *'public'* and *'private'* in order to distinguish activities involving large-scale interaction from those taking place in small aggregations such as family or peer groups. An alternative distinction between different forms of social participation can be found in Putnam (Putnam, 2000) where social activities are divided into 'formal' and 'informal', the former include church attendance, volunteering, and everything related to community based project and political life, the latter, far more frequent, are 'less purposeful', 'less organized' 'more spontaneous and more flexible' forms of interaction like getting together for a drink, a dinner or a barbecue, gossiping with neighbors, watching TV with friends and so on.

Our paper is in line with Putnam (2000) and Antunes and Gaitz (1975) in allowing social participation to take different forms. In particular, we argue that the ethnic composition of the neighborhood where the young people live has differential effects on spontaneous participation and on a more conventional form of interaction in which people share a specific aim, as stated by Putnam (2007).

While the link between ethnicity and participation has been studied for long time for the USA, very few papers address the topic for England. However, these pieces of work have in general the advantage of trying to study different forms of participation separately. Platt (2007) analyzes the relationship between illness, caring and ethnicity on social participation and she finds that different ethnic groups are characterized by diverse patterns of socialization, but the different types of social interaction (e.g organized activities and simple going out) turn out to be complements. Finally, using BHPS data, Li (2006) studies whether ethnicity (among other variables) determines social capital. Once again, the results show that the conclusions that can be drawn vary both across models differing for the type of participation analyzed and across different ethnic groups.

1.2.2 Measures and effects of ethnic diversity

A very interesting literature in economics focuses on the impact of ethnic diversity on several outcomes.[5] The definition of ethnic diversity is an umbrella term encompassing at least two different (although related) aspects and it has been measured through a set of different indicators.

The first aspect regards the degree of heterogeneity characterizing an area.[6] Ottaviano and Peri (2006) define 'culturally diverse cities' those having a larger share of foreign born people and they argue that cultural diversity affects both wages and rents. In a companion paper, Ottaviano and Peri (2005) measure cultural diversity by using an index constructed on the basis of the main language spoken at home and they conclude that wages for whites in diverse cities are higher than elsewhere. A tool which has been widely used in the literature in order to describe ethnic diversity is a decreasing transformation of the Herfindhal concentration index which is related to interpreted as the probability that two individuals, randomly drawn from the entire population, belong to the same ethnic group. The starting point for the economic literature using such an index can be considered the article by Easterly and Levine (1997), in which the authors found that ethnic heterogeneity affects negatively many economic outcomes at the macro level. The same results are achieved by Alesina, Devleeschauwer, Easterly, Kurlat, and Wacziarg (2003) by using both a fractionalization index computed by distinguishing groups on the basis of the language they speak and and a version of the same index distinguishing within language groups on the basis of certain physical characteristics.

A second aspect describing ethnic composition is ethnic segregation, measuring the degree of separation between different groups.[7] The definition of ethnic segregation has been used in many different formulations. For example Borjas (1998) defines 'ethnic segregated ghettos' those areas where 'the population that belongs to the respondent ethnic group is at least as large as would have been expected if the ethnic group was randomly allocated to the neighborhood'. Borjas' paper finds that ethnic spill-overs are significant for young people. Although there is no agreement on an index which best measures segregation, the literature has mainly used the Duncan and Duncan dissimilarity index (Duncan and Duncan, 1955).[8] Using the Duncan and Duncan index,[9] Cutler and Gleaser (1997) show that spatial segregation of different ethnic groups has an effect on on schooling, employment and the probability to become single mother and it harms Blacks more than Whites.[10] The Duncan and Duncan index is the indicator we will use to describe ethnic segregation in the reminder of our paper.

Few papers test the effects of fractionalization and segregation together. Gleaser, Schelnkman,

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[5] A thorough review is Alesina and La Ferrara (2005).

[6] The words 'heterogeneity', 'fragmentation' and 'fractionalization' has been used by the literature to define the same phenomenon i.e. the degree of (ethnic) homogeneity.

[7] A third concept could be the idea of 'ethnic polarization' which is discussed in Montalvo and Reynal-Querol (2002). Although interesting, such a concept does not enter our model and it will not presented in details.

[8] Other widely used indices are the square root index of segregation introduced by Hutchens (Hutchens, 2001, 2004) and the index of isolation (Bell, 1954). For a discussion on the properties of some indices of segregation see also Jenkins, Micklewright, and Schnepf (2006)

[9] Together with the exposure index

[10] A similar result is achieved by Echenique and Roland (2007) by using a new index called the 'spectral segregation index' (SSI).

and Shleifer (1995) study the effect of ethnic diversity on population growth for a cross-section of American cities and they find no effect of fractionalization but a positive effect of segregation for cities having large non whites communities. A paper explicitly claiming the need of using both measures is La Ferrara and Mele (2007). The authors analyze the link between ethnic diversity and public school expenditure and focus on the effects of changes in segregation for a given level of fractionalization. The authors find that segregation has a positive impact on average public school expenditure both at the MSA level and at the district level.[11] However, segregation leads to a more unequal distribution of spending among districts belonging to the same metropolitan area.

1.2.3 Ethnic diversity and social participation

Very few papers study explicitly the relationship between ethnic diversity and social participation by stressing the importance of the ethnic composition of the neighborhood. A very interesting piece of work in this area, both for the topic addressed and for the methodology adopted, is Alesina and La Ferrara (2000). In their paper, the authors explore the socio-economic determinants of social participation in a set of social activities (ranging from professional associations to church groups or literary clubs) by focusing on the role played by ethnic fractionalization.[12] By observing that preferences are likely to be determined by ethnicity and economic status and after testing their hypothesis by using USA data from the General Social Survey for the years 1974-1994, the authors conclude that there might be a link between ethnic fractionalization and social participation.

A recent paper addressing the topic for the UK is Letki (2008), which uses the Citizen Survey and Census data to study how racial fractionalization affects the degree of social capital. The author argues that the results supporting the hypothesis that ethnic fractionalization has an important impact on social capital might be driven by an omitted variable problem. In fact, after controlling for an index of Multiple Deprivation at the ward level,[13] the impact of ethnic diversity is insignificant in most of the cases analyzed.[14] We think that this lack of results might be due to the choice of aggregating all the types of activities into a single group.

[11] MSA is the acronym indicating metropolitan areas in the USA, districts are a lower level aggregation and they are nested into MSA

[12] In this paper and in the one presented in the following paragraph ethnic fractionalization is measured by using the transformation of the Herfindhal concentration index we have introduced in the previous section

[13] the index is released by the department of the Environment and it covers six domains: income, employment, education, skills and training, health, housing and access to services.

[14] However, as argued by Alesina and La Ferrara (2005), ethnic fractionalization can also have an effect on social participation through deprivation. In fact, racial or ethnic fractionalization can also be the cause of poor investment in physical infrastructures and so be positively correlated with deprivation, As a consequence, controlling for those variables can also lead to underestimation of the impact of ethnic fractionalization.

1.2.4 Our contribution

This paper makes several contributions.

The first one is the attempt of studying the effects of ethnic diversity on people's behavior by explicitly distinguishing between different forms of social participation. In doing so, we try to find a contact point between the sociological literature aiming at classifying different social activities and the papers which, especially in economics, analyze the impact of ethnic diversity on various socio-economic outcomes. For our classification, we borrow Putnam's (Putnam, 2000) distinction between 'formal' and 'informal' activities, but we move the demarcation line in order to take into account the different geographical level where the two groups of activities take place. In particular, we stress the idea that activities can be divided into 'structured' and 'less structured', where the former are, in Putnam's terminology, 'more purposeful' in the sense that people do not meet only for the sake of staying together, but they get together because they share a common aim. As a consequence, we consider 'structured' a very broad range of activities ranging from Putnam's (Putnam, 2000) forms of 'civic and political participation' to less formal groups of actions like playing sport or going to the cinema. We argue that all these different activities share the characteristics of not being completely casual, since they must be planned in advance, perhaps discussing timing and methods with friends or peers. The opposite of such structured forms of socialization is the most casual interaction, i.e. the simple 'hanging around' with friends, which, in the case of the teenagers we are interested in, is a very important and common way of creating social ties. In particular, we argue that 'unstructured' social participation is likely to take place in the neighborhood where the kids live, while more structured activities have a broader geographical scope.

Explicitly modeling young people's choice within a geographical hierarchy is the second contribution of our paper. We focus on two levels of the English geography: the ward and the districts which is the level of aggregation into which wards are nested.[15] The reason why we use wards as our lower level is that, according to the Office for National Statistics, the ward is the 'key building block of the English administrative geography', wards are used for the election of local government councillors and they can enjoy a certain degree of autonomy. The higher level of aggregation we use is based on the the local authority districts. The local authority districts constitute the most important geographical unit both because they enjoy greater administrative autonomy than the wards and because, since the 'Local Government Reorganisation' which took place in the 90s, the districts are in charge of providing many important services, previously supplied by the counties. In particular, the districts are responsible for the cultural and recreational functions, which is why we assume that structured social activities take place at that upper level of aggregation.

The third contribution is intimately related to the first two and it derives from the idea that alternative concepts describing the ethnic composition of a given area (namely 'ethnic fractionalization' and 'ethnic segregation') measure two different aspects of ethnic diversity. In our explanation we follow La Ferrara and Mele (2007) in stressing the importance of considering a geographic hierarchy organized on different levels of aggregation and we model

[15] For a more detailed description of the English geographical hierarchy, see the data appendix

explicitly the relationship between segregation and fractionalization and its effects on alternative forms of social participation. In particular, we argue that, in order to explain participation in more structured activities, a probabilistic concept as measured by the index of fractionalization might not be enough to explain the forces driving social interaction and the possibility of searching within the districts must be taken into account.

Moreover, our paper focuses on social participation for teenagers which has hardly been analyzed in the literature, in spite of being of crucial importance for the future of the society (see Cunha and Heckman, 2008). Furthermore, young people are more likely to choose activities just maximizing their own utility with no sons, no old parents, no spouses involved in the decision. Finally, neighborhood effects seem to play an important role in shaping young people's preferences as stated by Case and Katz (1991), who claim that interaction with peers strongly shape young people's behaviors.

The last contribution is an attempt to solve the problem of potential endogenous sorting into districts ant it suggests an historically driven IV strategy to identify the causal effect of ethnic diversity on social participation.

1.3 The model

The model developed in this section explains how fractionalization and segregation[16] influence social interaction. In our model, which is inspired by Alesina and La Ferrara (2000) one, social interaction is influenced by two different characteristics of the agents: their ethnicity and their geographical location.

We consider two different geographical units: the ward, in which most of the unstructured social interaction takes places, and the district. We chose the district as our higher level of aggregation, since we think that the young people rarely create social ties out of it. Furthermore, our choice of allowing structured forms of participation to take place at the district level is particularly meaningful in the case of England where the cultural and recreational functions are now under the responsibility of the Local Authorities.

Since 'homophily' is a broadly observed phenomenon in the adolescent networks (see for example Currarini, Jackson, and Pin, 2007; McPherson, Smith-Lovin, and Cook, 2000), we assume that young people derive more utility matching with people similar to them, moreover, we allow the players to be characterized by different levels of 'tolerance' toward different ethnic groups. The choice is modeled as a simultaneous game whose payoffs are a function of the share of people of the same ethnicity who choose the same activity. Therefore, all the payoffs will be strictly greater than zero and smaller or equal to one. The model explains why and in which cases equilibria characterized by a certain level of integration can arise.

1.3.1 Two actions and one parameter of tolerance

Let us consider a country composed by wards aggregated into districts. Let us assume for simplicity that there is just one district divided in two wards. In any ward two ethnic groups live: British *(b)* and non British *(n)*. Therefore, the population can be divided in 4 groups: British who live in ward 1 *(b1)*, British who live in ward two *(b2)*, non British who live in ward 1 *(n1)* and non British who live in ward two *(n2)*. Each group has to decide simultaneously whether to be involved in a *social activity (SA)*, which takes place within the district or to choose a less structured form of social interaction i.e. to *'hang around' (HA)* in the ward. People derive more utility from social interactions with people of the same ethnicity (*b or n)* and each type has its own level of 'tolerance' towards ethnicity, γ_{gi}, which is a parameter between 0 and 1, where γ_{gi} =1 identifies people who do not care about ethnicity. We assume that all the individuals of the same type choose the same action. In fact, the unit under analysis (the ward) is little and we believe that peer pressure and social influence are very strong when we analyze small groups of young people.

The young people are characterized by a group specific[17] utility function with the usual characteristics of monotonicity and concavity. In formulas:

$$\frac{\partial U_g(A)}{\partial -g} \leq 0 \tag{1}$$

[16] We adopt the definition of segregation measured by the Duncan and Duncan index

[17] The groups are *b1, b2, n1, n2*

$$\frac{\partial U_g(A)}{\partial g} \geq 0 \tag{2}$$

$$\frac{\partial^2 U_g(A)}{\partial^2 g} \leq 0 \tag{3}$$

$$\frac{\partial U_{gi}(A)}{\partial \gamma_{gi}} \geq 0 \tag{4}$$

where $A = SA, HA$, $i = 1, 2$ and g= b, n.

From now on, we will consider a specific utility function, which has the stated properties:

$$U_{g1}(SA) = \frac{g1(SA) + g2(SA) + \gamma_{g1}((-g1(SA)) + (-g2(SA)))}{g1(SA) + g2(SA) + (-g1(SA)) + (-g2(SA))} \tag{5}$$

$$U_{g2}(SA) = U_{g1}(SA) \tag{6}$$

$$U_{g1}(HA) = \frac{g1(HA) + \gamma_{g1}(-g1(HA))}{g1(HA) + (-g1(HA))} \tag{7}$$

$$U_{g2}(HA) = \frac{g2(HA) + \gamma_{g2}(-g2(HA))}{g2(HA) + (-g2(HA))} \tag{8}$$

where gi(A) is the number of people belonging to group g who live in ward i and who choose the action A.

The first model we propose is a simultaneous game with four players and two actions where people maximize the utility functions presented in the equations (5)-(8)

There are 16 candidates to be a equilibrium in pure strategies, but just 4 of them can actually exist.

These are:

$$(b1, n1, b2, n2) = (HA, SA, HA, SA) \tag{9}$$

in which all the British 'hang around' and all the other are involved in social activities, and the opposite case

$$(b1, n1, b2, n2) = (SA, HA, SA, HA) \tag{10}$$

$$(b1, n1, b2, n2) = (HA, SA, SA, HA) \tag{11}$$

and

$$(b1, n1, b2, n2) = (SA, HA, HA, SA) \tag{12}$$

Equilibria (9) and (10) are equilibria with perfect segregation, while (11) and (12) are equilibria with partial integration

Equilibria with perfect segregation. Candidates (9) and (10) are equilibria with perfect segregation for each distribution of the ethnic groups within the district. In this type of equilibria each ethnicity (in both wards) chooses the same activity, so there is no social interaction between British and not British and everyone achieves the maximum possible utility. Equilibria with perfect segregation take place even when the two ethnic groups cohabit in the same ward, this means that equilibria with perfect segregation could arise also in the absence of perfect geographical segregation.

Equilibria with partial integration. Candidates (11) and (12) are equilibria with partial integration for particular sizes of the sub populations *b1, b2, n1, n2* (see Appendix 1).

In equilibria (11) and (12), even if those belonging to two of the groups[18] achieve an utility level smaller than one, they have no incentive to deviate. This implies that there are some distributions of the population (with some degrees of segregation) which permit equilibria in which people of different ethnic groups find it optimal to interact. Apart from (9)-(12), we can easily rule out other types of equilibria, since it does not exist any composition of the population that supports them. The detailed description is presented in Appendix 1.

Proposition 1. *(9)-(12) are all equilibria if* $b1 = b2$ *and* $n1 = n2$.

Proof. Recall that candidates (9)-(10) are equilibria for each distribution on the population. Equilibrium (11) exists if *SA* is the best reply both for *n1* and for *b2*, since *b1* and *n2* already achieve the maximum possible pay-off. This means that two conditions have to be met.

$$U_{n1}(SA) \geq U_{n1}(HA) \tag{13}$$

$$U_{b2}(SA) \geq U_{b2}(HA) \tag{14}$$

condition (13) implies that

$$\frac{n1(SA) + \gamma_{n1} b2(SA)}{b2(SA) + n1(SA)} \geq \frac{n1(HA) + \gamma_{n1} b1(HA)}{b1(HA) + n1(HA)} \tag{15}$$

which means $b1 \geq b2$

while condition (14) implies that

$$\frac{b2(SA) + \gamma_{b2} n1(SA)}{b2(SA) + n1(SA)} \geq \frac{b2(HA) + \gamma_{b2} n2(HA)}{b2(HA) + n2(HA)} \tag{16}$$

which means $n2 \geq n1$.

Similarly (12) exists if *SA* is the best reply both for *b1* and *n2*, since *b2* and *n1* already achieve the maximum possible pay-off. It means that two conditions have to be met.

$$U_{b1}(SA) \geq U_{b1}(HA) \tag{17}$$

$$U_{n2}(SA) \geq U_{n2}(HA) \tag{18}$$

[18] Players of type b2 and n1 in 11 and of type b1 and n2 in 12

(17) and (14) imply that

$$\frac{b1(SA) + \gamma_{b1} n2(SA)}{n2(SA) + b1(SA)} \geq \frac{b1(HA) + \gamma_{b1} n1(HA)}{n1(HA) + b1(HA)} \tag{19}$$

which means $n1 \geq n2$

$$\frac{n2(SA) + \gamma_{n2} b1(SA)}{n2(SA) + b1(SA)} \geq \frac{n2(HA) + \gamma_{n2} b2(HA)}{n2(HA) + b2(HA)} \tag{20}$$

which means $b2 \geq b1$.

Therefore, in order to have both equilibrium (11) and equilibrium (12), we need $b1 = b2$ and $n1 = n2$. □

Proposition 2. *The game has only 2 equilibria if* $b1 < b2$ *and* $n1 < n2$ *or if* $b1 > b2$ *and* $n1 > n2$

Proof. In both cases neither conditions of equilibrium (11) nor condition of equilibrium (12) are met. □

Proposition 3. *For a given level of fractionalization, an increase of segregation does not decrease the number of people who play HA.*

Proof. It is easy to prove that an increase of the level of segregation that does not change the number of possible equilibria, increases the number of people who hang around.

Let us now consider an increase of the level of segregation changing the number of possible equilibria. It can be proved that the equilibrium with partial integration and high hanging around is more robust than the equilibrium with partial integration and less hanging around to changes in the number of possible equilibria due to an increase in segregation.

Framework 1 Let us first consider the case in which $n1 = n2$ and $b1 = b2$.

case 1 let us suppose some of the non British in ward 2 move to ward 1, i.e. $b1 = b2$ and $n1 > n2$. The ethnic fractionalization of the district is unaffected, but the two ethnic groups are distributed in a different way within it. In fact, this change increases the level of segregation, which was zero in the previous case.

In this new situation ($b1 = b2$ and $n1 > n2$), the conditions for the existence of equilibrium (12) are not met and just equilibrium (11) survives.

In equilibrium (11) the number of people who hang around ($n1 + b2$) is greater than the number of people who are involved in social activities ($n2 + b1$), since $n1 \geq n2$ and $b1 = b2$.

case 2 Assume now some of the non British in ward 1 move to ward 2, i.e $b1 = b2$ and $n1 < n2$.

In this case the conditions for existence of equilibrium (11) are not met and just equilibrium (12) survives.

In equilibrium (12) the number of people who hang around $(n2 + b1)$ is greater than the number of people who are involved in social activities, since $n1 < n2$

The previous cases show that, starting from the 4 equilibria case, an increase in segregation makes the equilibrium where fewer people hang around unfeasible and it does not affect the other equilibrium of partial integration, in which more people hang around.

case 3 Let us assume now that both some of the non British and some of the British in ward 1 move to ward 2, but let us also assume also the two changes are different in size (therefore we can keep a positive level of segregation) i.e $b1 \leq b2$ and $n1 \leq n2$.

In this case neither the conditions of equilibrium (11) nor the conditions of equilibrium (12) are met, and we are left only with the equilibria of perfect segregation.

Framework 2 Let us now consider the case in which we have 3 equilibria: the 2 equilibria with perfect segregation and the equilibrium of partial integration in which more people hang around

case 1 Reaching a point where there are 4 equilibria by increasing the level of segregation is impossible, since in the four equilibria case segregation is always zero.

case 2 The only way to make the equilibrium with partial integration and high hanging around unfeasible is decreasing the level of segregation

Framework 3 Finally, let us now consider the case with just the equilibria with perfect segregation: an increase of segregation changing the number of possible equilibria, makes the equilibrium with high hanging around feasible and it does not affect the equilibrium with low hanging around

$\square$

1.3.2 Two actions and two parameters of tolerance

Now we modify the environment described before by introducing two different parameters of 'tolerance', β_{gi} and γ_{gi}. We can assume that tolerance is higher when we consider social activities, since the interest in the activity itself can compensate part of the disutility created by the interaction with people of a different ethnic group. In order to have $\gamma_{gi} \geq \beta_{gi}$ for all γ_{gi} and $0 \leq \beta_{gi} \leq 1$, we can fix $\gamma_{gi} = \sqrt{\beta_{gi}}$[19]. Parameter γ_{gi} is type specific and it is known by the other players.

Thus, we still have the same simultaneous game as before, but the utility functions for HA are modified as follows:

$$U_{g1}(HA) = \frac{g1(HA) + \beta_{g1}(-g1(HA))}{g1(HA) + (-g1(HA))} \tag{21}$$

$$U_{g2}(HA) = \frac{g2(HA) + \beta_{g2}(-g2(HA))}{g2(HA) + (-g2(HA))} \tag{22}$$

Also in this case the utility is increasing in β.

$$\frac{\partial U_{gi}(SA)}{\partial \beta_{gi}} \geq 0 \tag{23}$$

The utility function depends on the percentage of people of the same ethnic group who choose the same activity. The introduction of two different parameters of tolerance helps us studying not only the effect of a change in the geographical collocation of different ethnic groups within the districts, but also the effect of changes in the ethnic mixture of the districts itself. In fact, Since $\gamma_{gi} \geq \beta_{gi}$, a change in the composition of the population affects the two activities in different ways. The following proposition explains this mechanism.

Proposition 4. *A change in district's fractionalization that does not change the level of segregation in the district has a greater effect on HA than on SA.*

Proof. Let us assume that British people (b) are the majority. Consider first the effect of participation in social activities chosen by British people due to a change in the share of non British people, which means a change in ethnic fractionalization. The utility to be considered is

$$U_{bi}(SA) = Sb(SA) + \gamma_{bi} Sn(SA) \tag{24}$$

Where *Sb(SA)* and *Sn(SA)* are the shares of British and non British who play SA. If we express (24) in terms of the share of the Non British who are involved in that activity, it becomes:

$$U_{bi}(SA) = 1 - Sn(SA) + \gamma_{bi} Sn(SA) \tag{25}$$

[19]The results of the model hold for all $\gamma_{gi} \geq \beta_{gi}$

so the change in the utility due to a change in the composition of the population[20] is

$$\frac{\partial U_{bi}(SA)}{\partial Sn} = -1 + \gamma_{bi} \leq 0 \tag{26}$$

However, the increase of non British has an effect also on the other activity which is

$$\frac{\partial U_{bi}(HA)}{\partial Sn} = -1 + \beta_{bi} \leq 0 \tag{27}$$

since $\gamma_{bi} \geq \beta_{bi}$, $-1 + \gamma_{bi} \geq -1 + \beta_{bi}$, so the utility of SA decreases less than the utility of HA.

The opposite is true, once we consider the choice of non British people.

$$\frac{\partial U_{ni}(SA)}{\partial Sn} = 1 - \gamma_{ni} \geq 0 \tag{28}$$

$$\frac{\partial U_{ni}(HA)}{\partial Sn} = 1 - \beta_{ni} \geq 0 \tag{29}$$

since $\gamma_{ni} \geq \beta_{ni}$, $1 - \gamma_{ni} \leq +1 - \beta_{ni}$, i.e. the utility of SA increases less than the utility of HA.

And it is true in both wards i.

However, since b is the majority, at the aggregate level, the first effect prevails on the second, thus the net effect of a change in the ethnic composition on both activities is negative and it is greater in absolute value for spontaneous forms of social interaction.

□

The feasible equilibria are still the four we have already described, but the introduction of two different parameters of tolerance relaxes the conditions for the existence of the equilibria with partial integration. In general we can say that the higher is the level of tolerance γ_{gi}, the more likely are the equilibria of partial integration. The following example explains how equilibria depend on the parameter of tolerance.

Let us suppose that all the agents know the exact value of parameter γ_{gi}, so they can use this information in order to make their choices.

Example 1. *consider the case in which $b1 = b2$ and $n1 > n2$. We have the two equilibria with perfect segregation and equilibrium (12) $\forall$ γ_{gi}, as in the case studied in the previous paragraph Furthermore, we have also equilibrium (11) for some values of γ_{b2}. Since in this case players b1 and n2 already obtain utility equal to one, we just have to check the conditions for the other players. Thus, in order to have equilibrium (11), we need the following conditions to be met.*

$U_{n1}(SA) \geq U_{n1}(HA)$ i.e. $\frac{n1(SA)+\gamma_{n1}b2(SA)}{b2(SA)+n1(SA)} \geq \frac{n1(HA)+\beta_{n1}b1(HA)}{b1(HA)+n1(HA)}$ which is always true since $\gamma_{gi} \geq \beta_{gi}$ and $b1 = b2$

by construction $U_{b2}(SA) \geq U_{b2}(HA)$ i.e. $\frac{b2(SA)+\gamma_{b2}n1(SA)}{b2(SA)+n1(SA)} \geq \frac{b2(HA)+\beta_{b2}n2(HA)}{b2(HA)+n2(HA)}$ which is true

$$\forall \frac{b2n1 - b2n2}{n1(b2+n2)} \leq \gamma_{b2} \leq 1 \tag{30}$$

[20]Let us assume, without loss of generality that an increase of non British takes place

The value $\frac{b2n1-b2n2}{n1(b2+n2)}$ *is admissible, because it is greater than 0 since* $n1 \geq n2$
There are still some individuals with high γ_{b2}*, who decide to play SA.*

1.3.3 Three actions and three parameters of tolerance

In this paragraph we introduce a third action: staying at home (N). The key assumption of this section is that the utility derived from staying at home is strictly lower than one, i.e. for the ones who decide to stay at home it is impossible to reach the maximum level of utility. This captures the idea that socializing increases people's utility. In this new specification of the model the number of possible equilibria increases considerably (81, 3 strategies for 4 players). In addition to equilibria (9)-(12), just 4 other equilibria are possible.

These are the following:

$$(b1, n1, b2, n2) = (HA, N, SA, HA) \tag{31}$$

$$(b1, n1, b2, n2) = (HA, SA, N, HA) \tag{32}$$

$$(b1, n1, b2, n2) = (N, HA, HA, SA) \tag{33}$$

$$(b1, n1, b2, n2) = (SA, HA, HA, N) \tag{34}$$

Each player chooses to stay at home if her reservation utility ($\overline{U}$) is greater than the utility achieved when she is involved in another activity (HA or SA).

The example 1, described in the previous paragraph, is modified as follows:

Example 2. *we have the 2 equilibria with perfect segregation and equilibrium* (11) *with partial integration if* $\overline{U_{n2}} \leq \frac{n2+\gamma_{n2}b1}{n2+b1}$ *and* $\overline{U_{b1}} \leq \frac{b1+\gamma_{b1}n2}{n2+b1}$

The equilibria in which one group plays N exist when the utility of staying at home is greater than or equal to the utility of being involved in social activities,[21] *so respectively when*

$$\overline{U_{n1}} \leq \frac{n1 + \gamma_{n1}b2}{n1 + b2} \tag{35}$$

$$\overline{U_{b2}} \leq \frac{b2 + \gamma_{b2}n1}{n1 + b2} \tag{36}$$

$$\overline{U_{b1}} \leq \frac{b1 + \gamma_{b1}n2}{b1 + n2} \tag{37}$$

and

$$\overline{U_{n2}} \leq \frac{n2 + \gamma_{n2}b2}{b1 + n2} \tag{38}$$

It comes without saying that equilibrium (12) and equilibria (33)-(34) are mutually exclusive (if we disregard the case in which $\overline{U}_{gi}$ *is exactly equal to the threshold)*

[21] It is because γ_{gi} is always greater or equal β_{gi} and because $b1 = b2$

Proposition 5. *Among the young people involved in a social activity, the ones belonging to a minority are more tolerant.*

Proof. We will prove this proposition in the case of two ethnicities, when the reservation utilities of the different ethnic groups are the same, so that a different level of participation is not the consequence of a different value of the outside option.

Let us consider the case in which all the players derive the same utility from staying at home, $\overline{U_{b1}} = \overline{U_{n1}} = \overline{U_{b2}} = \overline{U_{n2}}$.

Let us now consider the case in which both *b1* and *n2* want to play SA, therefore equilibrium (12) arises[22] and conditions (37)-(38) hold.

Let us define now $Sb1=\frac{b1}{b1+n2}$ and $Sn2=\frac{n2}{b1+n2}$, conditions (37)-(38) become:

b1 plays SA if

$$\overline{U_{b1}} \leq Sb1 + \gamma_{b1} Sn2 \tag{39}$$

which means

$$\overline{U_{b1}} \leq 1 - Sn2 + \gamma_{b1} Sn2 \tag{40}$$

$$\overline{U_{b1}} \leq 1 + (-1 + \gamma_{b1}) Sn2 \tag{41}$$

or

$$-1 + \gamma_{b1} \geq \frac{\overline{U_{b1}} - 1}{Sn2} \tag{42}$$

$$\gamma_{b1} \geq \frac{\overline{U_{b1}} - 1 - Sn2}{Sn2} \tag{43}$$

and if we consider *n2*

$$\overline{U_{b1}} \leq Sn2 + \gamma_{n2} Sb1 \tag{44}$$

$$\overline{U_{b1}} \leq Sn2 + \gamma_{n2}(1 - Sn2) \tag{45}$$

$$\gamma_{n2} \geq \frac{\overline{U_{b1}} - Sn2}{1 - Sn2} \tag{46}$$

So $\gamma_{b1} \leq \gamma_{n2}$ if $Sn2 \leq \frac{1}{2}$ □

It means that, when *n2* is the minority ($Sn2 \leq \frac{1}{2}$) they will decide to be involved in a social activity just if their level of tolerance (γ_{n2}) is very high. This result is similar to the result found by Alesina and La Ferrara (2000). Note that in this case the ones who stay at

[22]We can easily prove that the same is true if (12) arises

home are not the ones belonging to the minority in their ward, but the ones who does not have a valid outside option in the district.[23]

1.3.4 Testable predictions

Our model contains *in nuce* some predictions which can be easily tested in the data.

Testable prediction 1 (based on proposition 3): controlling for fractionalization, the coefficient indicating the effect of segregation on HA should be non negative.

Testable prediction 2 (based on proposition 4): controlling for segregation, a change in fractionalization affects more HA than SA.

Testable prediction 3 (based on proposition 5): minorities will participate less when the option 'stay at home' is taken into account. This means than we should get more negative coefficients for the dummy variables indicating ethnic minorities when we include in the model also people who do not take part in any social activity.

Moreover, data on social participation for young people can also shed light on one of the crucial assumptions of our theoretical framework i.e. the complementarity between structured activities and the simple hanging around near home.

[23]The implication is the following: if I am a minority and I live in a ward in which I am the majority, I can still decide to stay at home if I can not find people of my type in the district

1.4 Empirical analysis

1.4.1 Data

The main data we use come from the first wave of the *'Longitudinal Study of Young People in England' (LSYPE)*, a new dataset created by the *'Department for Children, Schools and Families'(DCSF)* which contains detailed information for around 15000 pupils living in England. Data were collected between 30 March and 19 October 2004 and refer to young people in year 9 at school who were born between 1 September 1989 and 31 August 1990. The dataset is composed of different files, each derived from a separate section of the questionnaire. Apart from the 'young person section', where the questions are asked directly to the child, there is a 'household section', a 'main parent section', a 'young person history section' and an 'individual parent section'. Moreover, the dataset is useful for our research since ethnic minorities have been over-sampled, which implies that it is possible to derive separate results for relatively small ethnic groups.

In addition, a great advantage of the survey is that it is possible to link each respondent to the 'Lower Super Output Areas' (LSOA) in which she lives, which permit to construct the whole geographical hierarchy aggregating LSOA into wards, wards into districts, districts into counties.[24] Given such a rich structure, it is also potentially possible to link any measure computed at area level. In order to construct our indices of ethnic composition, we used data from the 2001 Population Census. The reason for our choice is that census data permit a high level of disaggregation (we used data at ward level) and they are representative of the population, whereas survey data can suffer from bias due to sampling design and differential non-response errors.[25]

Census data report the raw number of people living in each ward classified by ethnic group. The finest ethnic categorization available in the 2001 census distinguishes among: British, Irish, other whites, mixed white and black Caribbeans, mixed white and black Africans, mixed white and Asians, other mixed, Indians, Pakistanis, Bangladeshis, other Asians, Black Caribbeans, Black Africans, Other Blacks, Chinese, Others.[26] There is no agreement on how to aggregate these categories into coarser groups. In particular, it is not clear how 'mixed people' should be classified. On the one hand, one might want to classify, for example, individuals who have a black African parent and a white one in the black African group, but on the other hand it is tempting to group all the 'mixed' together in the same broad category. The latter choice emphasizes the degree of assimilation into the British society, but it adds together people having completely different backgrounds. When the researchers are interested in cultural specific variables, creating the category of 'mixed' can hide important differences. For this reason we chose not to create the 'mixed category' and we added data for mixed people to the closest ethnic minority group.[27]

[24] In order to aggregate census data at ward level, we used the Neighbourhood Statistics provided by the *'Office for National Statistics'*

[25] In principle, we could have used bootstrap techniques applied to LSYPE data as suggested in Jenkins, Micklewright, and Schnepf (2006), but the small sample size for most of the districts would not have permitted us to get reliable estimates.

[26] It is self reported ethnicity

[27] As a consequence 'mixed white and black Caribbean' are considered 'Caribbean' and so on

1.4.2 Variables involved and descriptive statistics

Summary statistics of the variables we used in our empirical analysis can be found in table 1.

Social participation In order to derive information on social participation, we use a couple of questions in the LSYPE youth questionnaire asking whether, in the four weeks before the interview, the respondent has done any of the activities presented in a list.[28] We chose some of the activities presented and we divided them into several groups.

The theoretical framework we have presented earlier in the paper urges us to distinguish between the simple not very purposeful 'hanging around' and a richer set of social activities implying a certain degree of planning. In order to construct the variable describing the first type of interaction, we use the entry in the list referring to the simple hang around near the respondent's home. Such an entry is really important for our purposes, since it explicitly mentions the geographical level of aggregation in which the activities take place, as stated in our theoretical model. In order to fully exploit this characteristics of our data, we decided not to use the last entry in the list, i.e. the one referring to the hanging around in the high street or in the town/city center. In fact, we think that such a form of social interaction might share some of the characteristics we described for more structured forms of social participation, since it implies making a move from a place to another.

Among the other social activities, we distinguish between forms of civic and political participation (i.e. going to political meetings or demonstrations, doing community work or going to youth clubs) and other forms of participation which we label 'sports and amusements' including: playing snooker, darts or pool, taking part in sports, going to see a football match or other sport event, going to a party, dance nightclub or disco, going to cinema, theater or concert. Although this second distinction is not used in our theoretical model, we decided to keep the traditional demarcation line between more community oriented activities and more self oriented ones as suggested by both Putnam (2000) and Antunes and Gaitz (1975) classification. In that, this paper adds also new pieces of evidence to the literature on the determinants of civic participation for ethnic minorities.

One might have noticed that 'hanging around with friends in the high street', 'going to a pub', 'going to an amusement arcade' and 'playing an instrument' do not belong to any group. The reason for the first exclusion has been already explained above and it relates to the need of testing our hypothesis on the geographical scope of different activities. We excluded playing an instrument because even those playing in a band are likely to spend a lot of time practicing alone, which can hardly be considered a social activity. For a similar reason we also excluded 'going to an amusement arcade', since it does not necessarily imply any form of interaction with peers. Finally, we excluded 'going to a pub' both because it lies between structured and unstructured forms of participation and because of the age of our sample. In fact, being the LSYPE respondents at this stage all younger than 18 years, the proportion of those going to a pub is likely to be a very selected sub sample of people who

[28]The exact list, as well as the question wording is reported in the appendix 2. Notice that the respondents can choose more than one activity.

probably engage in illegal activities, given that drinking alcohol is not allowed by the law for the class of people we are considering.

We can notice from table 2 that, although the participation rate is on average very high, it varies considerably across activities: almost half of those interviewed went to the cinema, more than 50 per cent of them took part in a sport activity, while less than 2 per cent took part in a political demonstration. In addition, a big percentage of young people just hang around both near home (around 55 per cent) and in the city center (around 30 per cent). It is interesting to notice that the percentage of respondents who hang around near home is much higher that the percentage of those going to the city center. This is not surprising, given the age of the individuals interviewed and it confirms our hypothesis that most of the spontaneous socialization takes place in the ward rather than in the district. Moreover, hanging around with friends seems to be the most common social activity, showing that failing to study such a form of socialization like most of the literature does, at least for the sub sample we consider, would hide an important aspect of people's social life. Active political participation is not an option many respondents choose (perhaps just because they are still too young), but, once we adopt a broader definition of politics and we consider all the activities implying a high level of civic engagement, such as being involved in community works or being enrolled in a youth club, participation in civic activities seems to be quite important.

Neighborhood level variables Among the explanatory variables, the ones we are mainly interested in are fractionalization and segregation. In order to measure fractionalization, we used the commonly used transformation of the Herfindahl concentration index according to the formula:

$$F_i = 1 - \sum_k s_{kj}^2 \tag{47}$$

Where F_j is the fractionalization index for the district j, while s_{kj} is the share of ethnic group k in the total population of the district. Like the other indices, this index of fractionalization ranges from 0 to 1, with a value close to zero indicating a low level of heterogeneity within the community and values close to 1 indicating extreme fractionalization. Table 3 reports the least and the most fragmented districts in England, showing that London is the city in which most of the not British people reside, while in the north the percentage of British is close to 100% and the fractionalization index is just above 0.002.

In order to measure segregation, we used the Duncan and Duncan index which can be written as:

$$D_j = \frac{1}{2} \sum_{i=1}^{W_j} \mid \frac{nb_{ij}}{NB_j} - \frac{b_{ij}}{B_j} \mid \tag{48}$$

Where nb_{ij} and b_{ij} are the numbers of non British and British people in the ward level i=1,.., W_i , NB_j and B_j are the numbers of non British people and British people in the district level and W is the number of wards in the district. Segregation is a more complex concept than fractionalization ad it necessarily implies a comparison between a lower and an upper level (in our case the ward and the district). The indices of segregation compare the level of ethnic homogeneity characterizing each ward with the level of homogeneity characterizing the district, as a consequence, a high value of the index indicates a district where people are clustered at ward level. The Duncan and Duncan index has been widely used sice it has an easy and useful interpretation, given that it can be interpreted as a 'share of people belonging to one of the groups that should move to another ward (without being replaced) in order to make the proportions between groups at ward level equal to the ones at the district level'.

Table 3 shows that as in the case of fractionalization, segregated districts are not equally distributed across England, since the northern-western areas are the most segregated, while in the south east residential separation between ethnic groups is not an issue. The choice of computing both indices at district level is in line with our theoretical model, since we think it reflects the distances that the young people might travel in order to take part in social activities

In graphs 1, 2 and 3 we plotted the relationship between ethnic diversity and social participation, considering the two different indices and the three groups of activity. Without conditioning on other variables, it is impossible to distinguish the sign of the correlation between the segregation index and the different types of social involvement. On the contrary, in line with proposition 4 of our theoretical model, we can observe an inverse relationship between ethnic fractionalization and spontaneous participation.

It is possible, of course, that the indices presented above might capture some of the heterogeneity among districts which is not necessarily due to differences in their ethnic composition. In order to control for a set of characteristics of the neighborhood which could be correlated with both our measures of ethnic composition, we used the IDACI[29] index of Multiple Deprivation, we took from the Pupil Level Annual School Census (PLASC) for 2004[30] and we merged it into the main data. We chose the IDACI index since we are interested in the multiple deprivation for children. The IDACI index is available at Super Output Area which is even smaller than the ward. However, district level indices of deprivation can be computed by taking a weighted average of the values computed for each LSOA.[31]

Individual level and family levels controls At the individual level we have obviously controlled for ethnicity, which helps us shed light on the patterns of social participation for different ethnic groups which has has been largely studied by sociologists throughout the last three decades. Due to the big sample size achieved, together with the over sampling of the ethnic minorities, our survey data provide a big number of interviews for non British respon-

[29]The acronym IDACI stand for Income Deprivation Affecting Children Index and it represents the proportion of children aged 0-15 living in deprived households. the index is constructed on the basis of the number of children living in household receiving income support, income-based JSA households, pension Credit (Guarantee) households, Working tax Credit households where they are children receiving Child Tax Credit and whose equivalized income (excluding housing benefits ad before housing costs) is below 60% of the median of the population , child Tax Credit households not eligible for the schemes above whose equivalized income (excluding housing benefits and before housing costs) is below 60% of the median of the population, households composed by asylum seekers in England in receipt of subsistence support, accommodation support or both

[30]PLASC is part of the National Pupil Database (NPD)

[31]The calculation of the indices at district levels required the LSOA Level population at risk estimates available under request for each LSOA in the UK. See the data appendix for a detailed description.

dents, which permits to carry out reliable analysis also for subgroups that can not usually be analyzed separately. In order to avoid using an excessive number of ethnic dummies, we have aggregated the different ethnicities into the nine groups we have already presented earlier in the paper. Table 4 shows the ethnic composition of young people in the full sample. We can notice that more than 15 per cent of the LSYPE respondents define themselves as not British with Indian, Caribbean and Pakistani together representing half of the foreign population.

A look at the patterns of participation of different ethnic groups in table 2 provides some interesting insights. In general, Pakistani and Bangladeshi tend to participate less than their peers belonging to different ethnic groups. On the contrary, the participation rate of Caribbean and Black people, especially in civic activities, turns out to be quite high. On the side of spontaneous participation, British and Caribbean young people are the ones who hang around the most. However, even if ethnicity seems to be a driving force in explaining social participation, these data alone are not able to shed light on the mechanisms driving involvement in social activities.

As further controls at the individual level we use a dummy variable indicating whether the respondent was born in 1989 and another one indicating whether her main language at home is not English. With the first variable we want to capture any effect due to age, together with any other force affecting in a different way people who were born in a different calendar year, irrespective of the cohort they belong to when they enrol into school.[32] We are interested in the main language spoken by the respondents because we want to distinguish the role of constraints from the role of preferences. We expect that people whose main language is not English face linguistic barriers, which makes it difficult for them to interact with English speakers. We can think this linguistic constraint is not very binding for a large set of the population, since just the 2-3 per cent of the young people interviewed declared that at home they are used to speak a language different from English. Finally, we controlled for gender.

Moreover, we construct a variable which takes the value one if the school the young person attends provides any club or sport group. This variable is intended to provide some information about the supply side of participation opportunities with respect to sport. It may be that poor people do not take part in sports because they can not rely on adequate facilities, rather than because they are unwilling to be involved. If this supposition is true, the presence or absence of sport facilities in the school should be significant for the participation in ‘sports and amusements’. By looking at the percentage of young people whose schools do not provide sport facilities (less than 8 per cent of the population), we can imagine that the main reason why some young people decide not to play sport is not due to the supply side. One might argue that such a variable could be endogenous, since parents who want their children to participate in sports are likely to choose schools with good sport facilities. LSYPE contains information on the reasons why the respondents' family chose the school the child attends and none of the respondents indicated the presence of sport facilities as a main reason for the children to enrol in a particular school, so we can discount the possibility of this variable being endogenous.

[32] All the respondents in the LSYPE sample belong to the same cohort and they are mainly born in 1989 or 1990. There is a small group of people who were born before or after these dates, but they have been excluded from the sample

The last group of variables we use gives interesting information on respondents' parental background which is also useful to control for selection into districts. The first variable indicates whether the young people usually eat with their family and it takes the value of 1 if the respondent has never eaten with his family in the week before the interview. We are not trying to claim the existence of any causal relationship between having dinner at home and participating in social activities, however, the variable can be seen as a proxy for the importance of family ties as claimed by Putnam (2000).[33] Finally, at the family level control for age and education of the main parent[34] and for a variable indicating which quintile of the distribution of the household income the respondent's family belongs to.

1.4.3 The Econometric model

In order to understand the effect of the ethnic composition of the neighborhood on each form of social participation we have just presented ('sports and amusements', 'civic activities' and 'hanging around near home'), we estimate the model by using a multivariate probit.[35] The choices of taking part in the three groups of activities are treated as interdependent but not mutually exclusive. At a minimum, interdependency is likely to exist between an individual's choices because of time constraints, while the reason for non-mutually-exclusiveness is that, while the different activities are substitutes in each point in time, they are compatible over the time span considered in the survey question.

The multivariate probit is a multiple-equations extension of the univariate probit allowing for non zero correlation among the error terms. The model is estimated through simulated maximum likelihood using the Geweke-Hajivassiliou-Keane (GHK) simulator (see Cappellari and Jenkins, 2003) and with standard errors clustered at the district level.

Let the latent variables y^*_{1ij}, y^*_{2ij} and y^*_{3ij} be, respectively, the propensity of taking part in 'sports and amusements', in 'civic activities' or in 'hanging around near home' for respondent i in district *j*. By using the latent continuous variable specification for probit models, the multivariate probit can be written as follows:

$$y^*_{1ij} = \mathbf{x}_{1ij}\beta_1 + \epsilon_{1ij} \tag{49}$$

$$y^*_{2ij} = \mathbf{x}_{2ij}\beta_2 + \epsilon_{2ij} \tag{50}$$

$$y^*_{3ij} = \mathbf{x}_{3ij}\beta_3 + \epsilon_{3ij} \tag{51}$$

with

[33] Putnam (2000) observes that having a meal together is a 'traditionally important form of social connectedness' and he uses the frequency of family dinners to describe the variation over time of the strength of family ties

[34] We have included a variable indicating that the main parent has no qualification

[35] We have also estimated the model linearly by using seemingly unrelated models as in Zellner (1962), and the results are substantially the same as those obtained through multivariate probit (see appendix)

$$y_{1ij} = 1 \quad if \quad y^*_{1ij} > 0 \tag{52}$$
$$y_{2ij} = 1 \quad if \quad y^*_{2ij} > 0 \tag{53}$$
$$y_{3ij} = 1 \quad if \quad y^*_{3ij} > 0 \tag{54}$$

$\mathbf{x}$= fractionalization index, segregation (Duncan and Duncan index), idaci, variables at the individual level and variables at the household level.

The coefficients β_1, β_2, β_3, are the parameters of interest.

It is assumed that $\epsilon_1, \epsilon_2, \epsilon_3$ are error terms distributed as a multivariate normal with mean of zero and variance-covariance matrix V with V=1 on the leading diagonal and correlations $\rho_{ij} = \rho_{ji}$. If the off-diagonal correlations are equal to zero, the model is equivalent to a set of unrelated probit models, so, even if the hypothesis of interdependency was not correct, the estimates would not be affected.

1.4.4 Results

Let us start with a setting in which the option 'stay at home' is not feasible i.e. the one described in paragraphs 3.1-3.3. Our main interest is analyzing how the ethnic composition of the district, in both its aspects of segregation and fractionalization, affects social participation. Testable prediction 1 predicts that the coefficient for segregation in a model including also a measure of fractionalization can not be negative in the case of less structured forms of social interaction.

Table 6 presents the set of results obtained on the sub sample of those involved in at least one form of participation, which captures the idea that staying at home is not a valid option at this stage. In the simplest specification we included only the indices describing the ethnic composition of the neighborhood. In a slightly more complete model we added the IDACI index at district level to control for unobserved characteristics of the neighborhood and in the full model we added all the controls at the individual and family level we presented in the previous paragraphs.

It is easy to check that the prediction of the model is confirmed by our empirical analysis, given that the coefficient for segregation in the case of the variable describing spontaneous hanging around with friends in the neighborhood is positive and highly significant. Moreover, the result is robust to different specifications of the model and it becomes even stronger when new controls are added. The rational behind it is that any increase in segregation which leaves fractionalization unaffected is necessarily a result of a redistribution of the ethnic groups within the district which increases the homogeneity within wards. It is worth noticing that the predictions we can derive from the model for SA are exactly the opposite as those for HA, which implies that segregation should have a non positive coefficient in the case of more structured activities, which is what we observe in the data.

Testable prediction 2 predicts that, ceteris paribus, an increase of fractionalization has a greater (negative) effect on HA than on SA. As a consequence, we expect to get a negative and significant coefficient for fractionalization for the case of spontaneous interaction in the ward and a much more shaded result for more organized forms of social participation. Again, this is confirmed by our regression in table 6 in which the coefficient for ethnic fractionalization in the case of less structured activities is negative and highly significant, while it is insignificant in all the other cases.[36] The negative effect of fractionalization in the case of the simple hanging around with friends in the ward can be seen as a complement of the effect we found for segregation. In fact, in fragmented communities people can not rely on spontaneous forms of interaction because the probability of meeting someone of the same ethnic group simply by 'hanging around' is low, however, in segregated communities, due to the clustering of ethnic groups, British children can be more confident that in wandering around their neighborhood they will meet peers having a similar ethnic background.

The signs of the ethnic dummies deserve further comments. In fact, among those who take part in at least one form of social participation, British young people seem to be more likely to hang around with friends in the ward, while young people belonging to ethnic minorities seem to get more involved in more structured forms of participation. This can be due both to ethnic related preferences and to a mechanism close to the one we used in our theoretical model claiming that, by taking part in more structured social activities, people can engage in a within district process of search, allowing them to join sub groups where they are not the minority. On the contrary, in the ward ethnic minorities are usually the minority, which stops them to choose the simple hanging around.

Both our theoretical model and the results we have just discussed suggest that there is a form of substitutability between structured and less structured forms of participation, at least for those who take part in some forms of socialization. Table 8 (panel above) reports the signs of the estimated correlations between the three groups of activities. It is easy to notice that the results are in line with our classification of forms of social participation, given that the correlation between sports and amusements and civic activities is positive, thus confirming the idea that they all belong to the broader group we defined as the group of the 'more purposeful' activities. Similarly, the simple hanging around has negative and significant correlation with any other activity and this, again, is a result confirming our initial hypothesis. All the correlations we have just discussed are significant at 1 percent level of significance. Incidentally let us point out that all the correlations are found to be significantly different from zero, which suggests that there is interdependence among equations which gives some evidence in favor of the use of the multivariate probit.

Let us now extend the analysis to the full sample by including also those young people who are not involved in any activity. in the light of our theoretical framework, this is equivalent of making the option 'staying at home' feasible. Recall that introducing the action 'staying at home' leads to the equilibria (31), (32), (33), (34), which are similar to the equilibria (9), (10), (11), (12) where 'N' crowds out SA. In testable prediction 3 we argue that this is particularly true for the case of ethnic minorities.

The main difference between table 6 and table 7 is probably the behavior of the ethnic

[36] It is worth noticing that this lack of significance is mostly due to low estimates of the coefficients rather than to high values of the standard errors, showing that the difference in the significance level is not due to the different number of activities used to construct our alternative forms of social participation

dummies in the case of more structured social activities. Our results show that, when we run the regression on the full sample, the dummies for ethnic minorities for social activities becomes less positive and significant (and in some cases they turn also out to be negative) which means that the group of non British is split in two parts one of those plays SA, while the other plays N as predicted by our model. In fact, for those having a high γ or low $\overline{U}$ staying at home is not an option and those who are not involved in HA (namely the non British) choose to take part in a more structured social activity. The fact that the action 'staying at home' crowds out participation in more structured social activities, while it does not affect spontaneous participation has an interesting policy implication. Making structured social activities more attractive can be seen in the light of our model as an exogenous shifting in γ and $\overline{U}$ making γ to rise and $\overline{U}$ to decrease. This means that investing in sports or in youth groups could increase social participation for young people without having any negative effect on spontaneous aggregation.

The models in tables 7 and 8 are also useful to discuss and test some of the explanations for social participation suggested in the early sociological literature on the topic. For example, the negative and significant coefficient for segregation on civic activities is in line with the compensation hypothesis suggested by Myrdal, Steiner, and Rose (1944) and it can be explained by observing that, where segregation is low, ethnic minorities are more dispersed in the territory and they react to such a situation by opting for an Hirshmann's type (Hirschmann, 1970) voice mechanism. Another possible explanation is that there is a sort of substitution between the strength of ties felt within a young person's familiar-peer group and the consciousness of belonging to the society as a whole. Therefore, in segregated societies people prefer the interaction within their own ethnic group and such behavior 'crowds out' more broadly based activities. When we look at the pattern of participation in civic activities, we obtain results confirming both other empirical evidence available for the UK and the literature on social participation in the USA. In fact, our regressions show that, while Indians are less likely to join youth groups or to participate in civic activities, black Africans and black Caribbeans are more likely than British young people to take part in such activities, even when we do not consider church attendance.

In general, the complexity of the ethnic effects we found confirms the need of analyzing separately different ethnic groups and different forms of social participation.

Let us look at the behavior of the IDACI Index both in the model with neighborhood level variables and in the full model. In the model in column (2) the variable has the expected coefficients, given that it is negative and significant for the case of sports and amusements, positive and significant in the case of the spontaneous aggregation and not significant (although positive) in the case of civic activities. The explanation for the first result can be that being involved in activities belonging to the first group requires paying a ticket or a fee, while the other activities are mainly for free. In this light, the coefficient for hanging around can be read as the other side of the coin, given that in deprived areas the only possible opportunity of socialization is likely to be the simple hanging around in the street. The lack of significance for the coefficient for deprivation in the case of civic activities reflects a complex mechanism, given that on the one hand deprivation can be associated with lack of education and political awareness, while, on the other hand, it can lead to an an Hirshmann's type voice mechanism leading to participation in community oriented activities.[37]

It is interesting to notice that when we control for personal and family level characteristics the significance of the coefficients computed for the IDACI index disappears, while other variables turn out to be significant. In particular, young people raised in wealthier families with older and more educated parents are more likely to get involved in sports and amusement while the opposite is true for the spontaneous aggregation. We think that the behavior of the IDACI index in model (2) picks up average characteristics of those living in a specific area rather than characteristics of the area itself, which explains why the effects found in model (2) disappear when more controls are added. This does not happen to our indices of ethnic composition since their coefficients in the cases we are interested in become even more significant in the full model.

The behavior of the variable proxying for the importance of familiar ties gives other interesting pieces of information. The coefficient of the variable is positive and significant for the generic 'hanging around' variable, while it is negative in the remaining cases (although not significant for civic activities). Although the effect of the variable can not be considered a causal effect, the coefficient seems to capture a form of heterogeneity between families, showing that the more cohesive families are also those that encourage social participation in more structured activities.

The variable indicating that English is not the main language for the respondent is negative and statistically significant for every form of social participation, although we control for ethnic background. Moreover, its effect has comparable size for the three forms of socialization. This can be interpreted as the part of the behavior of ethnic minorities explained by constraints rather than by preferences. This seems to suggest that the ethnic minorities have a lower degree of social interaction, not only because of their different system of values, but also because they face linguistic constraints. However, such a conclusion must be drawn with great caution since not having English as one's mother tongue may also be due to an unobserved heterogeneity which makes the group under study to differ from other migrant belonging to the same ethnic background. In fact, it is not easy to decide whether speaking a language other than English at home causes a lack of social interaction or it is a consequence of a lower propensity of interacting with the English environment. Unfortunately, we are not able to completely distinguish between the two effects.

Unsurprisingly, the value of coefficient for the variable proxying for the presence of sport facilities at school is higher and more significant for the model studying participation in the first group of activities which includes sports. It suggests that, ceteris paribus, the presence of many organized activities near home might increase the level of participation of young people. This, again, confirms that the observed pattern in social participation is the result of both the demand and the supply side. However, it is interesting to notice that being able to join a sports group does not crowd out participation in other types of activities which means that demand and preferences do play an important role in people's choices. Finally, slightly older respondents are a little bit more likely to be involved in spontaneous socialization and

[37] Hirschmann (1970)

males tend to participate more than females, especially when sports and amusements are considered.

Our final comments relate to the correlations between pairs of equations estimated on the full sample and shown in table 8. Now we do not have any negative correlation, which is in line with the idea that people having a higher propensity to stay at home do not take part in any activity, regardless of whether they are spontaneous or more structured.[38] However, the strongest correlation seems to be the one between the two activities we grouped in the SA group and this, once again, confirms our link between the theoretical model we propose and the LSYPE data.

1.4.5 Tackling the endogeneity problem

One of the main problems in the literature on neighborhood effects is that the identification of causal relationships with respect to neighborhood characteristics can be problematic. In fact, if people endogenously select into areas on the basis of some unobserved characteristics (Tiebout, 1956; Dustmann and Preston, 2001), it becomes difficult distinguishing between the effect of the neighborhood as a whole and the sum of the individual effects of its inhabitants.

In order to address this problem, we adopt different strategies. First of all we use census data for 2001 i.e. three years before the interview. On the one hand such a choice permits to overcome the problem of a simultaneous determination of the ethnic composition of the neighborhood and the choices of social participation of young people, on the other hand the distance in time is not huge, thus permitting to capture the characteristics of the cultural environment where the young people have been leaving and where social norms are formed.

Moreover, the indices for the ethnic composition of the neighborhood are constructed at district level, in order to avoid the sources of endogeneity due to Tiebout type sorting within districts (see Card and Rothstein, 2007). Finally, the endogeneity problem is mitigated by the fact that young people are less mobile than adults (see Cutler and Gleaser, 1997) and they are not directly involved in parental location decisions, therefore the choice of the neighborhood in which the young people live is not directly correlated with their taste for social cohesion and it depends mainly on parental characteristics we can control for.

Instrumental variables analysis All the strategies mentioned above could not be enough to fully address the potential problem of endogenous sorting. As a consequence, we perform an instrumental variables analysis using different sets of instruments. In line with La Ferrara and Mele (2007), we first take the fractionalization index as exogenous and we focus only on the index of ethnic segregation, which we think is more at risk of being endogenous. The main reason for this choice is that, while in the case of the fractionalization index constructing a district level indicator can fully solve the problem of endogenous selection within district, in the case of the segregation index at district level this is not possible, given that the distribution of ethnic groups within the local authority does play a role in the definition of the index. As a consequence, the degree of internal cohesion of each ethnic group within the district could influence both segregation and social participation. However, in a second step we suggest an

[38] This is in line with what observed by Platt (2007)

instrument also for fractionalization and we argue that the two aspects of ethnic diversity we focus on are the results of partially different historical processes.

Instrumenting ethnic segregation In order to instrument the index of segregation we use historical data. As we have already mentioned, the data we use to construct our indices of ethnic composition were collected in 2001, three years before LSYPE data, such a distance in time could not be enough to avoid endogeneity, therefore we decided to go back in time and study the historical determinants of ethnic diversity in the UK. We claim that the forces which drove ethnic migration in the past are correlated with social participation in 2004 only through the actual ethnic composition.

Our identification strategy for the case of segregation is based on a well known stylized fact in the UK, i.e. that the most racially segregated cities coincide with the so called mill towns:[39] a definition which groups together a number of towns which used to lead the industrial revolution due to their importance in the textile (mainly cotton) industry. The reason for the correlation between the textile industry and ethnic segregation is that the mill towns experienced a huge flows of migrants (mainly Pakistani) which never mixed with the English majority. Such a pattern of migration into clusters continued also after the Second World War, when workers from both the Caribbean and the Indian subcontinent moved to the area attracted by an excess of demand of workers due to labour shortage.

In line with this idea, we selected a group of cities listed as mill towns in 1830,[40] then we computed the geodetic distance (i.e. the shortest path along the earth at sea level between each district in England and these new reference points) according to the formula:[41]

$$\begin{aligned} dist_{ab} &= \arccos(\sin(lat(a)) * \sin(lat(b)) + \cos(lat(a)) \\ &\quad * \cos(lat(b)) * \cos(\mid (long(b) - long(a)) \mid)) * 6371 \end{aligned} \tag{55}$$

where a and b are the two points considered, *lat(a)*, *lat(b)*, *long(a)* and *long(b)* are the latitude and the longitude in radians of each point and the number 6371 is the radius of the earth in kilometers.

Finally, we took the mean distance between each point and the first two closest mill towns[42] as follows:

$$segr\_iv_i = \frac{dist_{i\bar{j}} + dist_{i\bar{k}}}{2} \tag{56}$$

where

$$\bar{j} : dist_{i\bar{j}} = min(dist_{ij}) \forall j \tag{57}$$

and

[39] Violent racially driven riots took place former mill towns like Oldham, Bradford, Leeds and Burney in 2001 which confirms that ethnic segregation keeps on having consequences nowadays

[40] As a robustness check we performed the same exercise by using a more comprehensive list of mill towns encompassing a longer time span and the results do not change substantially. The results of these regressions are available under request.

[41] In our formula we assume the earth is a regular sphere, which is a commonly used approximation

[42] We used two reference points in order to account for geographical clustering

$$\overline{k} : dist_{i\overline{k}} = min(dist_{ij}) \forall j \neq \overline{j} \quad (58)$$

The first column of table 9 shows the results of the first stage when fractionalization is taken as exogenous. As suggested by Angrist and Krueger (2001), the first stage regressions are simple OLS models[43] where all the covariates are averaged at district level like in Alesina and La Ferrara (2000). As expected, the distance from the mill towns is negatively correlated with segregation and this confirms the causal link we use for our identification strategy. Moreover, the F test on the excluded instruments satisfies both the Staiger and Stock (1997) and the Stock and Yogo (2005) thresholds, thus giving some evidence against the insurgence of the week instrument problem.

Being our model non linear, in the second stage we use a control function approach including the residuals of the reduced-form equation for segregation as an additional explanatory variable.[44] The results of our second stages are shown in tables 10, 11, 12. Accounting for endogenous segregation makes the results for the coefficients for ethnic composition stronger than the ones we got in our previous models. A reason for that could be that some of the more segregated districts are located in quite big cities having a more complex social structure, better chances of taking part in political activities and smaller emphasis on spontaneous aggregation. This could hide some of the effects of segregation on our different forms of social participation. Another reason why we get stronger results after performing the IV analysis could be due to the well know 'attenuation bias' which can arise as a consequence of the way in which the data are aggregated into our indices (see Card and Rothstein, 2007). Using predictions based on the structural determinants of segregation, but unrelated to the way in which this is measured, can eliminate this further source of endogeneity.

[43]We had also run beta models and fractional models like in Papke and Wooldridge (1996), but the results were similar in terms of sign and significance of the coefficients to those obtained with the OLS. These results are available under request.

[44]Following Angrist and Krueger (2001) have also estimated linear second stages (SUR models) where the potentially endogenous variables are substituted by their fitted counterparts computed in the first stage. The results are reported in the appendix and they are substantially the same as the ones we obtained through the control function approach

Instrumenting ethnic fractionalization One might argue that not only segregation but also fractionalization could be endogenous. On a more interesting note, it can be claimed that aggregated instruments could pick up a source of heterogeneity which is not necessarily related to the causal mechanism we are trying to isolate. Furthermore, there could be an additional problem in using both the index of fractionalization and the index of segregation and it arises when the two indices are just two different measures of the same phenomenon, which leads to multicollinearity as well as to difficulties in the interpretation of the coefficients. In the next paragraph we suggest a possible instrument for ethnic fractionalization and, at the same time, we show that the two aspects of ethnic diversity we use are actually driven by different historical processes.

In order to instrument fractionalization, we compute the distance of each district with the main British ports of entry in the first half of the 20th century and we take the mean distance from the two nearest reference points as stated in (56), (57) and (58). There are two reasons why our reference points can be considered exogenous. First of all the position of the ports is quite exogenously determined, given that it depends strongly on the morphology of the land. Second, we selected the list of the places of entry into the UK according to a historical document i.e. the *Aliens Act* (1905-1919) in which entry was restricted through a number of approved ports, namely: Cardiff, Dover, Folkestone, Grangemouth, Grimsby, Harwich, Hull, Leith, Liverpool, London, Newhaven, Southampton, the Tyne Ports and Plymouth.[45]

A methodology similar to ours is also used in Ottaviano and Peri (2006) for the USA, but it differs from the strategy used here because Britain is an island and it is probably easier defining specific ports of entry, given that we do not have to deal with political boundaries such as the the Mexican and the Canadian frontier for the United States. Moreover, our approach is original because it selects the reference points on the basis of a historical analysis and on a specific legislative act.

One might argue that historical information might be only weakly correlated with the actual ethnic composition. There are some historical reasons why this may be not the case. The first reason is that the composition of the ethnic minority population has not changed much. Holmes (2001) observes that even before the First World War the groups we consider were the biggest non European ethnic minority groups composing the mosaic of the British society, with the Chinese community being the smallest in size, in line with our recent data. The second reason is related to the history of migration in Britain. The British immigration law in place in the 19th century permitted unrestricted entry of migrants into Britain. However, starting from the 1905 *Aliens Act* and throughout the whole century, more and more restrictions were posed. We think the British legislative activity with respect to migration can be divided into two phases: an early phase based on restrictions related to ports of entry and a later phase based on restrictions through vouchers and quota system. From 1905 to 1919 it was possible to enter the country just through a restricted number of ports. Evidence shows that until the mid 1940s ethnic minorities were confined to London, the ports and some university towns (see Holmes, 2001)[46] After the Second World War, migrants started

[45]Plymouth was added later, (see Pellew, 1989)

[46]Little (1948) observes that in ports like Cardiff *'the most bitter competition between white and coloured seamen took place'* and such a fight was followed by the *Special Restriction (Coloured Alien Seamen) Order*

moving to the great conurbations, this process went hand in hand with a great diversification in the occupational structure and a greater involvement in political life. In line with such a trend, the *Commonwealth Immigrants Act* of 1962 set up an entry system for Commonwealth workers based on vouchers[47] which was followed by a quota system under the 1968 Act and by further restrictions based on evidence of partiality in 1971.

The reasons why we do not compute the distances from the large clusters formed in the 60s are twofold. First of all it could not be enough to tackle endogeneity, given that this second wave of migration was influenced by the right movements in America and by the so called 'race relations industry', both of which are likely to be correlated with social participation. Secondly, even in this second phase, the residential choices of ethnic minorities were still strongly influenced by the previous restrictions on the ports of entry. In fact, the immigration control of the 1960s made it impossible temporary migration and forced new migrants to join the pioneers in places where they were already settled down.[48]

Table 9 shows the results of the first stages where also fractionalization is taken as endogenous. Although it is probably not as strong as our instrument for ethnic segregation, the distance from the ports listed in the Aliens Act does predict well the values for the index of fractionalization and its coefficient has the expected negative sign. It is perhaps more interesting to look at the pattern of significance of our instruments since it suggests that we are isolating a causal mechanism, rather than simple heterogeneity at area level. In fact, the distance from the mill towns is significant only for predicting ethnic segregation, while it does not play any role in predicting ethnic fractionalization. The results for the case of ethnic fractionalization describe a completely different scenario and we observe a significant coefficient for the distance from the ports of entry and an insignificant coefficient for the distance from the mill towns.

The results from the second stages (see tables 10, 11, 12) both in terms of coefficients and in terms of standard errors, do not differ significantly from those we got when we assumed fractionalization was exogenous. The effect of applying our instrumental variable strategy is perhaps more subtle in the case of ethnic fractionalization and this is in line with our belief that such an indicator, if constructed at district level, is likely to be less endogenous than the Duncan and Duncan index at district level we used to measure ethnic segregation. This hypothesis is also suggested by the fact that the residuals from the first stage equation for fragmentation, when included in the second stages, are not significant.

in 1925

[47]Previously commonwealth workers had enjoyed at least formally unrestricted entry in the country

[48]See again Holmes (2001)

1.5 Conclusions

This paper addresses the question of whether and how the ethnic composition of the area where young people live affects their pattern of social participation. We distinguish between spontaneous and more structured forms of participation and we argue that while the former are likely to take place in the ward where the individuals reside, the latter have a broader scope and they take place in the district. We show that, due to the existence of the possibility of searching within district, it is possible to have equilibria with partial integration where the separation between ethnic groups is not complete.

Both our theoretical model and our empirical application suggest that ethnic fractionalization discourages spontaneous socialization, while ethnic segregation seems to make it easier. The results on more structured activities are more shaded and they vary a bit when different sub groups of activities are considered. However, we still find a negative effect of segregation on participation in civic activities. Our empirical analysis on the determinants of participation shows that, at least for the sub sample of those taking part in at least one activity, the simple 'hanging around' in the neighborhood is a substitute for more structured activities, namely civic activities and 'sport and amusements'. Our predictions do not change when we control for endogenous selection into districts: after applying an instrumental variable approach using historical data, the results we got are even stronger especially in the case of ethnic segregation. Moreover, our instrumental analysis shows that ethnic segregation and ethnic fractionalization are the result of different historical processes and they measure two separated aspects of ethnic diversity.

In conclusion, our empirical analysis shows that the ethnic composition of the neighborhood, however measured, has a robust effect on spontaneous socialization and a much weaker effect on other forms of social interactions. Such a finding supports one of the main hypothesis of our theoretical framework, i.e. that in the case of more structured activities, people give less importance to the ethnicity of those they interact with. This contains also a policy implication which, in line with Putnam (2007), argues that in order to foster ethnic cohesiveness a country should provide people with chances for of sharing a common aim through different opportunities of social participation.

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Appendix 1: Description of the equilibria

Proposition A1.1: In the game with two actions and one parameter of tolerance $\nexists$ a distribution of the population that supports the following equilibria.

- $(b1, n1, b2, n2) = (SA, SA, SA, SA)$

  Proof. everybody has an incentive to deviate and "hang around" in her own ward, obtaining a payoff equal to one. □

- $(b1, n1, b2, n2) = (HA, HA, HA, HA)$

  Proof. everybody has an incentive to deviate and play SA, obtaining a payoff equal to one. □

- $(b1, n1, b2, n2) = (HA, SA, SA, SA)$, $(b1, n1, b2, n2) = (SA, HA, SA, SA)$, $(b1, n1, b2, n2) = (SA, SA, HA, SA)$, $(b1, n1, b2, n2) = (SA, SA, SA, HA)$

  Proof. Since people from one ward are "hanging around", one of the two wards is "empty", so there is an incentive to play HA there, obtaining a payoff equal to one. □

- $(b1, n1, b2, n2) = (SA, SA, HA, HA)$:

  Proof. people living of ethnicity b living in 1 and people of ethnicity n living in 1 have an incentive to play HA in their own ward (ward one), obtaining the maximum pay off. □

- $(b1, n1, b2, n2) = (HA, HA, SA, SA)$:

  Proof. people of both ethnicities living in 2 have an incentive to play HA in their own ward (ward two), obtaining the maximum pay off. □

- $(b1, n1, b2, n2) = (SA, HA, HA, HA)$, $(b1, n1, b2, n2) = (HA, SA, HA, HA)$, $(b1, n1, b2, n2) = (HA, HA, SA, HA)$, $(b1, n1, b2, n2) = (HA, HA, HA, SA)$

  Proof. Let us consider the equilibrium $(b1, n1, b2, n2) = (SA, HA, HA, HA)$: people living in n2 have an incentive to deviate and to play SA with the players of their own type (living in b1), obtaining the maximum payoff. The same applies to players in b2, n1 and b1 in the other cases □

number and nature of equilibria in a game with two actions and one parameter of tolerance Let us summarize the number and the nature of the equilibria the different cases. In addition to (9) and (10) we have:

- if $b1 > b2$ and $n1 < n2$: equilibrium (11)
- if $b1 > b2$ and $n1 > n2$: neither equilibrium (11) nor equilibrium (12) can take place
- if $b1 > b2$ and $n1 = n2$: equilibrium (11)
- if $b1 < b2$ and $n1 < n2$: neither equilibrium (11) nor equilibrium (12) can take place
- if $b1 < b2$ and $n1 > n2$: equilibrium (12)
- if $b1 < b2$ and $n1 = n2$: equilibrium (12)
- if $b1 = b2$ and $n1 < n2$: equilibrium (11)
- if $b1 = b2$ and $n1 > n2$: equilibrium (12)
- if $b1 = b2$ and $n1 = n2$: both equilibrium (11) and equilibrium (12)

number and nature of equilibria in a game with two actions an two parameters of tolerance Let us summarize the number and the nature of the equilibria the different cases. In addition to (9) and (10) we have:

- if $b1 > b2$ and $n1 < n2$: (11) $\forall \gamma_i$ and (12) if $\gamma_{b1} > \frac{b1n2-b1n1}{n1(b1+n2)}$ and $\gamma_{n2} > \frac{b1n2-b2n2}{b2(b1+n2)}$
- if $b1 > b2$ and $n1 > n2$: (11) if $\gamma_{b2} > \frac{b2n1-b2n2}{n2(b2+n2)}$ and (12) if $\gamma_{n2} > \frac{b1n2-b2n2}{b2(b1+n2)}$
- if $b1 > b2$ and $n1 = n2$: (11) $\forall \gamma_i$ and (12) if $\gamma_{n2} > \frac{b1n2-b2n2}{b2(b1+n2)}$
- if $b1 < b2$ and $n1 < n2$: (11) if $\gamma_{n1} > \frac{b2n1-b1n1}{b1(b2+n1)}$ and (12) if $\gamma_{b1} > \frac{b1n2-b1n1}{n1(b1+n2)}$
- if $b1 < b2$ and $n1 > n2$: (11) if $\gamma_{n1} > \frac{b2n1-b1n1}{b1(b2+n1)}$ and ($\gamma_{b2} > \frac{b2n1-b2n2}{n2(b2+n2)}$ and 12) $\forall \gamma_i$
- if $b1 < b2$ and $n1 = n2$: (11) if $\gamma_{n1} > \frac{b2n1-b1n1}{b1(b2+n1)}$ and (12) $\forall \gamma_i$
- if $b1 = b2$ and $n1 < n2$: (11) $\forall \gamma_i$ and (12) if $\gamma_{b1} > \frac{b1n2-b1n1}{n1(b1+n2)}$
- if $b1 = b2$ and $n1 > n2$: (11) if $\gamma_{b2} > \frac{b2n1-b2n2}{n2(b2+n2)}$ and (12) $\forall \gamma_i$
- if $b1 = b2$ and $n1 = n2$: (11) and (11) $\forall \gamma_i$

Proposition A1.2: In the game with three actions and two parameters of tolerance $\nexists$ a distribution of the population that supports the following equilibria.

- $(b1, n1, b2, n2) = (N, SA, SA, SA)$, (SA, N, SA, SA), (SA, SA, N, SA), (SA, SA, SA, N)

  Proof. everybody has an incentive to deviate and "hang around" in her own ward, obtaining a payoff equal to one. □

- $(b1, n1, b2, n2) = (N, HA, HA, HA)$, (HA, N, HA, HA), (HA, HA, N, HA), (HA, HA, HA, N)

  Proof. everybody has an incentive to deviate and play SA, obtaining a payoff equal to one. ☐

- $(b1, n1, b2, n2) = (SA, HA, SA, N)$, (SA, N, SA, HA), (HA, SA, N, SA), (N, SA, HA, SA)

  Proof. Players who play N have an incentive to play HA, since the payoff obtained by staying at home is strictly less than one. ☐

- $(b1, n1, b2, n2) = (N, HA, SA, HA)$, (SA, HA, N, HA),(HA, N, HA, SA), (HA, SA, HA, N)

  Proof. Players who plays N have an incentive to play SA, since the payoff obtained by staying at home is strictly less than one. ☐

- $(b1, n1, b2, n2)$ =(N , N, N, HA), (N, N, HA, N), (N , HA, N, N), (HA, N, N, N), (N, N, N, SA), (N, N, SA, N), (N, SA, N, N), (SA, N, N, N), (N, N, N, N)

  Proof. Players who plays N have an incentive to play either HA SA, since the payoff obtained by staying at home is strictly less than one. ☐

- $(b1, n1, b2, n2)$=(N, N, SA, HA), (N, N, HA, SA),(N, N, SA, SA), (N, N, HA, HA),

  Proof. Nobody in ward one is involved in social activity, so people of both ethnic groups living in ward 1 have an incentive to play HA ☐

- $(b1, n1, b2, n2)$=(SA, HA, N, N), (HA, SA, N, N),(SA, SA, N, N), (HA, HA, S, S),

  Proof. Nobody in ward two is involved in social activity, so both people of both ethnic groups living in 2 have an incentive to play HA ☐

- $(b1, n1, b2, n2)$=(N, HA, N, HA),

  Proof. Both people of ethnic group b living in 1 and people of ethnic group b living in 1 have an incentive to play SA ☐

- $(b1, n1, b2, n2)$=(N, SA, N, SA),

  Proof. Both people of ethnic group b living in 1 and people of ethnic group b living in 2 have an incentive to play HA ☐

- $(b1, n1, b2, n2)$=(N, HA, N, SA),

  Proof. People of ethnic group b living in 2 have an incentive to play HA ☐

- $(b1, n1, b2, n2)$=(N, SA, N, HA),

  Proof. People of ethnic group b living in 1 have an incentive to play HA ☐

- $(b1, n1, b2, n2)$=(HA, N, HA, N),

  Proof. People of ethnic group n living in both wards 1 and 2 have an incentive to play SA ☐

- $(b1, n1, b2, n2)$=(SA, N, SA, N),

  Proof. People of ethnic group n living in both wards 1 and 2 have an incentive to play HA ☐

- $(b1, n1, b2, n2)$=(HA, N, SA, N),

  Proof. People of type n living in ward 2 have an incentive to play HA ☐

- $(b1, n1, b2, n2)$=(SA, N, HA, N),

  Proof. People of type n living in ward 1 have an incentive to play HA ☐

- $(b1, n1, b2, n2)$=(N, HA, HA, N), (HA, N, N, HA)

  Proof. The players who play N has an incentive to play SA ☐

- $(b1, n1, b2, n2)$=(N, SA, SA, N), (SA, N, N, SA)

  Proof. The players who play N has an incentive to play HA ☐

- $(b1, n1, b2, n2)$=(N, SA, HA, N)

  Proof. People of type b living in ward 1 have an incentive to play HA , while People of type n living in ward 2 have an incentive to play SA ☐

- $(b1, n1, b2, n2)$=(N, HA, SA, N)

  Proof. People of type b living in ward 1 have an incentive to play SA , while People of type n living in ward 2 have an incentive to play HA ☐

- $(b1, n1, b2, n2)$=(SA, N, N, HA)

Proof. People of type n living in ward 1 have an incentive to play HA , while People of type b living in ward 2 have an incentive to play SA □

- $(b1, n1, b2, n2)$=(HA, N, N, SA)

Proof. People of type n living in ward 1 has an incentive to play SA , while people of type b living in ward 2 have an incentive to play HA □

- $(b1, n1, b2, n2)$=(HA, HA, N, SA), (HA, HA, SA, N), (N, SA, HA, HA)

Proof. The players who stay at home have an incentive to play HA □

- $(b1, n1, b2, n2)$=(N, HH, SA, SA), (SA, SA, HA, N)

Proof. All the players who play SA have an incentive to play HA □

- $(b1, n1, b2, n2)$=(N, SA, SA, HA)

Proof. People of type b living in ward 1 have an incentive to play HA □

- $(b1, n1, b2, n2)$=(HA, SA, SA, N)

Proof. People of type b living in ward 2 has an incentive to play HA □

- $(b1, n1, b2, n2)$=(SA, SA, N, HA), (SA, SA, HA, N)

Proof. Players of ward 1 have an incentive to play HA □

- $(b1, n1, b2, n2)$=(SA, HA, N, HA)

Proof. Players who play N have an incentive to play SA □

- $(b1, n1, b2, n2)$=(SA, N, HA, HA)

Proof. People of type b living in ward 2 have an incentive to play SA □

number and nature of equilibria in a game with three actions and two parameters of tolerance The following list summarize the nature and the number of the possible equilibria. In addition to (9) and (10), we have:

- **if** $b1 > b2$ **and** $n1 < n2$: (11) if $\overline{U_{n1}} \leq \frac{n1+\gamma b2}{n1+b2}$ and $\overline{U_{b2}} \leq \frac{b2+\gamma n1}{n1+b2}$; (31) if $\overline{U_{n1}} \geq \frac{n1+\gamma b2}{n1+b2}$; (32) if $\overline{U_{b2}} \geq \frac{b2+\gamma n1}{n1+b2}$; (33) if $\overline{U_{b1}} \geq \frac{b1+\gamma n2}{b1+n2}$; (34) if $\overline{U_{n2}} \geq \frac{n2+\gamma b1}{b1+n2}$;

- **if** $b1 > b2$ **and** $n1 > n2$: (31) if $\overline{U_{n1}} \geq \frac{n1+\gamma b2}{n1+b2}$; (32) if $\overline{U_{b2}} \geq \frac{b2+\beta n2}{n2+b2}$; (33) if $\overline{U_{b1}} \geq \frac{b1+\beta n1}{b1+n1}$; (34) if $\overline{U_{n2}} \geq \frac{n2+\beta b2}{b2+n2}$;

- **if** $b1 > b2$ **and** $n1 = n2$: (11) if $\overline{U_{n1}} \leq \frac{n1+\gamma b2}{n1+b2}$ and $\overline{U_{b2}} \leq \frac{b2+\gamma n1}{n1+b2}$;(31) if $\overline{U_{n1}} \geq \frac{n1+\gamma b2}{n1+b2}$; (32) if $\overline{U_{b2}} \geq \frac{b2+\gamma n1}{n1+b2}$; (33) if $\overline{U_{b1}} \geq \frac{b1+\gamma n2}{b1+n2}$; (34) if $\overline{U_{n2}} \geq \frac{n2+\gamma b1}{b1+n2}$;

- **if** $b1 < b2$ **and** $n1 < n2$: (31) if $\overline{U_{n1}} \geq \frac{n1+\beta b1}{n1+b1}$; (32) if $\overline{U_{b2}} \geq \frac{b2+\gamma n1}{n1+b2}$; (33) if $\overline{U_{b1}} \geq \frac{b1+\beta n1}{b1+n1}$; (34) if $\overline{U_{n2}} \geq \frac{n2+\gamma b1}{b1+n2}$;

- **if** $b1 < b2$ **and** $n1 > n2$: (11) if $\overline{U_{n1}} \leq \frac{n1+\gamma b2}{n1+b2}$ and $\overline{U_{b2}} \leq \frac{b2+\gamma n1}{n1+b2}$; (31) if $\overline{U_{n1}} \geq \frac{n1+\gamma b2}{n1+b2}$; (32) if $\overline{U_{b2}} \geq \frac{b2+\gamma n1}{n1+b2}$; (33) if $\overline{U_{b1}} \geq \frac{b1+\beta n1}{b1+n1}$; (34) if $\overline{U_{n2}} \geq \frac{n2+\beta b2}{b2+n2}$;

- **if** $b1 < b2$ **and** $n1 = n2$: (12) if $\overline{U_{n2}} \leq \frac{n2+\gamma b2}{n2+b1}$ and $\overline{U_{b1}} \leq \frac{b1+\gamma n2}{n2+b1}$;(31) if $\overline{U_{n1}} \geq \frac{n1+\beta b1}{n1+b1}$; (32) if $\overline{U_{b2}} \geq \frac{b2+\gamma n1}{n1+b2}$; (33) if $\overline{U_{b1}} \geq \frac{b1+\beta n1}{b1+n1}$; (34) if $\overline{U_{n2}} \geq \frac{n2+\beta b2}{b2+n2}$;

- **if** $b1 = b2$ **and** $n1 < n2$: (11) f $\overline{U_{n1}} \leq \frac{n1+\gamma b2}{n1+b2}$ and $\overline{U_{b2}} \leq \frac{b2+\gamma n1}{n1+b2}$;(31) if $\overline{U_{n1}} \geq \frac{n1+\gamma b2}{n1+b2}$; (32) if $\overline{U_{b2}} \geq \frac{b2+\gamma n1}{n1+b2}$; (33) if $\overline{U_{b1}} \geq \frac{b1+\beta n1}{b1+n1}$; (34) if $\overline{U_{n2}} \geq \frac{n2+\gamma b1}{b1+n2}$;

- **if** $b1 = b2$ **and** $n1 > n2$: (12) if $\overline{U_{n2}} \leq \frac{n2+\gamma b2}{n2+b1}$ and $\overline{U_{b1}} \leq \frac{b1+\gamma n2}{n2+b1}$;(31) if $\overline{U_{n1}} \geq \frac{n1+\beta b1}{n1+b1}$;31) if $\overline{U_{n1}} \geq \frac{n1+\gamma b2}{n1+b2}$; (32) if $\overline{U_{b2}} \geq \frac{b2+\gamma n1}{n1+b2}$; (33) if $\overline{U_{b1}} \geq \frac{b1+\gamma n2}{b1+n2}$; (34) if $\overline{U_{n2}} \geq \frac{n2+\gamma b1}{b1+n2}$;

- **if** $b1 = b2$ **and** $n1 = n2$: (11) and (12); (31) if $\overline{U_{n1}} \geq \frac{n1+\gamma b2}{n1+b2}$; (32) if $\overline{U_{b2}} \geq \frac{b2+\gamma n1}{n1+b2}$; (33) if $\overline{U_{b1}} \geq \frac{b1+\gamma n2}{b1+n2}$; (34) if $\overline{U_{n2}} \geq \frac{n2+\gamma b1}{b1+n2}$;

Appendix 2: variables definition

We considered two different questions about young people's participation. The question wording is the following:

Question 1:

Here is a list of things people can do when they are not at school. Can you please tell me which, if any, you have been to or done in the last four weeks?

- Played snooker, darts or pool
- Took part in any kind of sport
- Gone to see a football match or other sports event
- Gone to an amusement arcade
- Gone to a party, dance, nightclub or disco
- Gone to a pub or bar
- Gone to a cinema, theatre or concert
- Played a musical instrument
- All of these
- None of these

Question 2:

Here is a list of some more things people do when they are not at school. Can you please tell me which, if any, you have been to or done in the last four weeks? Just read out the numbers.

- Gone to a political meeting/march, rally or demonstration
- Done community work (such as helping elderly, disabled or other dependent people; cleaning up the environment; helping volunteer organizations or charities)
- Gone to a youth club or something like it (including scouts or girl guides)
- Just hubv ng around/messed about near to your home
- Just hung around/messed about in the high street or the town/city centre
- All of these
- None of these

Question 3: 'How many times had taken part in religious classes in last 7 days?'

- more than once a week
- about once a week,

- two or three times a month,
- about once a month
- less than once a month.

Question 4:
'How many times had friend round the house in last 7 days?' The possible outcomes are:

- None
- Once or twice
- 3-5 times
- More than 6 times

Question 5:
How many times gone out with friends in last 7 days?
The possible outcomes are, as before:

- None
- Once or twice
- 3-5 times
- More than 6 times

Appendix 3: Geography and data

The Longitudinal studies of Young People in England contains a variable indicating the output area (OA) where each respondent lives and this permits to link each observation with a huge number of variables describing the neighborhood characteristics measured at different levels of aggregation.

English geographical hierarchy In order to understand the structure of our data, is worth giving some basic information on the English geographical hierarchy. The lowest available level of aggregation is the output area (OA) containing around 150 households which are quite homogeneous in terms of characteristics of the dwelling. The OA are aggregated into LSOAs (Lower Super Output Areas containing around 600 households), then into MSOAs (Middle Super Output Areas containing around 2500 households). The complete structure would include also Upper Super Output Areas (USOAs), which are not available yet.

OA are nested into wards. in England there are almost 8000 wards with an average population of around 5500 individuals, they are used for the election of local government councillors and they are nested into Local Authority districts (LA), which are composed, on average, by 23 electoral wards. The districts can be of four different types: metropolitan districts (36), non-metropolitan districts (239), London Boroughs (32[49] plus the city of London) and unitary authorities (46). Among those, the first three groups have been created as the lower level of two-tier authorities, being higher level authorities in the two-tier structure known as metropolitan and non metropolitan counties in case of metropolitan and non metropolitan districts, while London boroughs are part of Greater London. On the contrary, the unitary authorities are single-tier authorities and they do not belong to any county. Finally, both types of local authorities are grouped into 9 Government Office Regions (GORs[50]), corresponding to level 1 of the 'Nomenclature of Territorial Units for Statistics' (NUTS).

An alternative geography used in England is the postal geography. The UK is divided into many postcode units (about 1,78 million), which are grouped in more than 10000 postcode sectors, then into around 3000 postcode districts and finally into around one hundred postcode areas. The postcodes do not have any geographical meaning and they are simply groups of up to 100 adjacent addresses used for organizing the delivery of the mails. For this reason, we chose to limit our use of the postal geography just to the computation of the distances between cities we used for our instrumental variables. Using the postal geography to derive locational attributes is a common practice and it is due to the fact that the Office of National Statistics assigns centroids to postcodes thus making it possible to compute distances among between each couple of units in the country. The postal geography and the geography used in the census are not exactly compatible, but at our level of aggregation they can be jointly used with limited loss of precision by using the look up tables provided by the ONS.

[49] City of London, Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Camden, Croydon, Ealing, Enfield, Greenwich, Hackney, Hammersmith and Fulham, Haringey, Harrow, Havering, Hillingdon, Hounslow, Islington, Kensington and Chelsea, Kingston upon Thames, Lambeth, Lewisham, Merton, Newham, Redbridge, Richmond upon Thames, Southwark, Sutton, Tower Hamlets, Waltham Forest, Wandsworth, Westminster.

[50] North East, North West, Yorkshire and The Humber, East Midlands, West Midlands, East of England, London, South East, South West

data Sources For our analysis we used data taken from different data sources we merged into the main LSYPE dataset. The indices of ethnic composition are derived the 2001 census for England. Census data permit to compute the exact number of people for each ethnic group living in each ward in 2001. Moreover, we have linked the LSYPE records to the relevant 'index of deprivation affecting children' available through the Pupil Level Annual School Census (PLASC) dataset for 2004. As we have already mentioned, the IDACI index is released at LSOA level so that the figure for the districts must be computed as a weighted average of the single records for al the LSOA in the district. Setting up the system of weights requires the SOA Level population at risk estimates which can be obtained from the 'Department for Communities and Local Government'. This permits to compute at the district level both the number of children actually used to compute the IDACI index and the number of those at risk of being deprived (the denominators in the calculus of the index). Once computed the indices at district level, they have been added to the main data.

Appendix 4: Tables

Table 1: Descriptive statistics for the selected sample

variable	obs	mean	st.dev	min	max
sports amusements	9772	0.852	0.08	0	1
political social	9772	0.247	0.086	0	1
hang about	9772	0.548	0.122	0	1
fractionalization	308	0.152	0.147	0.02	0.676
segregation	308	0.197	0.108	0.058	0.619
idaci	308	0.185	0.091	0.052	0.585
age main parent	9772	41.63	5.982	20	72
no qualification	9772	0.176	0.381	0	1
no dinner	9772	0.089	0.284	0	1
no mother tongue	9772	0.023	0.152	0	1
clubs	9772	0.934	0.246	0	1
male	9772	0.505	0.499	0	1
born in the 1989	9772	0.322	0.467	0	1
income	9772	23378.38	11979.74	0	40000
other white	9772	0.016	0.127	0	1
indian	9772	0.029	0.169	0	1
caribbean	9772	0.028	0.165	0	1
mixed	9772	0.016	0.126	0	1
african	9772	0.018	0.136	0	1
pakistani	9772	0.016	0.126	0	1
bangladeshi	9772	0.006	0.081	0	1
chinese	9772	0.003	0.055	0	1

Table 2: Participation in social activities (%)

Ethnic group	Sports and amusements					Civic activities			Spontaneous participation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Other white and Irish	27.82	66.36	21.11	27.05	58.09	1.59	4.95	16.27	45.51	31.41
Caribbean	18.47	53.25	17.11	36.38	53.00	1.38	3.74	29.32	52.13	28.97
African	15.88	49.69	13.14	24.16	48.23	1.16	3.52	24.12	34.59	19.08
Pakistani	25.36	56.32	10.64	7.85	33.36	2.02	2.58	14.24	30.71	12.97
Bangladeshi	18.89	37.92	11.29	9.81	29.75	1.75	3.20	17.86	31.89	14.25
Indian	24.01	52.19	10.99	17.26	52.13	1.71	3.12	13.11	32.93	20.09
Chinese	17.10	53.09	3.35	17.82	47.64	0	0	16.44	34.88	23.45
British	27.20	50.70	20.63	28.74	49.36	1.23	4.5	20.76	58.47	30.92
other	20.19	60.14	17.17	20.55	53.40	2.19	3.53	14.99	38.03	23.27
mean	26.33	57.85	19.62	27.60	49.25	1.29	4.32	20.43	55.33	29.54

Table 3: Segregation and fractionalization in English districts

District	Region	Index
Least segregated districts		**dissimilarity index**
Castle Point	East Anglia	0.0584
Ashfield	East Midlands	0.064
Sedgemoor	South West	0.0696
Basildon	East Anglia	0.0697
Hertsmere	East Anglia	0.0701
Most segregated districts		
Burnley	rest of north west	0.5207
Bradford	West Yorkshire	0.5242
Pendle	rest of north west	0.5531
Oldham	Greater Manchester	0.5777
Blackburn with Darwen	rest of north west	0.6198
Least fragmented districts		**fractionalization index**
Easington	Rest of North	0.0202
Sedgefield	Rest of North	0.0237
Derwentside	Rest of North	0.024
Wear Valley	Rest of North	0.0261
Alnwick	Rest of North	0.0275
Most fragmented districts		
Lambeth	Inner London	0.6548
Tower Hamlets	Inner London	0.6586
Haringey	Inner London	0.6662
Newham	Inner London	0.6714
Hackney	Inner London	0.6761

Table 4: Composition of the sample and the population

Ethnicity	number	Percentage in the sample	Percentage in the population
Other white and Irish	232	1.51	1.86
Caribbean	1061	6.88	2.87
African	704	4.57	1.97
Pakistani	940	6.10	2.26
Bangladeshi	722	4.68	0.90
Indian	1195	7.75	3.28
Chinese	44	0.29	0.39
British	10103	65.55	84.27
other	411	2.67	2.20

Table 5: Participation in social activities

Activity	Percentage
sports and amusements	
Snooker, Dart, pool	26.33
Sport	57.85
Sport event	19.62
Party, dance	27.60
Cinema	49.25
Civic activities	
Political demonstrations	1.29
community work	4.32
Youth club	20.43
Hang around near home	55.33
excluded activities	
hang around in the city centre	29.54
Pub or bar	15.01
Instrument	23.35
amusement arcade	16.70

Table 6: Results for the multivariate probit on the sub sample of those involved in at least one form of participation

	(1) just ethnic diversity						(2) neigh level variablrd						(3) full model					
	sport amusement		civic activities		hang around		sport amusement		civic activities		hang around		sport amusement		civic activities		hang around	
fract	-0.0712		0.1788	**	-0.9083	***	0.1747		0.1747	*	-1.0563	***	-0.0573		0.0946		-0.4033	***
	(0.122)		(0.085)		(0.088)		(0.135)		(0.103)		(0.103)		(0.143)		(0.125)		(0.123)	
segr	0.0249		-0.3004	***	0.2837	***	0.1322		-0.3011	***	0.2138		0.1322		-0.2709	**	0.5003	***
	(0.154)		(0.089)		(0.102)		(0.134)		(0.106)		(0.151)		(0.185)		(0.133)		(0.159)	
idaci	1.2888	***	-0.6024	***	0.2847	***	-0.7461	***	0.0071		0.4554	**	-0.0586		0.1992		0.1885	
	(0.034)		(0.029)		(0.036)		(0.253)		(0.193)		(0.193)		(0.212)		(0.230)		(0.203)	
age mp							1.3828	***	-0.6028	***	0.2293	***	0.0069	***	0.0015		-0.0093	***
							(0.044)		(0.035)		(0.040)		(0.003)		(0.003)		(0.002)	
no qual													-0.1610	***	-0.0604		0.0869	**
													(0.047)		(0.041)		(0.037)	
no dinner													-0.1851	***	-0.0213		0.1651	***
													(0.054)		(0.057)		(0.049)	
no mother t													-0.0788		-0.2287	***	-0.1922	***
													(0.095)		(0.073)		(0.070)	
no clubs													0.3915	***	0.0269		0.0105	
													(0.074)		(0.058)		(0.057)	
gender													0.3823	***	0.0171		0.1019	***
													(0.031)		(0.027)		(0.024)	
born in 1989													0.0329		-0.0128		0.0404	
													(0.048)		(0.031)		(0.029)	
inc-2nd													0.1177	**	0.0050		0.0632	
													(0.058)		(0.061)		(0.054)	
inc-3rd													0.1223	**	-0.0935	*	-0.0169	
													(0.053)		(0.053)		(0.040)	
inc-4th													0.1717	***	-0.0061		0.0044	
													(0.056)		(0.044)		(0.039)	
inc-5th													0.3355	***	0.0012		-0.1505	***
													(0.059)		(0.049)		(0.033)	
other white													0.5195	***	-0.0237		-0.3043	***
													(0.187)		(0.125)		(0.097)	
asian													0.1756	**	-0.1696	***	-0.5671	***
													(0.081)		(0.060)		(0.057)	
caribbean													0.0883		0.2743	***	-0.1690	**
													(0.074)		(0.064)		(0.070)	
other													0.2849	*	-0.0024		-0.4107	***
													(0.152)		(0.108)		(0.095)	
african													0.2601	**	0.1889	**	-0.4108	***
													(0.105)		(0.083)		(0.063)	
pakistani													0.2590	**	0.0887		-0.7564	***
													(0.114)		(0.098)		(0.079)	
bangladeshi													0.0578		0.1990		-0.4040	***
													(0.121)		(0.129)		(0.092)	
chinese													-0.3188		0.3260		-0.2449	
													(1.086)		(0.279)		(0.412)	
Constant	1.2888	***	-0.6024	***	0.2847	***	1.3828	***	-0.6028	***	0.2293	***	0.3218	**	-0.7057	***	0.5619	***
	(0.034)		(0.029)		(0.036)		(0.044)		(0.035)		(0.040)		(0.140)		(0.159)		(0.112)	
Observations	13719						13718						9292					
Standard	errors	in	par	*	p< .10	**	p< .05	***	p< .01									

Table 7: Results for the multivariate probit on the full sample

	(1) just ethnic diversity						(2) neigh level variables						(3) full model					
	sport amusement		civic activities		hang around		sport amusement		civic activities		hang around		sport amusement		civic activities		hang around	
fract	-0.6478	***	0.0162		-1.0544	***	-0.3850	***	0.0383		-1.1655	***	-0.2634	**	0.0264		-0.4617	***
	(0.176)		(0.094)		(0.064)		(0.141)		(0.116)		(0.118)		(0.124)		(0.132)		(0.129)	
segr	-0.2735		-0.3552	***	0.1346		-0.1820		-0.3418	***	0.0891		0.0168		-0.2701	**	0.4519	***
	(0.198)		(0.097)		(0.118)		(0.186)		(0.095)		(0.166)		(0.174)		(0.118)		(0.137)	
idaci	1.2204	***	-0.6059	***	0.2670	***	-0.7588	***	-0.0681		0.3304	*	0.0713		0.2151		0.2207	
	(0.070)		(0.041)		(0.031)		(0.293)		(0.175)		(0.191)		(0.249)		(0.237)		(0.195)	
age mp							1.3177	***	-0.5983	***	0.2261	***	0.0054	**	0.0013		-0.0087	***
							(0.059)		(0.032)		(0.039)		(0.003)		(0.002)		(0.002)	
no qual													-0.1496	***	-0.0628		0.0735	**
													(0.045)		(0.043)		(0.031)	
no dinner													-0.1560	***	-0.0248		0.1538	***
													(0.059)		(0.045)		(0.046)	
no mmother t													-0.2439	***	-0.2724	***	-0.2495	***
													(0.059)		(0.066)		(0.065)	
no clubs													0.3860	***	0.0458		0.0460	
													(0.060)		(0.054)		(0.047)	
gender													0.4570	***	0.0532	**	0.1503	***
													(0.029)		(0.027)		(0.028)	
born in 1989													0.0440		-0.0075		0.0461	
													(0.031)		(0.035)		(0.030)	
inc-2nd													0.1087	**	0.0135		0.0709	*
													(0.048)		(0.047)		(0.039)	
inc-3rd													0.1266	**	-0.0773		0.0022	
													(0.050)		(0.053)		(0.041)	
inc-4th													0.2091	***	0.0134		0.0359	
													(0.052)		(0.042)		(0.042)	
inc-5th													0.3754	***	0.0302		-0.1016	***
													(0.058)		(0.048)		(0.035)	
other white													0.4963	***	-0.0021		-0.2664	**
													(0.174)		(0.124)		(0.123)	
asian													-0.0063		-0.1833	***	-0.5803	***
													(0.066)		(0.066)		(0.049)	
caribbean													0.0831		0.2761	***	-0.1523	**
													(0.077)		(0.073)		(0.061)	
other													0.1034		-0.0216		-0.4152	***
													(0.116)		(0.105)		(0.089)	
african													0.1260		0.1697	**	-0.4131	***
													(0.080)		(0.084)		(0.072)	
pakistani													-0.1952	***	-0.0107		-0.8281	***
													(0.064)		(0.107)		(0.066)	
bangladeshi													-0.2874	***	0.0695		-0.5215	***
													(0.081)		(0.116)		(0.092)	
chinese													-0.4455	*	0.2050		-0.3641	
													(0.265)		(0.322)		(0.278)	
Constant	1.2204	***	-0.6059	***	0.2670	***	1.3177	***	-0.5983	***	0.2261	***	0.2274		-0.7640	***	0.4196	***
	(0.070)		(0.041)		(0.031)		(0.059)		(0.032)		(0.039)		(0.168)		(0.107)		(0.098)	
Observations	14692						14691						9772					
Standard	errors	in	par	*	p¡.10	**	p¡.05	***	p¡.01									

Table 8: Correlations between the dependent variables

	sub sample					
	just ethnic		neighborhood		full	
ρ_{21}	0.0712	***	0.0767	***	0.0588	***
	(0.018)		(0.018)		(0.023)	
ρ_{31}	-0.0985	***	-0.0924	***	-0.0703	***
	(0.015)		(0.015)		(0.021)	
ρ_{32}	-0.0551	***	-0.0535	***	-0.0526	***
	(0.014)		(0.015)		(0.018)	
Observations	13719		13718		9292	
	full sample					
	just ethnic		neighborhood		full	
ρ_{21}	0.2045	***	0.2130	***	0.1741	***
	(0.013)		(0.020)		(0.018)	
ρ_{31}	0.1759	***	0.1699	***	0.1307	***
	(0.026)		(0.014)		(0.019)	
ρ_{32}	0.0151		0.0135		0.0033	
	(0.018)		(0.016)		(0.018)	
Observations	14692		14691		9772	
*	p<.10	**	p<.05	***	p<.01	

Table 9: First stage regression (linear, means at the district level)

	just segregation endogenous		both indices endogenous			
	segregation		segregation		fractionalization	
dist mill towns	-0.0003	***	-0.0002	***	0.0000	
dist ports			0.0002		-0.0003	**
fract	0.3940	***				
idaci	0.2912	***	0.3420	***	0.0775	
no dinner	0.0337		0.0280		-0.0088	
no mother tongue	-0.1546		0.0503		0.5359	***
no clubs	0.0463		0.0339		-0.0124	
other white	-0.1865		-0.0339		0.3825	***
indian	0.3337	***	0.4830	***	0.4248	***
caribbean	-0.3234	**	0.0516		0.9927	***
mixed	-0.1051		0.0033		0.2227	
african	-0.6125	***	-0.3610	**	0.5440	***
pakistani	0.6465	***	0.8241	***	0.4220	***
bangladeshi	-0.4416	***	-0.1869		0.6471	***
chinese	0.7073		0.7117		-0.0348	
fam controls	yes		yes		yes	
ind controls	yes		yes		yes	
Constant	0.2802	**	0.1502		-0.2408	**
F test on the excluded instruments	34.53		28.96		8.51	
Observations	308		308			

Table 10: Second stages on the sub sample of those involved in at least one form of participation

	just segregation endogenous						both endogenous					
	sport amusement		civic activities		hang around		sport amusement		civic activities		hang around	
fract	-0.0657		0.1520		-0.4495	***	-0.1432		0.1910		-0.4651	***
	(0.157)		(0.126)		(0.133)		(0.184)		(0.175)		(0.150)	
segr	0.2177		-0.7288	***	0.8372	***	0.1091		-0.6474	***	0.8534	***
	(0.290)		(0.220)		(0.235)		(0.299)		(0.250)		(0.248)	
Residuals segr	-0.1675		0.8613	***	-0.6341		-0.0771		0.7766	**	-0.6877	*
	(0.398)		(0.321)		(0.403)		(0.424)		(0.333)		(0.407)	
residuals fragm							0.4119		-0.5048		0.3238	
							(0.417)		(0.382)		(0.335)	
idaci	-0.0920		0.3542		0.0775		-0.0055		0.3031		0.0755	
	(0.215)		(0.232)		(0.240)		(0.230)		(0.231)		(0.247)	
age mp	0.0070	***	0.0015		-0.0092	***	0.0070	***	0.0014		-0.0092	***
	(0.003)		(0.003)		(0.002)		(0.003)		(0.003)		(0.002)	
no qual	-0.1599	***	-0.0635		0.0888	**	-0.1587	***	-0.0645		0.0893	**
	(0.047)		(0.041)		(0.037)		(0.047)		(0.042)		(0.037)	
no dinner	-0.1845	***	-0.0204		0.1641	***	-0.1846	***	-0.0208		0.1645	***
	(0.054)		(0.057)		(0.049)		(0.054)		(0.056)		(0.048)	
no mmother t	-0.0788		-0.2327	***	-0.1900	***	-0.0762		-0.2342	***	-0.1890	***
	(0.095)		(0.074)		(0.071)		(0.095)		(0.074)		(0.070)	
no clubs	0.3900	***	0.0283		0.0096		0.3896	***	0.0288		0.0093	
	(0.074)		(0.058)		(0.057)		(0.074)		(0.058)		(0.057)	
gender	0.3832	***	0.0162		0.1037	***	0.3841	***	0.0160		0.1037	***
	(0.032)		(0.027)		(0.024)		(0.032)		(0.027)		(0.024)	
born in 1989	0.0332		-0.0111		0.0388		0.0333		-0.0109		0.0385	
	(0.048)		(0.032)		(0.030)		(0.048)		(0.032)		(0.030)	
inc-2nd	0.1184	**	0.0068		0.0617		0.1190	**	0.0069		0.0618	
	(0.058)		(0.062)		(0.053)		(0.058)		(0.062)		(0.053)	
inc-3rd	0.1230	**	-0.0920	*	-0.0185		0.1230	**	-0.0919	*	-0.0187	
	(0.053)		(0.053)		(0.039)		(0.053)		(0.053)		(0.039)	
inc-4th	0.1742	***	-0.0063		0.0037		0.1740	***	-0.0061		0.0036	
	(0.056)		(0.045)		(0.038)		(0.056)		(0.045)		(0.038)	
inc-5th	0.3365	***	-0.0002		-0.1489	***	0.3381	***	-0.0013		-0.1483	***
	(0.059)		(0.049)		(0.033)		(0.059)		(0.049)		(0.033)	
other white	0.5250	***	-0.0370		-0.2934	***	0.5316	***	-0.0396		-0.2918	***
	(0.186)		(0.127)		(0.096)		(0.187)		(0.127)		(0.096)	
asian	0.1723	**	-0.1507	**	-0.5786	***	0.1887	**	-0.1592	**	-0.5782	***
	(0.082)		(0.060)		(0.057)		(0.083)		(0.065)		(0.056)	
caribbean	0.0908		0.2682	***	-0.1640	**	0.1022		0.2636	***	-0.1625	**
	(0.075)		(0.063)		(0.071)		(0.072)		(0.068)		(0.071)	
other	0.2844	*	-0.0057		-0.4039	***	0.2927	*	-0.0104		-0.4028	***
	(0.153)		(0.108)		(0.095)		(0.155)		(0.111)		(0.098)	
african	0.2634	**	0.1708	**	-0.3981	***	0.2748	***	0.1659	*	-0.3952	***
	(0.107)		(0.083)		(0.063)		(0.106)		(0.087)		(0.063)	
pakistani	0.2498	**	0.1282		-0.7841	***	0.2624	**	0.1205		-0.7859	***
	(0.116)		(0.102)		(0.076)		(0.113)		(0.105)		(0.074)	
bangladeshi	0.0653		0.1648		-0.3798	***	0.0762		0.1607		-0.3761	***
	(0.126)		(0.123)		(0.093)		(0.127)		(0.123)		(0.092)	
chinese	-0.3215		0.3390		-0.2586		-0.3122		0.3347		-0.2586	
	(1.091)		(0.276)		(0.408)		(1.087)		(0.278)		(0.403)	
Constant	0.3096	**	-0.6461	***	0.5174	***	0.3218	**	-0.6568	***	0.5156	***
	(0.151)		(0.157)		(0.116)		(0.156)		(0.159)		(0.117)	
Observations	9292						9292					
Standard	errors	in	par.	*	p<.10	**	p<.05	***	p<.01			

Table 11: Second stages on the full sample

	just segregation endogenous						both endogenous					
	sport amusement		civic activities		hang around		sport amusement		civic activities		hang around	
fract	-0.2704	**	0.0861		-0.4995	***	-0.3546	**	0.1100		-0.5277	***
	(0.133)		(0.130)		(0.129)		(0.170)		(0.168)		(0.119)	
segr	0.0690		-0.6974	***	0.7725	***	-0.0449		-0.6400	***	0.7673	***
	(0.293)		(0.162)		(0.240)		(0.281)		(0.202)		(0.254)	
Residuals segr	-0.1235		0.8130	***	-0.6022	*	-0.0296		0.7512	**	-0.6332	**
	(0.452)		(0.311)		(0.312)		(0.458)		(0.340)		(0.296)	
residuals fragm							0.4297		-0.4211		0.3661	
							(0.413)		(0.286)		(0.315)	
idaci	0.0489		0.3591		0.1080		0.1432		0.3256		0.1223	
	(0.245)		(0.230)		(0.209)		(0.276)		(0.233)		(0.221)	
age mp	0.0055	**	0.0014		-0.0084	***	0.0056	**	0.0014		-0.0084	***
	(0.003)		(0.002)		(0.002)		(0.003)		(0.002)		(0.002)	
no qual	-0.1484	***	-0.0644		0.0742	**	-0.1465	***	-0.0650		0.0749	**
	(0.045)		(0.043)		(0.031)		(0.045)		(0.044)		(0.032)	
no dinner	-0.1562	***	-0.0302		0.1495	***	-0.1568	***	-0.0305		0.1497	***
	(0.059)		(0.045)		(0.047)		(0.058)		(0.045)		(0.046)	
no mmother t	-0.2424	***	-0.2794	***	-0.2484	***	-0.2385	***	-0.2805	***	-0.2469	***
	(0.059)		(0.064)		(0.066)		(0.059)		(0.065)		(0.065)	
no clubs	0.3823	***	0.0456		0.0435		0.3809	***	0.0461		0.0428	
	(0.060)		(0.055)		(0.047)		(0.060)		(0.055)		(0.047)	
gender	0.4561	***	0.0536	**	0.1503	***	0.4563	***	0.0536	**	0.1502	***
	(0.029)		(0.027)		(0.027)		(0.029)		(0.027)		(0.027)	
born in 1989	0.0437		-0.0087		0.0437		0.0443		-0.0084		0.0435	
	(0.031)		(0.035)		(0.031)		(0.031)		(0.035)		(0.031)	
inc-2nd	0.1099	**	0.0155		0.0706	*	0.1104	**	0.0154		0.0708	*
	(0.049)		(0.047)		(0.039)		(0.049)		(0.047)		(0.039)	
inc-3rd	0.1272	**	-0.0763		0.0009		0.1271	**	-0.0763		0.0007	
	(0.050)		(0.052)		(0.041)		(0.050)		(0.052)		(0.041)	
inc-4th	0.2072	***	0.0136		0.0352		0.2066	***	0.0137		0.0351	
	(0.052)		(0.041)		(0.043)		(0.052)		(0.041)		(0.043)	
inc-5th	0.3749	***	0.0270		-0.1045	***	0.3763	***	0.0262		-0.1038	***
	(0.057)		(0.047)		(0.036)		(0.057)		(0.047)		(0.036)	
other white	0.4935	***	-0.0069		-0.2531	**	0.5019	***	-0.0083		-0.2505	**
	(0.174)		(0.122)		(0.122)		(0.174)		(0.123)		(0.123)	
asian	-0.0068		-0.1721	***	-0.5980	***	0.0115		-0.1774	***	-0.5945	***
	(0.064)		(0.062)		(0.048)		(0.065)		(0.067)		(0.048)	
caribbean	0.0869		0.2679	***	-0.1503	**	0.0988		0.2653	***	-0.1471	**
	(0.077)		(0.071)		(0.062)		(0.076)		(0.076)		(0.062)	
other	0.1034		-0.0218		-0.4188	***	0.1124		-0.0249		-0.4164	***
	(0.116)		(0.105)		(0.089)		(0.116)		(0.106)		(0.089)	
african	0.1252		0.1540	*	-0.3982	***	0.1376	*	0.1511	*	-0.3936	***
	(0.079)		(0.084)		(0.071)		(0.078)		(0.087)		(0.070)	
pakistani	-0.1993	***	0.0281		-0.8588	***	-0.1859	***	0.0226		-0.8582	***
	(0.065)		(0.110)		(0.067)		(0.064)		(0.112)		(0.066)	
bangladeshi	-0.2855	***	0.0351		-0.5049	***	-0.2755	***	0.0328		-0.4999	***
	(0.085)		(0.108)		(0.098)		(0.085)		(0.108)		(0.098)	
chinese	-0.4616	*	0.2418		-0.3507		-0.4535	*	0.2391		-0.3494	
	(0.265)		(0.318)		(0.274)		(0.264)		(0.317)		(0.272)	
Constant	0.2208		-0.7136	***	0.3747	***	0.2334		-0.7214	***	0.3758	***
	(0.173)		(0.109)		(0.097)		(0.174)		(0.113)		(0.098)	
Observations	9772						9772					
Standard	errors	in	par.	*	p<.10	**	p<.05	***	p<.01			

Table 12: Second stages: correlations between the dependent variables

	subsample			
	just segregation		both indices	
	endogenous		endogenous	
ρ_{21}	0.0526	**	0.0526	**
	(0.022)		(0.022)	
ρ_{31}	-0.0742	***	-0.0743	***
	(0.018)		(0.018)	
ρ_{32}	-0.0631	***	-0.0629	***
	(0.016)		(0.017)	
Observations	9292		9292	
	full sample			
ρ_{21}	0.1865	***	0.1865	***
	(0.020)		(0.020)	
ρ_{31}	0.1430	***	0.1429	***
	(0.018)		(0.019)	
ρ_{32}	-0.0140		-0.0139	
	(0.017)		(0.017)	
Observations	9772		9772	
Standard	errors	in	parentheses	
*p<.10	**	p<.05	***	p<.01

Table 13: Results for the seemingly unrelated models

	sub-sample						full sample					
	sports amusements		civic activities		hang about		sports amusements		civic activities		hang about	
fract	-0.0059		0.0329		-0.1547	***	-0.0531		0.0129		-0.1713	***
	(-0.025)		(-0.052)		(-0.049)		(-0.036)		(-0.045)		(-0.052)	
segr	0.0197		-0.0894	*	0.188	***	0.0034		-0.0848	**	0.1695	***
	(-0.028)		(-0.047)		(-0.053)		(-0.029)		(-0.042)		(-0.054)	
idaci	-0.0124		0.0695		0.0708		0.0117		0.0695		0.0802	
	(-0.037)		(-0.071)		(-0.061)		(-0.054)		(-0.07)		(-0.07)	
age main parent	0.0012	**	0.0005		-0.0035	***	0.0011	*	0.0005		-0.0032	***
	(-0.001)		(-0.001)		(-0.001)		(-0.001)		(-0.001)		(-0.001)	
no qualification	-0.0302	***	-0.0198		0.0322	**	-0.0357	***	-0.0199		0.0267	**
	(-0.008)		(-0.012)		(-0.014)		(-0.012)		(-0.013)		(-0.011)	
no dinner	-0.0354	***	-0.0073		0.062	***	-0.0356	**	-0.0071		0.0583	***
	(-0.013)		(-0.013)		(-0.017)		(-0.014)		(-0.016)		(-0.018)	
no mother tongue	-0.0099		-0.0718	***	-0.0723	**	-0.0688	***	-0.0788	***	-0.0906	***
	(-0.015		(-0.023)		(-0.031)		(-0.015)		(-0.023)		(-0.024)	
no clubs	0.0827	***	0.0083		0.0037		0.0997	***	0.0144		0.0173	
	(-0.015		(-0.021)		(-0.022)		(-0.019)		(-0.015)		(-0.019)	
gender	0.0623	***	0.0051		0.0392	***	0.0965	***	0.0161	*	0.0566	***
	(-0.006		(-0.01)		(-0.01)		(-0.007)		(-0.009)		(-0.011)	
born in 1989	0.0048		-0.0039		0.0152		0.0086		-0.0022		0.0173	**
	(-0.006		(-0.01)		(-0.01)		(-0.007)		(-0.01)		(-0.009)	
inc-2nd	0.0237	**	0.0018		0.0229		0.0279	**	0.0038		0.026	
	(-0.011		(-0.016)		(-0.018)		(-0.012)		(-0.015)		(-0.016)	
inc-3rd	0.0235	**	-0.0297	**	-0.0072		0.0322	***	-0.0243		0.0004	
	(-0.01		(-0.015)		(-0.014)		(-0.012)		(-0.015)		(-0.016)	
inc-4th	0.0316	***	-0.0019		0.0014		0.048	***	0.0041		0.0128	
	(-0.011)		(-0.013)		(-0.016)		(-0.012)		(-0.013)		(-0.018)	
inc-5th	0.055	***	-0.0001		-0.0573	***	0.077	***	0.0076		-0.0404	**
	(-0.01)		(-0.016)		(-0.014)		(-0.011)		(-0.016)		(-0.017)	
other white	0.0688	***	-0.0082		-0.1193	**	0.0882	***	-0.0026		-0.1071	**
	(-0.019)		(-0.036)		(-0.047)		(-0.019)		(-0.037)		(-0.044)	
indian	0.0264	**	-0.0506	**	-0.2195	***	-0.0012		-0.0535	***	-0.2264	***
	(-0.011)		(-0.02)		(-0.022)		(-0.017)		(-0.017)		(-0.018)	
caribbean	0.0149		0.0962	***	-0.064	***	0.0183		0.0944	***	-0.0602	***
	(-0.012)		(-0.026)		(-0.023)		(-0.016)		(-0.022)		(-0.022)	
mixed	0.0436	**	-0.0023		-0.1587	***	0.0213		-0.0059		-0.1626	***
	(-0.019)		(-0.032)		(-0.035)		(-0.024)		(-0.03)		(-0.036)	
african	0.0398	***	0.0639	**	-0.1601	***	0.0246		0.0558	**	-0.1628	***
	(-0.014)		(-0.03)		(-0.027)		(-0.017)		(-0.027)		(-0.027)	
pakistani	0.0392	***	0.0275		-0.2893	***	-0.057	***	-0.0013		-0.3134	***
	(-0.014)		(-0.032)		(-0.027)		(-0.02)		(-0.025)		(-0.025)	
bangladeshi	0.0034		0.0658		-0.1557	***	-0.1001	***	0.0239		-0.2023	***
	(-0.024)		(-0.04)		(-0.037)		(-0.024)		(-0.037)		(-0.034)	
chinese	-0.0552		0.1094		-0.0954		-0.1145		0.0715		-0.1364	
	(-0.083)		(-0.094)		(-0.129)		(-0.084)		(-0.085)		(-0.106)	
Constant	0.7161	***	0.2402	***	0.7155	***	0.6517	***	0.2194	***	0.6599	***
	(-0.032)		(-0.042)		(-0.04)		(-0.042)		(-0.04)		(-0.039)	
Observations	9292						9772					
st	errors	in	par	*	$p < .10$	**	$p < .05$	***	$p < .01$			

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[51] The data in tables 2, 1, 4 and 5 are weighted. In table 8 the variable 1 is 'sports and amusements', the variable 2 is 'civic activities' and the variable 3 is 'hanging around'. In table 9 the covariates are means at the district level of all individual controls in tables 7 and 8. In tables 6, 7, 8, 9, 10, 11, 12 standard errors are clustered by districts and, in tables 10, 11, 12, 13, 14, 15 they are also bootstrapped to account for the generated variable problem.

Table 14: Results for the seemingly unrelated models: second stages: sub sample

	just segregation endogenous			both endogenous		
	sports amusements	civic activities	hang about	sports amusements	civic activities	hang about
fract	-0.0077	0.0524	-0.1735***			
	(0.026)	(0.048)	(0.053)			
fract (fitted)				-0.0204	0.0688	-0.1793***
				(0.031)	(0.051)	(0.055)
segr (fitted)	0.0330	-0.2413***	0.3261***	0.0232	-0.2243***	0.3271***
	(0.045)	(0.075)	(0.087)	(0.044)	(0.068)	(0.088)
idaci	-0.0172	0.1235	0.0208	-0.0043	0.1041	0.0206
	(0.038)	(0.081)	(0.088)	(0.042)	(0.069)	(0.077)
age main parent	0.0012**	0.0004	-0.0035***	0.0012**	0.0004	-0.0034***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
no qualification	-0.0301***	-0.0200*	0.0329**	-0.0301***	-0.0198	0.0332**
	(0.009)	(0.011)	(0.014)	(0.008)	(0.013)	(0.015)
no dinner	-0.0354***	-0.0076	0.0624***	-0.0354***	-0.0076	0.0626***
	(0.012)	(0.017)	(0.021)	(0.013)	(0.017)	(0.019)
no mother tongue	-0.0098	-0.0735***	-0.0706***	-0.0094	-0.0739***	-0.0701**
	(0.016)	(0.022)	(0.027)	(0.016)	(0.021)	(0.028)
no clubs	0.0826***	0.0086	0.0030	0.0826***	0.0088	0.0029
	(0.018)	(0.020)	(0.025)	(0.015)	(0.019)	(0.022)
gender	0.0623***	0.0051	0.0393***	0.0622***	0.0053	0.0394***
	(0.007)	(0.010)	(0.011)	(0.005)	(0.010)	(0.010)
born in 1989	0.0047	-0.0037	0.0146	0.0048	-0.0037	0.0145
	(0.007)	(0.009)	(0.012)	(0.007)	(0.011)	(0.011)
inc-2nd	0.0237*	0.0020	0.0229	0.0236**	0.0021	0.0230
	(0.012)	(0.019)	(0.018)	(0.012)	(0.017)	(0.016)
inc-3rd	0.0236**	-0.0295**	-0.0071	0.0235**	-0.0294*	-0.0071
	(0.012)	(0.014)	(0.014)	(0.011)	(0.015)	(0.015)
inc-4th	0.0317***	-0.0019	0.0015	0.0317***	-0.0019	0.0014
	(0.011)	(0.016)	(0.016)	(0.011)	(0.013)	(0.015)
inc-5th	0.0550***	-0.0003	-0.0573***	0.0552***	-0.0007	-0.0571***
	(0.011)	(0.015)	(0.016)	(0.011)	(0.013)	(0.014)
other white	0.0691***	-0.0126	-0.1153***	0.0706***	-0.0145	-0.1149***
	(0.020)	(0.041)	(0.044)	(0.018)	(0.031)	(0.040)
indian	0.0260**	-0.0441**	-0.2239***	0.0284***	-0.0475***	-0.2238***
	(0.011)	(0.019)	(0.025)	(0.010)	(0.018)	(0.024)
caribbean	0.0151	0.0945***	-0.0617***	0.0175	0.0909***	-0.0617***
	(0.013)	(0.027)	(0.021)	(0.013)	(0.023)	(0.022)
mixed	0.0435**	-0.0022	-0.1594***	0.0454**	-0.0052	-0.1592***
	(0.021)	(0.027)	(0.040)	(0.018)	(0.033)	(0.038)
african	0.0403***	0.0575*	-0.1548***	0.0428***	0.0540*	-0.1540***
	(0.014)	(0.031)	(0.029)	(0.014)	(0.030)	(0.028)
pakistani	0.0381**	0.0419	-0.3010***	0.0407***	0.0369	-0.3024***
	(0.016)	(0.031)	(0.033)	(0.013)	(0.032)	(0.030)
bangladeshi	0.0044	0.0557	-0.1459***	0.0064	0.0531	-0.1448***
	(0.022)	(0.038)	(0.042)	(0.022)	(0.044)	(0.043)
chinese	-0.0557	0.1140	-0.1001	-0.0543	0.1119	-0.1001
	(0.085)	(0.104)	(0.116)	(0.074)	(0.112)	(0.125)
Constant	0.7145***	0.2604***	0.6990***	0.7155***	0.2585***	0.6988***
	(0.035)	(0.042)	(0.045)	(0.032)	(0.046)	(0.035)
Observations	9292			9292		

st errors in par * $p < .10$ ** $p < .05$ *** $p < .01$

Table 15: Results for the seemingly unrelated models: second stages: full sample

	just segregation endogenous						both endogenous					
	sports amusements		civic activities		hang about		sports amusements		civic activities		hang about	
fract	-0.0542		0.0300		-0.1889	***						
	(0.038)		(0.046)		(0.048)							
fract (fitted)							-0.0773	*	0.0433		-0.1977	***
							(0.045)		(0.049)		(0.052)	
segr (fitted)	0.0128		-0.2197	***	0.2964	***	-0.0143		-0.2081	***	0.2894	***
	(0.067)		(0.056)		(0.101)		(0.061)		(0.073)		(0.099)	
idaci	0.0086		0.1153	*	0.0367		0.0334		0.0997		0.0411	
	(0.056)		(0.059)		(0.078)		(0.064)		(0.069)		(0.082)	
age main parent	0.0011	**	0.0004		-0.0032	***	0.0012	**	0.0004		-0.0032	***
	(0.001)		(0.001)		(0.001)		(0.001)		(0.001)		(0.001)	
no qualification	-0.0357	***	-0.0200		0.0273	*	-0.0353	***	-0.0197	*	0.0277	**
	(0.012)		(0.013)		(0.014)		(0.010)		(0.011)		(0.013)	
no dinner	-0.0356	**	-0.0073		0.0585	***	-0.0357	**	-0.0072		0.0586	***
	(0.014)		(0.014)		(0.015)		(0.016)		(0.015)		(0.018)	
no mother tongue	-0.0687	***	-0.0799	***	-0.0894	***	-0.0677	***	-0.0801	***	-0.0887	***
	(0.017)		(0.019)		(0.024)		(0.018)		(0.024)		(0.026)	
no clubs	0.0997	***	0.0147		0.0165		0.0993	***	0.0148		0.0163	
	(0.015)		(0.017)		(0.020)		(0.017)		(0.015)		(0.022)	
gender	0.0965	***	0.0161	*	0.0567	***	0.0965	***	0.0163	**	0.0568	***
	(0.007)		(0.009)		(0.011)		(0.007)		(0.008)		(0.010)	
born in 1989	0.0086		-0.0019		0.0168	*	0.0086		-0.0019		0.0167	*
	(0.007)		(0.008)		(0.009)		(0.006)		(0.009)		(0.009)	
inc-2nd	0.0279	**	0.0041		0.0257		0.0278	**	0.0042		0.0259	*
	(0.012)		(0.016)		(0.016)		(0.012)		(0.017)		(0.015)	
inc-3rd	0.0321	***	-0.0239	*	0.0003		0.0321	***	-0.0238		0.0002	
	(0.012)		(0.014)		(0.015)		(0.011)		(0.015)		(0.015)	
inc-4th	0.0480	***	0.0041		0.0129		0.0479	***	0.0041		0.0127	
	(0.012)		(0.014)		(0.017)		(0.012)		(0.014)		(0.015)	
inc-5th	0.0770	***	0.0074		-0.0405	***	0.0773	***	0.0071		-0.0401	***
	(0.012)		(0.014)		(0.015)		(0.011)		(0.014)		(0.014)	
other white	0.0884	***	-0.0065		-0.1034	**	0.0906	***	-0.0082		-0.1029	**
	(0.025)		(0.034)		(0.045)		(0.021)		(0.037)		(0.040)	
indian	-0.0017		-0.0476	***	-0.2305	***	0.0030		-0.0504	***	-0.2296	***
	(0.016)		(0.018)		(0.022)		(0.015)		(0.016)		(0.018)	
caribbean	0.0184		0.0930	***	-0.0581	**	0.0218		0.0896	***	-0.0580	**
	(0.014)		(0.022)		(0.025)		(0.015)		(0.021)		(0.025)	
mixed	0.0213		-0.0060		-0.1626	***	0.0238		-0.0087		-0.1623	***
	(0.026)		(0.031)		(0.033)		(0.025)		(0.028)		(0.040)	
african	0.0250		0.0502	*	-0.1577	***	0.0286		0.0469		-0.1568	***
	(0.018)		(0.030)		(0.025)		(0.022)		(0.030)		(0.026)	
pakistani	-0.0579	**	0.0121		-0.3248	***	-0.0541	***	0.0075		-0.3257	***
	(0.023)		(0.024)		(0.022)		(0.019)		(0.028)		(0.026)	
bangladeshi	-0.0995	***	0.0151		-0.1936	***	-0.0965	***	0.0127		-0.1925	***
	(0.026)		(0.027)		(0.038)		(0.028)		(0.033)		(0.038)	
chinese	-0.1147		0.0744		-0.1390		-0.1126		0.0725		-0.1388	
	(0.098)		(0.086)		(0.107)		(0.088)		(0.087)		(0.102)	
Constant	0.6504	***	0.2373	***	0.6448	***	0.6536	***	0.2361	***	0.6457	***
	(0.037)		(0.040)		(0.044)		(0.037)		(0.041)		(0.041)	
Observations	9772						9772					
st	errors	in	par	*	$p < .10$	**	$p < .05$	***	$p < .01$			

Appendix 4: Graphs

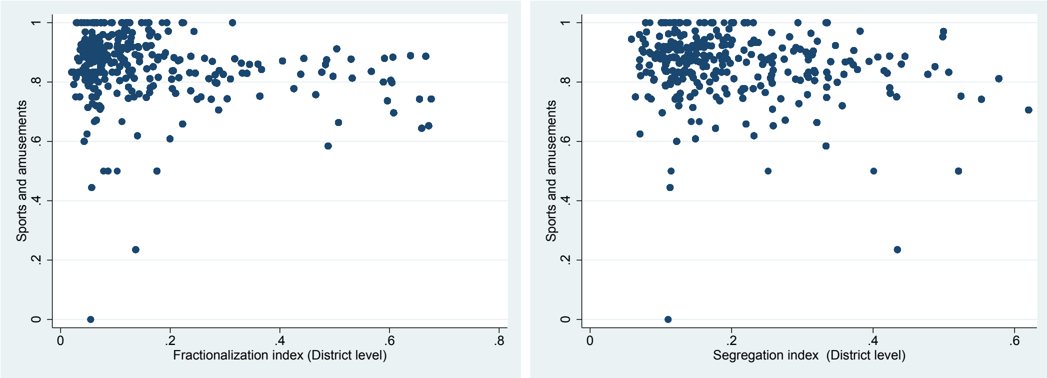

Figure 1: Ethnic diversity and participation in sports-amusements

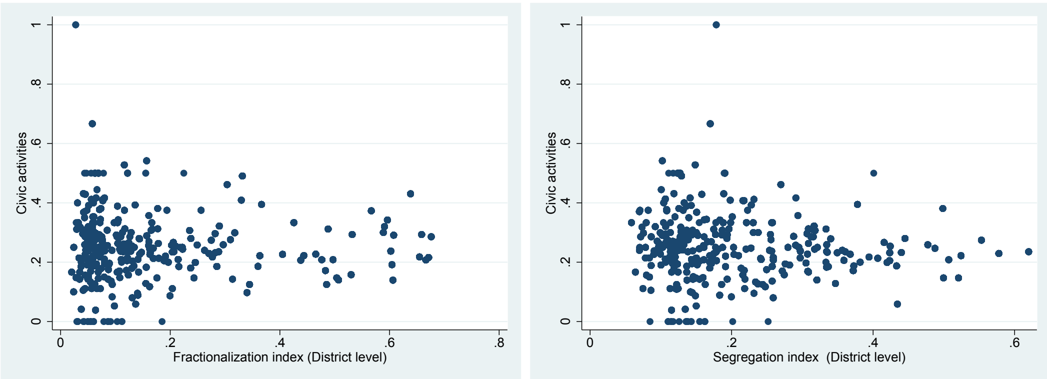

Figure 2: Ethnic diversity and civic participation

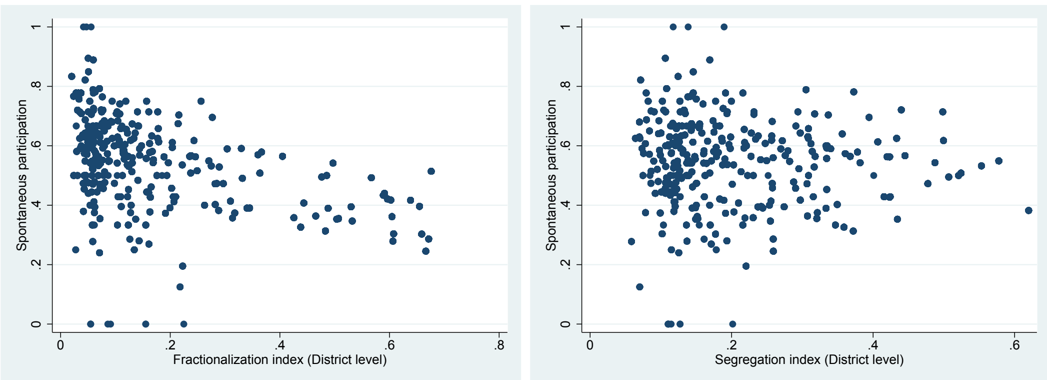

Figure 3: Ethnic diversity and spontaneous participation

Chapter 2

Average and distributional effects of the American Folic Acid Fortification: an evaluation in a quasi-experimental framework[1]

Abstract

The American program of folic acid fortification has increased the average amount of serum folate in the population and as such is deemed a successful public health intervention. We consider the effect of the fortification in a quasi experimental framework, evaluating also its distributional effects. We use several waves of the National Health and Nutrition Examination Survey (NHANES) to assess the effect of fortification on inequalities both in serum folate concentration and in Vitamin C, used as a proxy of the changes in nutritional habits. We find a reduction in inequality of both nutrients. We focus on the effect of the consumption of fortified ready to eat cereals computing the average treatment effect by using matching methods to solve the problem of selection on observables. In addition, we compute the quantile treatment effects on serum folate concentration, both under the assumption of rank invariance and relaxing it. We find a significant variability in the impact distribution, thus rejecting the common effects model. Finally, we correct our estimates by controlling for the change in dietary patterns, using the concentration of beta-carotene as a proxy.

KEYWORDS: Folic acid fortification, inequality, quantile treatment effect, matching, public policy.

[1] I am grateful to Jerome Adda, Agar Brugiavini, Eric Brunner, Laura Fumagalli and Mario Padula for helpful comments and suggestions

2.1) Introduction

The benefits and the possible harmful effects of a folic acid fortification are under debate in many countries. In fact, a sufficient intake of folic acid for women in the first weeks of the pregnancy and before its start decreases the probabilities to give birth to a baby affected by spina bifida, anencephaly and other neural tube defects (NTDs). In addition, an increase of concentration in folic acid could lower the incidence of cardiovascular diseases and cancer, even if the causal effect is not highly significant (Hung et al., 2003).

In the nineties several ways of tackling the problem of folate deficiency have been proposed. The first option consists in improving the dietary habits through information campaigns warning against the dangers of the diseases associated with low levels of folate[2]. In fact, many foods, in particular the green leafy ones, contain a high amount of dietary folate (the natural equivalent of folic acid), and it has been noticed that the women who follow the "U.S. Dietary Guidelines for Americans" and the "U.S. Dietary Pyramid" are able to reach 0.4 mg of folic acid a day, which is the amount of the nutrient needed to reduce the cases of NTDs of about 50% according to the "Centers for Disease Control" (CDC, 2002, 41(RR-14);001). Another available option is the fortification of some common products with chemical folic acid. It is worth noting that 1 mg of folic acid is equivalent to 1.7 mg of natural folate, when we consider their capacity to be transformed into serum folate in blood. The third option is taking dietary supplements in pills.
All the three alternatives have pros and cons. The first policy could increase the socioeconomic differences in health. The campaign could have a stronger impact on more educated and well-do individuals, who are less likely to be folate-deficient, since they are already more likely to follow a better diet. On the contrary, the compulsory fortification is the only policy which ensures the almost total coverage of the population and that "forces" people to consume the suggested amount of folic acid during the entire year, thus making even the unplanned pregnancies less risky. However, perhaps the main drawback is that such a policy can not be targeted on the more risky group. In addition, if the spread of supplemented foods is very large, it is impossible to "opt out" from the treatment, also for the ones who could be harmed by overconsumption. Finally, on the more philosophical point of view, one could argue that the State should not decide about the citizens' health without making them conscious of it. The third option is both potentially harmful and not effective since compliance is difficult to be achieved. For all these reasons, it can be considered just an ancillary tool.
The USA was the first country that tried to solve the problem of deficiencies in serum folate concentration, immediately followed by Canada and, later, by Chile and Australia. On the contrary, none of the European countries has yet followed the American example,

[2] An individual is considered depleted if her serum folate falls below the critical value of 7 nmol/L (see Jacques et al, 1999)

due to the still poor knowledge of the potential negative effects of unmetabolized folic acid. In many cases, the beginning of the intervention has been delayed due to concerns aroused after the initial enthusiasm that followed the implementation of the policy in the USA.[3]
Our paper focuses on the American supplementation, both because its ethnical and social diversified composition can provide some hints on the effect of the fortification on different ethnic groups, and because we can exploit the richness of the NHANES dataset.
The American effort to increase the folic acid intake in the target population started in 1992, when the US public health service recommended to women a high consumption of the nutrient, in order to limit the cases of NTDs which affect around 1/1000 livebirths in the country (Hernandez-Diaz et al 2001). At the same time as the recommendation started, a huge awareness campaign took place. However, just the 30% of women followed the advice. As a consequence, in 1996 the American government decided to recommend the folic acid fortification which became mandatory on 1 January 1998. Since that date, the US "Food and Drug administration" (FDA) ordered to fortificate with (chemical) folic acid (140 micrograms into 100 grams of grain) all the enriched (with niacin, thiamin, and riboflavin) cereal grain products.

The paper has two different goals. On the policy point of view, it adds more evidence to the analysis of pros and cons of a widely debated public health policy, trying to identify separately the direct effects of the fortification itself (and its second order consequences) and the changes in dietary patterns, using concentrations of vitamin C and beta-carotene as proxies of nutritional habits. On the methodological one, it applies new econometric techniques which have never been used in the medical literature. In addition, the paper can be included in the growing stream of research which evaluates the distributional effects of public policies, claiming that much is missed when just the average treatment effect is analyzed. Finally, the paper assesses the effect of the fortification on interesting groups (the depleted, for example) under alternative assumptions on the dependency of the potential outcomes in the treatment and in the control groups.

This paper is organized as follows. In section 2 we describe the previous evaluation both in an experimental and a not experimental framework underlying our contribution in the literature. In section 3 we present the descriptive evidence, the methods we use to evaluate the policy and the main results. Finally, in section 4, we address the problem of identifying the changes in nutritional habits. Section 5 concludes.

[3] In the UK, for example, in May 2007, the Food Standards Agency Board recommended the fortification of bread with folic acid. However, in October of the same year, the Chief Medical Officer (CMO) asked the Scientific Advisory Committee on Nutrition (SACN) to review some more medical evidence before implementing the policy. After the review, in October 2009, the SACN did not change its previous recommendation. See: SACN(2008)

2.2) Background

2.2.1) Previous evaluations

Many researchers, active in different scientific fields, evaluated the effect of the fortification, under multiple points of view.[4] Grosse et al. (2005), performing both a cost benefit (CBA) and a cost effectiveness analysis (CEA), estimate a fortification cost equal to 3 million dollars (due to price of fortificant and changes in labels of the fortified products) and they find a positive (economic) effect of the policy, even in the worst scenario considered (negative effect of folate with respect to anemia, importance of factors different from folate in preventing Neural tube defects, higher fortification costs).
Many evaluations of the folic acid fortification have been carried out: some assessed the effect of the governmental action on the incidence of NTDs in the period following the fortification; others measured the effect of the fortification in an experimental framework. Finally a group of evaluations compared the average level of serum folate in the population before and after 1998, using the National Health and Nutrition Examination Survey (NHANES). More recent evaluations assessed the distributional effects of the policy (mainly its different impact on people belonging to different ethnic groups) and its potential negative effects, due to folic acid overconsumption and its interactions with particular pathologies, i.e. the deficiency of vitamin B12 (see Morrison, 2007).
The effect of the fortification on the decrease in the incidence of NTDs in the USA is under debate. Hernandez-Diaz et al. (2001) used a controlled experiment and found a strong relationship between high folic acid intake and lower incidence of NTDs, given that mothers exposed to folic acid antagonists had a higher risk of having children affected by spina bifida, anencephaly, and encephalocele. However, the exact measure of the effect is still unclear. First, it is pretty difficult to identify the effect of the policy itself, given that it is not possible to carry out randomized experiments and, therefore, the evaluation simply consists in the assessment of the change in the prevalence of the diseases before and after the start of the fortification. In addition, the prevalence of neural tube defects is measured just on live births without taking into account miscarriages and abortions. However, all these evaluations rely on the assumption that pregnancy interruption rates did not change as an effect of the treatment.
By using information contained in birth certificates, a decrease of NTDs of about 19% has been estimated (Honein et al, 2001). On the contrary, according to a study conducted by the Centers for disease control and prevention (CDC),[5] the effect of the fortification was much stronger, i.e. there was a 27% decline of babies affected by NTDs.
Williams et al. (2005) measure the effect of the policy on different races/ethnic groups. They suggest that the decline in spina bifida and anencephaly was significant and high (around 35%) among not Hispanic white and Mexican-Hispanic, while it was not statistically significant among not Hispanic blacks. Nevertheless, the study does not explain whether this was due to the fact that Blacks did not select into the treatment (i.e.

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[4] For a sistematic review of the benefits and risks of folic acid intake, see Council on Science and Public Health (2006)
[5] http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5317a3.htm

they do not eat fortified products) or they have a different rate of folate absorption.

The capacity of the folic acid fortification in increasing the level of serum folate is not questioned and it has been proven both in an experimental framework and in a not experimental one.
Cuskelly et al (1999) conduct a randomized experiment and compare the levels in serum folate of people who were eating fortified cereals to those of individuals who did not, founding a statistically significant difference.

There is a huge strand literature on folic acid fortification using NHANES data. Jacques et al. (1999) show that cases of low folate concentrations were almost completely eliminated as an effect of the fortification. Pfeiffer et al. (2005) show that the fortification increased the amount of serum folate in the overall population. The same result has been obtained by Dietrich et al. (2004), who found that there was a significant increase in total folate (around 136%) among the not supplements takers and this applies in particular to females in the 20-39 age group. On the contrary when considering just dietary folate, it increased of just 20-30%. However, according to the authors, less of 10% of the women in childbearing age had a red blood cell folate concentration above the threshold associated with a lower risk of NTDs. Finally, according to Benthley et al (2005), the increase of folic acid intake in the American population after the fortification was not homogeneous by age, gender and race-ethnicity.
The increase in serum folate concentration seems to have slowed down in more recent times. In fact, Ganji et al (2006) documented a decrease of serum folate concentration in the most recent years after the sharp increase at the beginning of the fortification. The authors claim that this can be due to the change in the amount of fortificant contained in bread. In fact, the quantity of added folic acid lowered in the years 2002 and 2003.
The effect of the fortification is striking also when using data different from the NHANES. Data from The Framingham Heart Study (FHS) show that the effect of the fortification was an increase of both total folate and folic acid intake, while folate from food remained unchanged (Choumenkovitch et al., 2002). A similar result is suggested by the statistical analysis conducted by Caudill et al. (2001) on a subsample of women in childbearing age living in South California. The author found that women in childbearing age achieve an adequate level of serum folate after the fortification.[6]
Some authors address also distributional issues. Using NHANES data, Ford et al. (1999) study the importance of ethnicity and educational attainment in predicting the concentration of serum folate. The authors find that education is not strongly related to serum folate concentration while ethnicity seems to matter, given that African American and Mexican are characterized by a lower amount of folate in blood. The result can be explained in two different ways, one economic and the other biological. One possible explanation is that the fortification has a stronger effect on whites because their diet is richer in fortified foods (mainly cereals and bread) and because they have access to better information. The latter is that people belonging to different races/ethnic groups absorb folic acid in different ways. In fact, after a controlled supply of folic acid, African American women had the lowest mean amount of serum folate in the population, followed by Mexican American and Caucasian ones (Perry et al., 2004).

[6] It is worth noting that the study does not consider a control group before the fortification.

The folic acid fortification could also increase health inequality among different socioeconomic groups. A recent paper by Down et al (2008) assesses the effect of the fortification on inequality in health determined by inequality in nutrition[7]. By comparing concentration curves before and after the public policy intervention, the authors claim that in spite of a general increase of red blood folate (RBF) levels, differences in folate distribution between low and high income class still persist. In addition, concentration curves show an increase of the burden of deficiencies in folate that affects the lower socioeconomic group. Finally, with respect to the inequalities between ethnic groups, the prevalence ratio for non Hispanic blacks compared to non Hispanic whites increased as an effect of the fortification.[8]

There are also concerns about the possible negative effects on health of not metabolized folic acid, due to an excessive intake of the nutrient and a consequent folate concentration far above the optimal level.[9]
The percentage of people who is estimated to have passed the upper threshold ranges between 67% and 95%, depending on race, sex and age (Lewis et al, 1999). Given that, it is not clear whether or not it is worth exposing everybody to an increased or even excessive amount of folic acid to protect just a part of the population (Smith et al, 2008) and further research about the interaction between deficiencies in folate and deficiencies in vitamin B12 is needed[10]. According to the authors, folic acid could have an effect in masking anemia and it could have a double function (both negative and positive) in cancer formation (see also Choi et al, 2000 for an explanation of the mechanism linking carcinogenesis and folate deficiencies). In addition, they argue that evidence from clinical trials is not consistent in proving that low concentration of folic acid is a risk factor for cardiovascular diseases. The same evidence is also found by Hung et al (2003). Another possible negative effect could be the neurological deterioration of patients affected by anemia (Dickinson, 1995).
There is a growing literature on the determinants and the effects of folic acid overconsumption. After the fortification, people started consuming much more total folate than expected, twice the amount considered positive for the health, given that some cereals has been fortified more than the amount reported on the nutritional labels and people consume an amount of cereals above one serving (Quinlivan et al, 2002). Whittaker et al (2001) measured the amount of folic acid contained in fortified cereals and they found that, in half of the cereals analyzed, it was by far exceeding the labeled measure (about 150%). On the contrary, according to Yang et al. (2009) who use NHANES 2003/2004 and NHANES 2005/2006 a concentration of folate exceeding the upper level is present just among supplement users and not among the ones who consumed just ready to eat cereals and enriched cereal grain products.

[7] Considering the level of red blood cell folate and using NHANES data.
[8] In this case, the author did not consider the potential negative effect of folic acid exceeding the upper level threshold.
[9] Plasma concentration of Folate above 59 nmol/L is harmful for elderly according to Smith et al (2007) or 20 ng/mL (around 46 nmol/L) according to Yang (2009)
[10] For a study of such a relationship, see Smith, 2007

2.2.2) What is missing? Our contribution

Although extensive, the literature on the effects of the folic acid fortification has missed some fundamental questions. In fact, the evaluations based on randomized experiments are just able to measure the capacity of the body to metabolize folic acid and to transform it into serum folate, while they do not take into account the changes in behavior due to the policy and the determinants of the selection into treatment, which are both important issues from a public policy point of view. Actually, given that the fortification was anticipated by an awareness campaign, the self selection into treatment is likely not to be random, but it could depend on personal tastes (which can be age and ethnic group specific) and on the probability to incur in a pregnancy (which depends on age and gender). In addition, randomized experiments rely on small samples, so their results are not representative of a general population, in particular when we consider ethnic minorities.
On the contrary, the evaluations conducted using not experimental data (mainly NHANES) do not capture the exact effect of the policy, since they do not correct for period specific shocks and they do not address the problem of finding a counterfactual. In particular, the difference in average serum folate before and after the intervention is neither a measure of the average treatment effect on the treated (ATT) nor a measure of the average treatment effect in the population (ATE), which is the expected effect of the policy on a random individual drawn from the population. In addition, NHANES data do not cover the time span between 1994 and 1998 in which the FDA advised the firms to start the fortification and during which an increase on serum folate concentration could have taken place.
In conclusion, the difference in means of serum folate before and after 1998 does not capture just the effect of the fortification itself, but also the effect of a change in dietary habits[11] and the effect on the change in supply of supplemented foods (different from cereal grains products), due to a higher demand of such a products. In addition, it is not possible to rule out the possibility of an unobserved time specific shock.
In this paper we investigate the effect of the public intervention by applying new econometric techniques and by exploiting a quasi-experimental framework. In fact, in the first part of our econometric analysis we focus on the effect of the fortification of ready-to-eat cereals and we identify the ATT controlling for selection on observables, by using different matching methods. The choice of the object of interest deserves further explanation. We decided to disregard the effect of the fortification of flour for two main reasons. First of all, flour is contained in many foods in different percentages, thus making difficult to separate the treatment group from the control one. Secondly, we want to focus on the cases in which an explicit choice of being treated takes place, in order to investigate its correlation with the changes in consumption of fruit and vegetables. In fact, considering RTE cereals allows us to have an idea of the percentage of people who (self) selected into treatment and their main characteristics.[12] Finally, the analysis of a specific fortified food is based on the idea that, from a public health point of view, it is

[11] As we can see from early evaluations, the evidence of a change in dietary folate is not clear, given the high measurement error present in dietary intake data.
[12] For a formal explanation of self selection into treatment due to a utility maximization process, see Firpo (2007) and Heckman et al. (1997)

not just interesting whether or not a folic acid fortification is worth, but also which kind of products it is better to fortify to reach the target population without increasing overconsumption in the not deficient groups.
From a more methodological point of view, we analyze the policy from a different angle: given that, overall, the fortification both increased the amount of serum folate and decreased the incidence of NTDs, we want to access whether it was true for different parts of the distribution.
It means that we are not interested only in average treatment effects but also in the impact of the policy on different quantiles and on inequality in serum folate concentration, given the increasing attention on the potential negative effects of folic acid overconsumption.
We do so mainly by using the quantile treatment effect (QTE) estimator developed by Firpo (2007).
The general idea of studying inequality in serum folate concentration comes from the fact that nutrition plays an important role in creating health inequality, as pointed out by James et al. (1997)[13] since risk factors (i.e. obesity and hypertension) affect low socioeconomic groups more than rich individuals, given the poorest tend to consume energy-dense food[14] rather than nutrients-rich one. Considering the fact that cereals and other grain product are (cheap) products consumed mainly by the poor, the lowering of the costs of folate rich products[15] could lead to two different effects impacting on the socioeconomic differences in health. On the one hand, it could "force" poor people to assume a sufficient quantity of folic acid, thus declining the prevalence of spina bifida and other NTDs in that socioeconomic group; on the other hand, it could imply a change in the nutritional habits towards a more energy dense diet, in particular in the low socioeconomic group already affected by a higher prevalence of obesity, cardiovascular diseased and other not communicable diseases.
In our analysis of the difference in the impact of the treatment for different individuals, we test also the hypothesis of "common effect model". We do it by computing the variance of the treatment and by assessing its difference from zero, under alternative assumptions on the joint distribution of the treatment and the controlled group.
In the last part of our analysis we relax the assumption of rank invariance on which Firpo's (2007) estimator rely and we assess how this affects our previous estimates.
Finally, we measure the change in dietary patterns in a new way: by considering examination data rather than by using dietary recall interviews. At the descriptive and aggregate level, we consider the movement of two different nutrients: one folate related (vitamin C) and another one completely unrelated (ferritin). Instead, in our analytical part we choose beta carotene as a proxy of a folate-rich diet, since it is contained in leafy vegetables, which are a rich in folate as well.
We use this piece of information in two ways: parametrically by conditioning our matching procedure on the amount of beta carotene measured in the laboratory, and not parametrically, by stratifying our sample by different quantiles of the nutrient.

[13] In their article the authors use the British annual national food survey to show that low income groups consume more milk, meat, fat and sugars and cereals and less fresh vegetables.
[14] Usually cheaper in developed countries.
[15] The cost of acquiring folate decreases both because after the supplementation the richest foods in folic acid becomes the cheap ones (cereals) rather then the expensive ones (vegetables) and both in term of time spent in cooking.

2.3) Empirical analysis

2.3.1) Estimating the average treatment effect using matching methods

We are interested in the effect of the fortification of ready to eat cereals, since the amount of folic acid added in cereals is by far higher than the one added in other foods even above the label declaration (Whittacker et al. 2001). In addition, cereals do not enter in other recipes, so their consumption is likely to be voluntary. On the contrary, flour enters as a main or secondary ingredient in a wide range of foods, thus making almost impossible to identify the treatment group. As already said, we focus on the fortification of RTE cereals, therefore we consider as "treated" those people who declare to have eaten RTE cereals in the dietary recall interview. We recognize that dietary recall data are affected by measurement error due to imperfect recall, due to the not exact identification of both the recipes of the food consumed and their composition in terms of nutrients. However, we are confident that the interviewed can at least remember whether or not they had eaten RTE cereals and the brand they consumed.

The literature that does not use measures built on experimental data does not capture the true causal impact of the fortification. In fact, the observed difference between the outcomes of the treated and not treated can be decomposed as follows:

$$E(Y_{1i} \mid D_i = 1) - E(Y_{0i} \mid D_i = 0) = E(Y_{1i} \mid D_i = 1) - E(Y_{0i} \mid D_i = 1) + E(Y_{0i} \mid D_i = 1) - E(Y_{0i} \mid D_i = 0) \quad (1)$$

Where the subscript *"i"* means that in principle the effect should be tested on the same individual and then it should be averaged over all the individuals in the population.

$E(Y_{1i} \mid D_i = 1)$ represents the mean outcome on the treated after the introduction of the treatment (in our case the fortification of RTE cereals, after it has been made mandatory), while $E(Y_{0i} \mid D_i = 0)$ is the mean outcome on the untreated. On the right hand side, the first term $E(Y_{i1} \mid D_i = 1) - E(Y_{0i} \mid D_i = 1)$ represents the causal effect of the treatment on the treated (ATT), while the expression $E(Y_{0i} \mid D_i = 1) - E(Y_{0i} \mid D_i = 0)$ is a selection bias produced by the non random assignment into treatment. The fundamental problem here is that the potential outcome $E(Y_{i0} \mid D_i = 1)$ is not observed by the researcher, since each individual is observed in just one of the possible states (treated or not treated). In our case, it represents the level of serum folate the treated people would have had if they did not eat RTE cereals. This term is important if people who eat cereals are not randomly chosen, e.g. they are the ones who are more concerned about their folic acid intake. In order to estimate the ATT (and the ATE as well), we have to construct the term $E(Y_{0i} \mid D_i = 1)$ using matching strategies in the post treatment population. As already suggested, the evaluations that do not use an experimental or a quasi-experimental design are biased for two reasons: firstly, they do not consider the time specific shocks;

secondly, they do not construct valid counterfactuals.

To find a counterfactual, thus identifying the causal effect of the policy, we have to rely on two assumptions.

Assumption 1: unconfoundedness or **conditional independence** assumption, **CIA**: We have to assume that the selection into treatment is random, once controlled for observable characteristics X, formally $Y_0 \perp D_i \mid X$ (2)

Given the number of potential covariates to control for and to integrate on is huge, to avoid the so called *curse of dimensionality* problem, we model the probability of being in the treatment group given the observable characteristics via propensity score[16], so that (2) becomes

$$Y_0 \perp D_i \mid P(X) \tag{3}$$

If (3) holds, $E(Y_{0i} \mid D_i = 1, X) = E(Y_{0i} \mid D_i = 0, X)$ and we can use the observed value $E(Y_{0i} \mid D_i = 0, X)$ instead of the unobserved $E(Y_{0i} \mid D_i = 1, X)$

Under (3), it is possible to select a subgroup of the control group which is similar to the treatment group and, therefore, it can serve as a counterfactual.

Assumption 2: Common support assumption: control and treatment group rely on the same support
$0 < P\,(D = 1|X) < 1$ (4)

This means that, for the same value of the propensity score P(X), there is a strictly positive probability to find both an individual belonging to the control group and an individual belonging to the treatment group.

If (4) holds, we can estimate the average treatment effects for each value of the propensity score and integrate them over the distribution of the covariates.

In the first part of the paper we identify the effect of the fortification of RTE cereals in a quasi experimental framework, mimicking the counterfactual by matching treated individuals to comparable ones belonging to the control group.
We first estimate the propensity score and we check the balance of the covariates in the treatment and the control group to assess whether or not they have been made comparable within each propensity score stratus. We then use our estimated propensity score to match the observations by using two different kinds of matching procedures, in order to test the robustness of our results. We estimate the ATT both using a nearest neighbor matching,

[16]See Rosenbaum and Rubin (1983),

which pairs each treated individual with the most (observably) similar individual(s) in the control group, and by implementing a kernel matching, which links the outcome of each treated with the weighted outcomes of the individuals belonging to the control group.

2.3.2) Estimating the quantile treatment effect assuming rank invariance

Further econometric problems arise when one wants to estimate the treatment effect considering characteristic of the distribution other than the mean, e.g. when one wants to estimate the treatment effect on different quantiles of the serum folate distribution. The first conceptual difference arises in the definition of quantile treatment effect itself. In the first part of our analysis, we will use Firpo's (2007) definition, i.e. "the difference between the treated and the control group in quantiles of the marginal distribution", which considers the effects of the policy at the aggregate level.
The identification of the quantile treatment effect as defined above relies on the *"rank invariance"* assumption, requiring that an individual maintains the same position (rank) in both the distributions of potential outcomes (the concentration of serum folate in the presence of treatment and in the case of its absence). If the rank invariance assumption holds, the QTE is just the horizontal distance between the quantiles of the two different marginal distributions.
Unfortunately, rank invariance is a very strong assumption and the situation in which it does not hold has to be studied. There are two main ways to tackle the problem. The first strategy, proposed by Heckman et al. (1997) consists in making assumptions about the unobserved conditional distribution of the potential outcomes Y_0 and Y_1, and bind it by using classical tools of mathematic statistics and by computing the effect when some slippages from rank invariance are taken into account. The other option consists in simply changing the object of interest and studying a more general concept, which still has some practical relevance. In particular, according to Firpo (2007), even if rank invariance does not hold, the identified effect is still important from a point of view of policy. In fact, in presence of rank invariance, the QTE can be interpreted as effect of the fortification on an individual belonging to a particular quantile, which is the same before and after the treatment. On the contrary, without rank invariance, the quantile treatment effect is simply the difference between quantiles of the potential outcome distributions, which can be an interesting measure itself, since it gives an idea of the change in the shape of the distribution as an effect of the policy.
In practice, this means dividing the two marginal distributions in a number P of quantiles such that the level outcome of interest (in our case the serum folate concentration) can be seen as a function of the value in the different quantiles of the distribution, in the treatment and in the control group.
The univariate distributions can be expressed as $V_1 = (q_{1,\frac{1}{p}}, q_{1,\frac{2}{p}}, ...q_{1,1})$ and $V_0 = (q_{0,\frac{1}{p}}, q_{0,\frac{2}{p}}, ...q_{0,1})$ and their difference can be weighted using parameters $a_{\frac{j}{p}}$, which reflect the importance the policy maker attaches to different quantiles.
Therefore, the policy maker can decide to implement the treatment if

$$V_1 - V_0 = \sum_{j=1}^{P} a_{\frac{j}{p}} (q_{1,\frac{1}{p}} - q_{0,\frac{1}{p}}) \geq 0 \tag{5}$$

For given values of the weights $a_{\frac{j}{p}}$.

In this framework, the policy maker is not interested in which individuals benefit from the reform, but just in the number of people who actually do. In our case, Firpo's QTE identifies whether or not the effect of the policy was stronger in the lowest quantile of the distribution, but it does not identify the specific individuals who benefit from it.
Note that the effect of the folic acid fortification is likely to be positive for every quantile of the distribution, given that the amount of folic acid contained in the cereals is much higher than the amount of dietary folate contained in food. However, we can put different weight on different parts of the distribution to evaluate the total effect of the intervention.

Following Firpo (2007), we define the quantile treatment effect and the quantile treatment effect on the treated as:

Quantile treatment effect:

$$\Delta_{\tau} = q_{1\tau} - q_{0\tau} \tag{6}$$

$j = 0,1$ Where $q_{j\tau}$ is $\Pr[Y(j) \leq q] = \tau$ and where j = 1 indicates the distribution of the treated population)

Quantile treatment effect on the treated

$$\Delta_{\tau|T=1} = q_{1\tau|T=1} - q_{0\tau|T=1} \tag{7}$$

Where $q_{j\tau|T=1}$ is $\Pr[Y(j) \leq q \mid T = 1] = \tau$ and $j = 0,1$

For our estimation we use a two steps procedure: in the first step we compute a propensity score estimating the probability of being treated, while in the second step we perform a quantile treatment effect estimator, which uses the results of the propensity score to correct for the endogenous selection into treatment.

Since we do not know the joint distribution of Y_0 and Y_1, in the first step we computed the propensity score non-parametrically, by using the following kernel function.

$$K_{h,\lambda}(X_i - x) = \prod_{q=1}^{q1} k(\frac{X_{q,i} - x_q}{h}) \prod_{q=q1+1}^{Q} \lambda^{1(X_{q,i} \neq x_q)} \tag{8}$$

Where the q_1 regressors are continuous (in our case age) and $Q - q_1$ are discrete (ethic dummies, education and gender). The term $\prod_{q=1}^{q1} k(\frac{X_{q,i}-x_q}{h})$ is a standard product kernel for the continuous variables, while the term $\prod_{q=q1+1}^{Q} \lambda^{1(X_{q,i}\neq x_q)}$ measures the mismatch between the discrete ones. If h=∞ and $\lambda=1$ the model is estimated parametrically, since the bandwidth h consists in the entire interval.

In the second step we need to minimize the following function

$$q^E_{J.\tau} = \arg\min_q \sum_{i=1}^{N} \hat{\omega}^E_{j,i} \rho_\tau (Y_i - q) \qquad (9)$$

Where the check function $\rho_\tau(.)$ is

$$\rho_\tau(Y_i - q) = (Y_i - q)(\tau - I\{Y_i - q \leq 0\})$$

And the weights are defined as $\hat{\omega}^E_{j,i} = \dfrac{T_i}{N\,\hat{p}(X_i)}$

The function (9) is similar to the function used in the standard quantile regression framework, but its arguments are weighted by the inverse of the propensity score computed in the first stage[17].

Given that we use the propensity score to weight the observations, our quantile treatment effect estimator identifies unconditional quantile treatment effects under the assumption of selection into treatment based on observable characteristics X, i.e. the treatment is considered exogenous conditioning on X. In particular, the quantile treatment effects are identified under strong ignorability (Unconfoundness and common support) and under the additional assumptions of existence and uniqueness of quantiles (see Firpo, 2007).

2.3.3) Relaxing the rank invariance assumption

The other way to deal with the lack of information due to the not observability of the conditional distribution of the potential outcomes, consists in computing the quantile treatment effects under alternative assumptions about the dependency between the distribution of the treatment and the control group.
In fact, in order to estimate non linear effects, the knowledge of the dependency between

[17] The effect is estimated by using the command developed by Frolich and Melly (2008).

the potential outcomes in the control and in the treatment group (i.e. their cumulative density functions) is needed. However, given that we just observe individuals in one of the two states, we are just able to observe F_0 and F_1, i.e. the marginal distributions of serum folate for the two groups separately. The only way to derive the conditional distribution is making assumptions about the dependence of the two marginal distributions. One of them, the strongest possible is the rank invariance assumption.

Following Heckman et al. (1997), we proceed as follows. We compute the propensity score and we divide the sample into 5 different strata (quintiles) according to the value of the propensity score. Then we compute quantiles (50) of the two distributions and, within each propensity score stratus, we collapse[18] the observations into quantiles in order to have the same number of observations in the two groups. Assuming rank invariance (perfect positive correlation between Y_0 and Y_1) we compute the horizontal distance between the two values and we integrate it over the distribution of the propensity score, obtaining the final quantile treatment effect.
In addition, we compute the distribution of the treatment assuming perfect negative correlation between the two distributions, i.e. taking the horizontal difference between quantiles, when the control group has been sorted in the inverse order.
The cases of perfect positive dependence and perfect negative one are just two possible ways the two distributions can be related. To estimate the full distribution of the treatment, given all the possible rearrangements of the individuals within the groups, one should consider all the n! permutations (in our case 50!) of the treatment group and then compute the effect of the fortification considering all the horizontal differences in the n! random permutations. However, in order to decrease the computational burden, we consider 1000 random permutations of the quantiles of the distribution Y_0 (always within each propensity score stratus).

2.3.4) Data and descriptive evidence

We use data from successive waves of the National Health and Nutrition Examination Survey (NHANES III, NHANES 1999/2000, NHANES 2001-2002 and NHANES 2003-2004). The data set is a representative sample of the American population (once appropriately weighted). The dataset contains very detailed information on health status and concentration of nutrients in the blood including the concentration of serum folate in individuals aged 0 to 90. We also have a dataset on food intake to investigate nutritional habits.

We use the concentration in vitamin C[19] at the aggregate level to correct for the absence of a real counterfactual. The increase in serum folate can be due either to the fortification, or to a change in eating patterns with individuals eating more greens and vegetables over time. If the latter is true, we should see an increase in the average vitamin C

[18]We considered the mean value within each stratus.
[19] Serum folate is measured in ng/mL, Vitamin C is measured in mg/dL and ferritin in ug/dL in μ g/dL

concentrations since most vegetables are a rich source of both nutrients. On the contrary, if a change in nutrition habits took place independently from the government advice, and it was due, for example, to a change in the structure of prices, we should observe also a change in the distribution of nutrients not contained in the recommended vegetables and products. That is why we studied the change of ferritin, which is not contained in folate-rich food.

We first use the changes in concentration of the three nutrients to study the second order effect of the public policy: the change in inequality of serum folate concentration, which is a proxy of the distributional effects of the public policy. For the first part of the analysis we consider the effect of the entire governmental intervention without identifying the effect of the fortification itself and the effects of the awareness campaign. We can disregard the possible effects of a change in use of dietary supplements, because, according to the centers of disease control and prevention (CDC), data have not indicated a substantial change in supplements use as a consequence of the fortification. In addition, empirical evidence based on NHANES data shows that the consumption of dietary supplements decreases as a consequence of the supplementation (Benthley et al, 2006)
The original sample size is 39273 for serum folate, 27913 for vitamin C and 42706 for ferritin. After eliminating those with no relevant measures, the sample size dropped to 38881 for serum folate, to 27572 for vitamin C and to 42272 for ferritin.

We first compute the average concentration of serum folate, vitamin C and ferritin to assess the trend in the measures. To analyze the change in their distribution, we compute the cumulative distribution before and after the fortification. We also evaluate the inequality by calculating Generalized Lorenz curves and Gini coefficients for the concentration of serum folate and vitamin C for years before and after the fortification. Moreover, an analysis of the change in within-groups and between groups inequality has been done, by using Atkinson indices
Tables 2-5 provide descriptive statistics for the sample: since in the 1988 wave does not have relevant measures (around 500 individuals interviewed), we consider 9 different waves for serum folate (1989, 1990, 1991, 1992, 1993, 1994, 1999, 2001) and 8 for vitamin C (1989, 1990, 1991, 1992, 1993, 1994, 2003).

We computed the mean for each subgroup in order to understand the impact the fortification had on the different parts of the population. We also performed t-tests for folate and ferritin (Table 7)
The importance itself of folic acid in decreasing NTDs in newborn babies forced us to study separately the effect of the fortification on men and women, since future mothers represent the target of the public intervention.
Also race and ethnicity seem to be important characteristics, since nutritional habits are culture specific and the policy (both the awareness campaign and the grain fortification) could have changed the relative position of individuals of different races in the serum folate distribution.
Given that the governmental action took place in two different points in time and followed two different methods, we analyze separately the effects of the first phase (after 1992) and of the second one (after 1998)

Finally, we consider the partition between the individuals with low education (who have not completed the college) and the more educated ones (with a college degree)

Figure 1 displays the trend in serum folate and vitamin C. Although both graphs show an increasing trend in the nutrients, the growth of vitamin C is slower and smoother. Moreover, the folate concentration in the blood reaches its maximum in 1999 data (right after the start of the fortification) and it decreases a little in the following years. The same pattern cannot be found in the vitamin C data.

Figure 2 displays the cumulative distribution of serum folate and vitamin C. We study the cumulative distributions to find out the effect of the fortification on the distribution of both nutrients.
In order to study effect of the grain products fortification, we split the sample into two parts (before and after 1998) In particular, we want to assess whether the fortification produced only a shift in the curves (an increase in the mean without any relevant effect on inequality) or it was more effective for depleted individuals and it decreased the health inequality in the population. Another interesting issue is whether or not the grain product fortification changed the relative position of some subgroups in the distribution.
The first hint the cumulative distributions give us is the following: while there was a shift in both the distribution of serum folate and the distribution of vitamin C, the consumption of products rich in ferritin seems not to have changed. However, the cumulative distributions alone do not allow us to draw conclusions about the inequality reduction power of the folic acid fortification.
More specific tools are needed.

Figure 3 displays the Generalized (i.e. scaled up to the mean) Lorenz curves for the three nutrients. They confirmed that there was a decline in the level of inequality of folate concentration, while no improvements in inequality can be observed when the ferritin distribution is analyzed. As regards both ferritin and vitamin C, we can notice that the after fortification distributions always Lorenz-dominates the before fortification ones. This implies that it also second order stochastic dominates it. The former statement implies that all the individuals agree on considering the after fortification distribution preferable to the situation before the public health intervention, both in an efficiency (considering the mean) and in an equity (considering the inequality) point of view.

Table 6 provides a summary of the inequality before and after fortification for the overall population both by gender and by race-ethnicity.
We are interested in inequality between races-ethnicities because the incidence of NTDs prior the fortification was different for different racial/ethnic groups. For example, according to the report 6 of the Council of science and public health, children born from Hispanic mothers were 1.5 times more likely to be affected by spina bifida. Since the products fortified are not very common in the Latin-American diet, we are concerned that the fortification increased once more the gap between these socioeconomic groups. Figure 6 shows the increase of serum folate concentration for different ethnic-racial groups.

Figure 4 shows the change in inequality, measured by means of Gini indices, during the three steps of the fortification. We can easily notice that the first phase of the intervention caused, together with a slight increase in the mean, a greater inequality. From a policy point of view, it would be interesting to assess whether this result is due to a greater focalization of the public policy (e.g. women were more interested in the campaign) or to a different responsiveness of different subgroups of the population due, for example, to different levels of education achieved.

Figure 5 shows the results of the analysis of within-group and between-group inequality, performed using Atkinson indices with parameter equal to 2, in order to give more importance to changes in the bottom of the distribution. We chose to use this index instead of the Gini because the latter is sensible to changes in the median and we are not particularly interested in them.
We have considered 3 different partitions of the sample (by race-ethnicity, by gender, by target population), where, as target population, we defined women in chielbearing age, i.e. between 15 and 45.
We have also split the sample into three different points in time: before 1992 (before the government started to solve the problem of NTDs), between 1992 and 1998 (between the beginning of the campaign and the beginning of the fortification), and after 1998.
The graphs suggest that the first stage of the policy intervention (the awareness campaign) increased the differences in serum folate concentration, while subsequent fortification (a less targeted policy) decreased it.

2.3.5) Assessing the effect of the fortification of RTE cereals[20]

In order to study the effect of the policy on different quantiles, we focus on the first year after the fortification of RTE cereals has become compulsory. The core of the paper is thus based on the NHANES 1999/2000 dataset and we use both the laboratory and the dietary recall data.
We first analyze the effect of the fortification by simply comparing the mean value of serum folate among the RTE cereal eaters to the average concentration of serum folate among the non cereal eaters. We found a huge and significant difference between the two groups (see table 7), suggesting a clear and strong effect of the fortification.
However, as have already mentioned in section 2, the naïve estimator does not measure the correct causal effect of the policy, given that the treatment and the control groups are not homogeneous with respect to several dimensions, namely race-ethnicity, age and education (see table 14 when the unmatched sample is considered).

Let us now correct the estimate of the impact by considering the selection into treatment.

Recall that our identification strategy relies on a couple of assumptions implying strong ignorability: the conditional independence assumption (CIA) and the common support one.

[20] All the analyses are conducted using SI units (nmol/L) in order to compare the results with the findings of the literature

Since it is not possible to directly check the validity of the CIA assumption, we will support it by considering the descriptive evidence presented in figures 1 and 2 and, in general in the previous section.

Figure 1, shows a peek in serum folate and vitamin C concentration in 1992, the year in which the awareness campaign started. It means that, at least initially, the governmental intervention raised the awareness of the risks and the determinants of NTDs, thus inducing a change in people's nutritional behaviors. Therefore, we can assume that people had sufficient information to consider folate deficiencies as an issue and that the selection into treatment was not a random process. Recall that the main benefits in assuming folic acid are achieved by women in fertile age, since folic acid decreases the probability to give birth to children affected by NTDs. We thus expect that young women in a stable relationship are more willing to increase their amount of serum folate, while the campaign does not significantly affect old men. Finally, we can speculate that more educated people are more able to understand the benefits of the treatment and so they select into the treatment with a higher probability. Personal taste in food is another important factor affecting the selection into treatment. Given that taste is likely to be ethnicity specific, we believe we can partially control for it by including a dummy variable indicating the respondents' racial-ethnic group. Another part is random, but it is not correlated to the outcome, so it does not bias our estimates.

In conclusion, we decided to regress the dummy variable indicating the selection into treatment on age (and its higher order terms), ethnic-racial group, gender, educational level and their interaction and higher orders terms. At this stage, we do not address the issues of possible changes in nutritional habits induced by the fortification, which will be discussed in the next session.

The common support assumption does not create any problem, since all the observations are on support, so we can potentially match all the individuals in the control group and we do not miss any important piece of information by excluding *ex ante* observations from the matching procedure.

Both the matching strategies we apply perform pretty well and help us identifying the characteristics of the treated. As expected (results are shown in table 8) people belonging to ethnic minorities (Black, Mexican-Hispanic and other ethnic groups) are more likely to be included in the control group, while, even controlling for the race-ethnicity, more educated people seem to understand the effect of the policy better and eat more fortified cereals. It is worth noting that if selection into treatment is correlated to the probability of becoming pregnant, the fortification of RTE cereals does not help in lowering the prevalence of NTDs in unwanted pregnancies. In addition, our estimates show that gender does not explain the selection process. One possible explanation of the result is that nutritional habits are similar within households, which are likely to be homogeneous with respect to age, ethnic/racial origin and level of education, but not with respect to gender. Finally, none of the interaction terms is significant, but this can be due to the not linearity of the parametric form chosen for the estimation of the propensity score (probit specification)

To check the robustness of our estimates, and given the higher number of people included in the control group, we use two types of matching: a nearest neighborhood matching (one-to-one) and a kernel one. As expected, the estimates obtained using the kernel matching are lower than the ones obtained with the nearest neighborhood one. In fact, the kernel matching matches each treated individual with more than one person in the control group, so also observations different from the treated individuals are considered (although with a lower weight). We propose different tests to assess the quality of the two procedures. We perform a set of t-tests to compare the means of the variables in the two groups (see table 14 for the kernel matching) and in none of them we are able to reject the null hypothesis of equal means, thus indicating that the treatment and the control group are well balanced. In addition, the R squared of the regression on matched covariates is lower than the one on the unmatched sample (and very low in absolute terms) suggesting that, after controlling for observables, the selection into treatment is random and, therefore, it should not bias our results.

Both the matching procedures give us comparable results. The results are presented in tables 10 and 11. Standard errors are bootstrapped to overcome the generated variable problem, given that the propensity score has been estimated in the first stage and then used in the quantile regression. As expected, conditioning on the covariates reduces the estimated effect of the fortification, which is lower than the one find when we naively compare the means of the two groups (recall that the difference in average serum folate concentration between the two groups was 9.71).

Additionally, we measure the effect of the treatment on different quantiles of the distribution, by considering the evidence of the selection into treatment and given that individuals can choose the amount of treatment they want to take by selecting the most fortified cereals or by eating a greater quantity of them. We are interested in the distributional effect of the fortification because a well balanced policy, aiming at decreasing the prevalence of folate deficiencies, would mainly affect the lower quantiles of the distribution (in which the folic acid depleted individuals are contained) and it would leave the higher quantiles almost unchanged, thus avoiding problems of overconsumption underlined in the early medical literature.

First of all, we test whether our model can be seen as a "common effect model"[21], i.e. whether the program has the same effect on everybody. Previous evaluations suggest that this is not the case, given that different racial groups and age categories have different capacities of metabolizing folic acid. In addition, the amount of the treatment (in our case the amount of RTE cereals eaten) varies between individuals.
Testing the hypothesis of equal treatment is crucial for two reasons. First of all, the fortification and, more specifically, the amount of folic acid added to the RTE cereals rely on the underlying assumption that individuals eat a serving of cereals a day, which implies that the actual effects in the case of a failure of the equal treatment hypothesis could be very different from the predicted ones. In addition, if the common effect assumption holds, the distributional effects of the policy are null and the average effect is equivalent to the quantile treatment effect for each quantile of the serum folate distribution, implying that the only parameter of interest is the average treatment effect.

One of the possible ways of testing the validity of the common model assumption consists in computing the variance of the treatment, where a variance equal to zero

[21] See Heckman et al. (1997)

confirms the common effect hypothesis. In principle, our test would not be able to rule out the common effect hypothesis, since we do not know the structure of the dependence between the potential outcomes. However, we are able to identify the values of the correlation between the potential outcomes Y_0 and Y_1 for which it is possible to reject the common model assumption.

We can define the variance of the our treatment ($\Delta = Y_1 - Y_0$) as
$Var(\Delta) = Var(Y_1 - Y_0)$ (10)

We can write (10) as:

$$Var(\Delta) = Var(Y_1 - Y_0) = Var(Y_1) + Var(Y_0) - 2Cov(Y_1Y_0) \quad (11)$$

$$Var(\Delta) = Var(Y_1 - Y_0) = Var(Y_1) + Var(Y_0) - 2\rho\sqrt{Var(Y_1)Var(Y_0)} \quad (12)$$

We can thus derive the values of ρ under which the variance of the treatment is equal to zero. Notice that some of the objects in the previous equality are observable (namely $Var(Y_1)$ and $Var(Y_0)$), since they can be derived by the moments of the marginal distributions, while some other elements, such as $Cov(Y_1Y_0)$, are unobservable. Table 16 shows that the variance of the treatment is above zero for every value of the correlation between the two distributions, even when the perfect negative dependence (lower bound of the variance of the treatment) is assumed. Unambiguously, this rules out the hypothesis of equal treatment.

Another piece of evidence in favour of the existence of differences in the treatment among different percentiles of the distribution is given the estimates of the quantile treatment effects we derived by using the estimator proposed by Firpo (2007). We computed the quantile treatment effect for all the percentiles of the distribution, as shown in graph 8 and in the corresponding table 17. It is worth noting that, for all the quantiles considered, the effects are estimated with precision, given they are all significant at the 1% level. The part of the distribution less affected by the policy is the bottom one, where the treatment effect is just between 2 and 5. The estimated quantile effect is growing in the lowest part of the distribution and it is quite flat near the median, around which the increase seems to stop. On the contrary, it increases sharply around the 75th-80th percentile.
The not complete linearity of the effect could be due to two different forces in act. People in the top part of the distributions are those who are more likely to eat foods rich in folate/folic acid. As a consequence, if they do not adjust their dietary habits when the fortification takes place, they are likely to incur in the risk of overconsumption. On the contrary, people in the center of the distribution are probably used to a lower consumption of such foods and they could decrease their intake of dietary folate as a consequence of the greater availability of chemical folic acid at a lower price.
In order to have a more parsimonious description of the effect, we present also the estimates of the QTE when only three main percentiles (25th, 50th and 75th) are taken

into account. Results are shown in table 18.

Let us now relax the rank invariance assumption and investigate how this affects our estimates and our policy implications.
Table 20 presents the principal moments of the distribution of the impacts under the assumption of both perfect positive and perfect negative correlation. Notice than, when the rank invariance assumption does not hold, some negative effects of the policy can arise indicating a possible presence of a substitution effect between dietary folate and folic acid intake.
The analysis of the table corresponding to the case of perfect positive correlation confirms the results obtained by using Firpo's estimator,[22] with the effect of the programme increasing with quantiles. However, when we impose a negative correlation, some of the effects change their sign and the policy turns out to be more effective for the depleted individuals. Note that we consider quantiles of the distribution of the treated. Given that there is perfect negative dependence, and given that the higher effects are associated to high quantiles of Y_1, this means that the policy was increasing the amount of serum folate of those at the bottom of the distribution and it was decreasing the serum folate concentration of those at the top of it. This result does not contradict our previous findings obtained using Firpo's estimator, since they just describe the effect on the entire distribution. It can happen that the fortification increased overconsumption overall, but the individuals swap their places in the serum folate distribution.
A somehow intermediate situation is found when the quantiles of the two distributions are randomly matched[23]. In this case the distributions of the effect are similar for different quantiles, as shown in graph 9.[24]Estimates of the percentile of the distributions of the impacts are shown in table 21.

Let us now consider the economic meaning of the assumption of rank invariance. If we assume negative dependence between the potential outcomes it means that the individuals with a low folate intake before the beginning the fortification realize that they have to increase their serum folate concentration and they try to consume folate/folic-acid rich foods. On the contrary, people who were not depleted, lower their previous intake. Assuming positive dependence means that, those who were eating dietary folate rich foods before the beginning of the governmental intervention do so also after its beginning. Finally, the random matching hypothesis reflects the situation in which the fortification does not have any behavioural effect.

[22] They are not perfectly equivalent because, in Firpo's case we used the propensity score to weight the observations, here they are used to stratify the sample (and the effect is an average of the effects in the different samples).
[23] Recall that it takes place within the propensity score cells.
[24] Note that, fore sake of simplicity, the graph consider quantiles of the distribution of the control group, so that the effect can be interpreted as the expected effect on a particular quantile of the distribution under study before the implementation of the policy.

2.4) Tackling the problem of changes in dietary habits

So far we have not considered the effect of a change in nutritional habits. Our descriptive analysis shows a change in vitamin C concentration not followed by a change in ferritin concentration and that can suggest that of a change in nutritional habits did play a role in the found increase in the serum folate concentration.
In the following section we identify this effect and we correct our earlier estimates. Given the low reliability of data on food intake and considering that there is no agreement in the literature about whether or not a change in diet as a consequence of the fortification took place, we decided to use the information contained in the examination files of the survey.

Our identification strategy relies on the (partial) co-movement of vitamin C and folate due to their being both contained in green leafy vegetables. In section 3 we showed that the average concentration of both vitamin C and folate in the blood of NHANES members increased after the start of the awareness campaign in 1992. Unfortunately, in the NHANES 99/00 dataset the information on the concentration of vitamin C in blood is missing so that another approximation must be found. There are three possible "candidates" as proxies for the change in dietary habits following the folic acid fortification. These are vitamin A, vitamin E and beta-carotene, which all turn out to be correlated with the serum folate concentration, even before the fortification. This fact suggests that they could be correlated also with the selection into treatment.

In order to take into account changes in the dietary habits, we control for beta-carotene concentration. The reason why we chose it is that fortified cereals are added with both vitamin A and vitamin E, thus making them bad proxies for changes in nutrition independent from the consumption of RTE cereals. We control for dietary folate intake in two different ways: parametrically, using beta-carotene as an explanatory variable in the matching procedure, and not parametrically, stratifying our sample by quintiles of beta-carotene distribution.
Although the beta-carotene variable is not significant in the first stage of the matching (see table 9), both the procedures we apply lead to a further decrease in the size of the estimated average treatment effect of the folic acid supplementation (see table 12 for the parametric specification and table 13 for the non parametric ones). Notice that the inclusion of beta-carotene as an explanatory variable has two different aims: the first one is studying the changes in diet correlated with the selection into treatment (this is the reason why we include beta-carotene explicitly in the selection equation); the second one is simply washing out the amount of serum folate due to the intake of dietary folate. Even if the evidence of the impact of beta-carotene on the selection procedure is not striking, the second effect is still important.
The results confirm our previous findings, i.e. that part of the average increase in serum folate concentration is due to a change in the consumption of vegetables containing dietary folate.
The same results are obtained when we compute the quantile treatment effects a' la Firpo (2007). In fact, also in this case, the estimated impact of the fortification is reduced[25], in

[25] Once compared to the one estimated when dietary habits have not be taken into consideration

particular in the top part and the bottom part of the serum folate distribution, while no effect is found around the median (see table 19). This, again, supports our idea of a possible substitution between the two sources of folate.

2.5) Conclusions

Early analyses have found the American folic acid fortification to be successful, with a large increase in serum folate over the nineties. However, further investigation shaded light on the possible negative effects of the policy, leading to overconsumption of folic acid for given groups of the population. We first conducted a descriptive analysis using different waves of the National Health and Nutrition Examination Survey (NHANES III, NHANES 1999/2000, NHANES 2001/2002 and NHANES 2003/2004) covering the time period between 1988 and 2003, to understand the impact of different phases of the policy intervention. We found an increase in serum folate concentration right after the start of the awareness campaign on the importance of a high folic acid intake in 1992. In the same time period, we also found an increase of vitamin C. Our descriptive analysis suggests that a second order effect of the fortification was a reduction of inequalities in serum folate concentration, at least within the ethnic-racial groups. On the other hand, the effect on between group inequalities is still not clear, since there is evidence that some parts of the population (e.g. white-Americans) increased their amount of serum folate more than others.
These stylized facts suggest that the change in total folate in blood can be decomposed into a change in serum folate concentration caused by the folic acid fortification and a change in dietary folate intake, due to modified dietary habits, proxied by the concentration of vitamin C. In addition, the different impact of the fortification on different ethnic groups raised the problem of a possible endogenous selection into treatment.
In order to evaluate the effect of the folic acid fortification on different parts of the serum folate distribution and, in particular, in order to address the problem of overconsumption, we focused on the time span immediately following the beginning of the fortification, namely the years 1999-2000 (NHANES 1999/2000). In addition, we studied the fortification of ready-to-eat cereals, which are one of the main sources of folic acid after 1998.
We exploited the rich source of information contained in the NHANES data and we conducted the evaluation in a quasi-experimental framework by using different types of matching procedures and by controlling for different dietary patterns. For the first time in the literature, we studied the change in dietary folate consumption by using as a proxy the concentration of beta-carotene. In fact, we think that laboratory data are less affected by measurement errors than the data contained in the dietary recall part of the survey. In addition, they do not rely on a set of underlying assumptions regarding the composition of the foods eaten. We found evidence of (ethnic-race based) selection into treatment, confirming the stylized evidence presented in the first part of the paper. Consequently, controlling for endogenous selection into treatment reduced the estimated average treatment effect of the folic acid fortification that we found when we just naively

compared the average serum folate concentration in the treatment and in the control group. Such a finding, together with the analysis of the trends by subgroups, suggested that the intervention did not reach all the strata of the population in the same way. In addition, we found that part of the average increase in serum folate concentration can be explained by changes in diet, as suggested by our descriptive analysis and as pointed out by part of the literature. This confirms our idea that behavioral effects played a role in determining the difference in serum folate concentration, before and after 1998.

After rejecting the hypothesis of common effect model, we moved to the distributional effect of the fortification, investigating the impact of the policy on different quantiles of serum folate concentration by computing the quantile treatment effect developed by Firpo (2007). We found a stronger impact of the policy on the right tail of the distribution, thus suggesting that the policy increased overconsumption as well as decreased the prevalence of serum folate deficiencies. This result holds even when dietary habits are taken into account. Finally, relaxing the rank invariance assumption on which Firpo's estimator relies, we were able to link the effects of the policy to the change in individual behaviors, as a response to the change in folic acid availability.

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Appendix 2.1: graphs and tables

NUTRIENT	TOTAL		FEMALES		MALES	
	mean	obs.	mean	obs.	mean	obs.
Serum folate	11.56	38,881	12.23	20,186	10.85	18,695
Vitamin C	.89	27,572	0.95	14,372	.83	13,200
Ferritin	105.46	42,272	68.32	21,869	144.16	20,403

Table 1: Descriptive analysis of the data by gender

NUTRIENT	TOTAL		WHITE		BLACK		HISPANIC MEXICAN		OTHER	
	mean	obs.	Mean	obs.	mean	obs.	mean	obs.	mean	obs.
Serum folate	11.56	38,881	11.94	14,637	9.55	10,418	10.86	11,482	11.57	2,344
Vitamin C	0.89	27,572	0.90	10,939	0.82	7,793	0.90	7,536	0.89	1,304
Ferritin	105.46	42,272	106.63	15,640	113.07	11,420	85.92	12,630	102.73	2,582

Table 2: Descriptive analysis of the data by ethic group

NUTRIENT	TOTAL		LOW EDUCATION		HIGH EDUCATION	
	mean	obs.	mean	Obs.	mean	obs.
Serum folate	11.41	38,058	11.43	21,958	11.40	16,100
Vitamin C	0.89	27,563	0.90	14,770	0.88	12,793
Ferritin	107.53	40,72	86.38	24,617	121.23	16,108

Table 3: Descriptive analysis of the data by level of education

NUTRIENT	TOTAL		PHASE 1		PHASE 2		PHASE 3	
	mean	obs.	mean	obs.	mean	obs.	mean	obs.
Serum folate	11.56	38,881	6.48	11,776	7.99	11,193	15.42	15,912
Vitamin C	0.89	27,572	0.76	10,450	0.81	9,845	0.98	7,277
Ferritin	105.46	42,272	104.12	13,164	105.67	12,452	106.00	16,656

Table 4: Descriptive analysis of the data by steps of the fortification

NUTRIENT	TOTAL	GENDER		RACE			
		MALE	FEMALE	WHITE	BLACK	MX_HISPANIC	OTHER
Serum folate	0.37	0.36	0.37				
Vitamin C	0.37	0.32	0.30	0.32	0.30	0.26	0.26
Ferritin	.053	0.47	0.52	0.51	0.56	0.55	0.56

Table 5: Descriptive analysis of the inequality in serum folate, vitamin C and ferritin concentration (Gini indices)

variable	before the supplementation	after the supplementation	t-test	significance
Folate	7.039609	15.48512	-9.0420	***
Ferritin	102.3719	106.1037	-1.2142	
* $p < .10$ ** $p < .05$ *** $p < .01$				

Table 6: T-test for mean differences

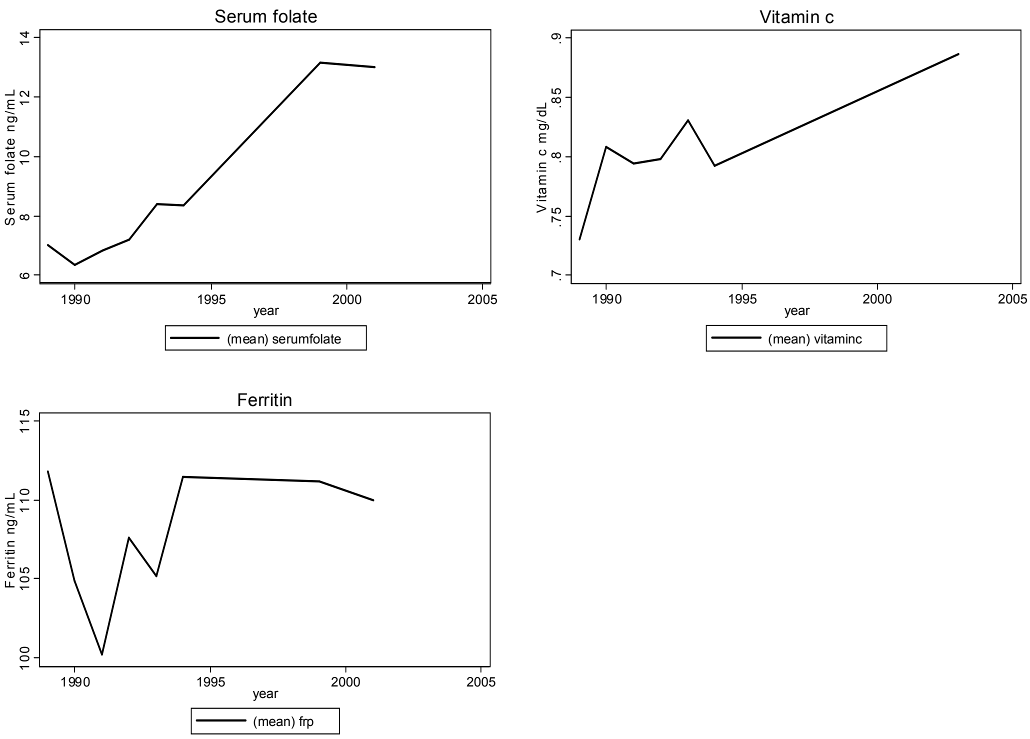
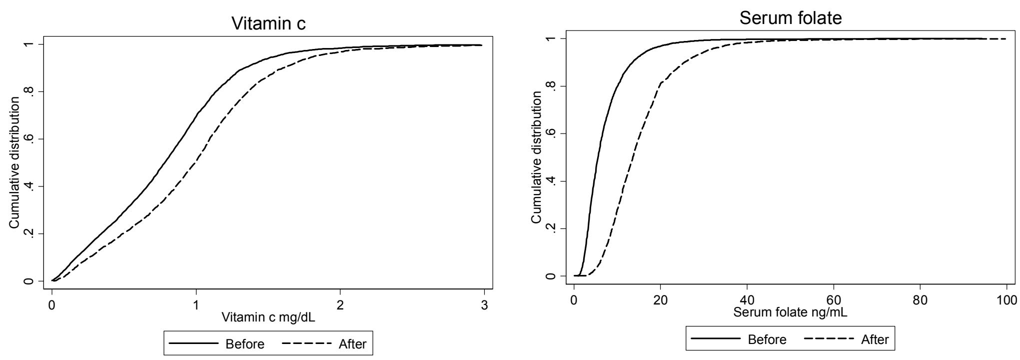


Figure 1: Trends in Average Serum Folate, Vitamin C and Ferritin



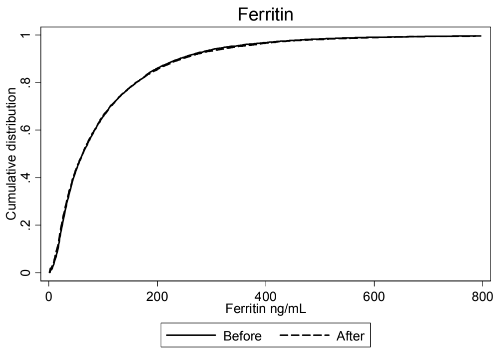
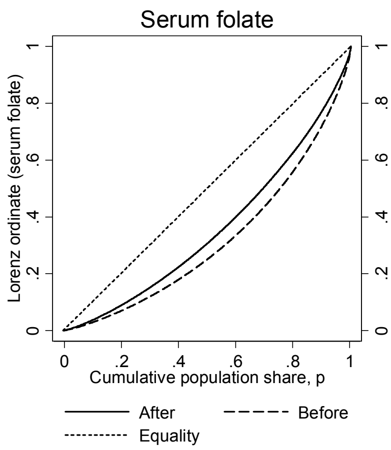
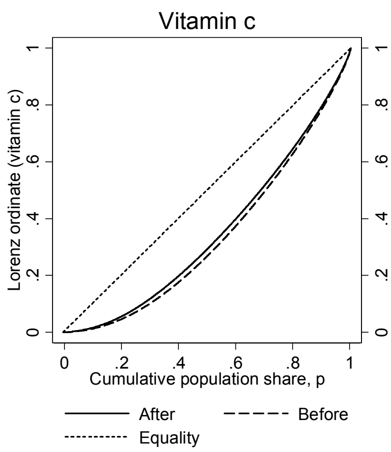


Figure 2: Cumulative Distribution of Serum Folate, Vitamin C and Ferritin Concentration





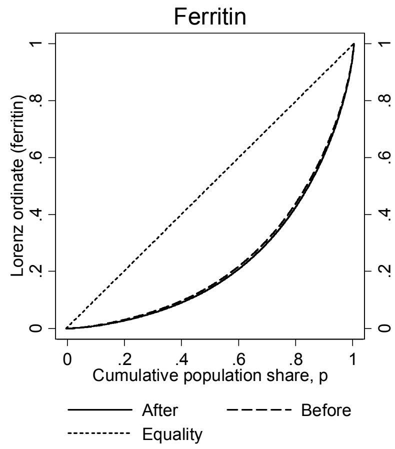


Figure 3: Lorenz Curves for Serum Folate,Vitamin C and Ferritin

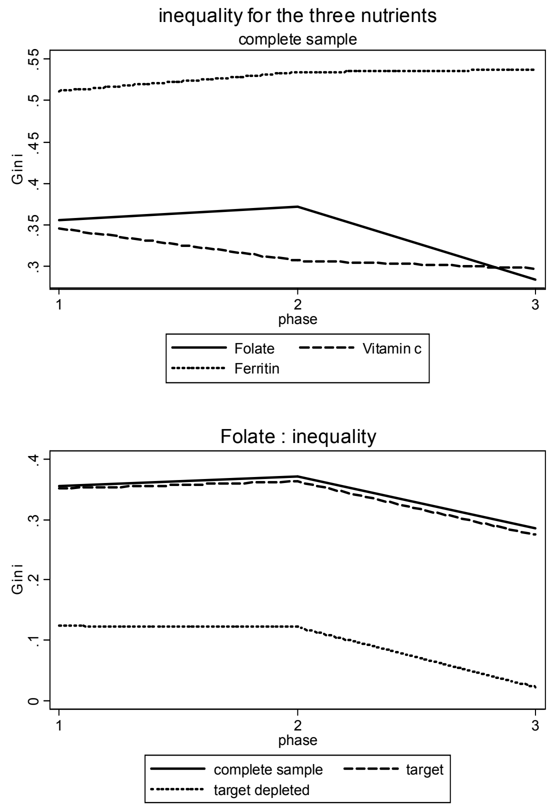


Figure 4: Gini indices dynamics

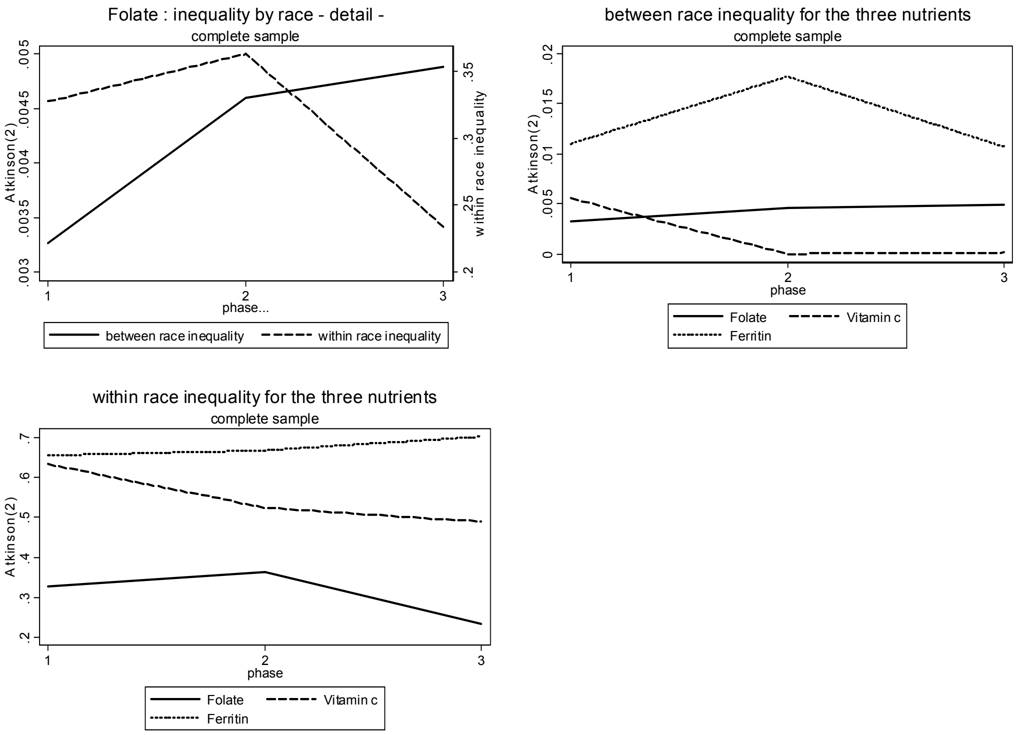


Figure 5: Within and between inequality

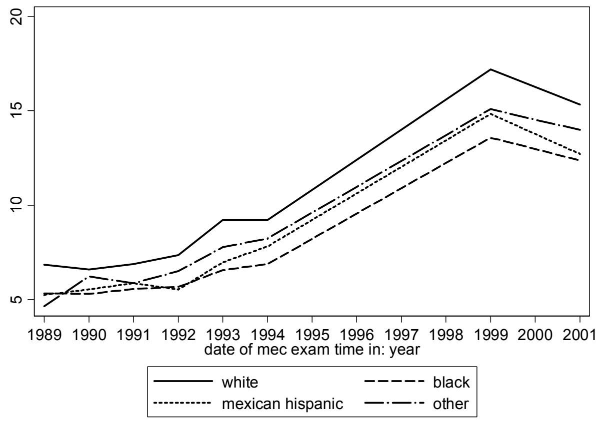


Figure 6: trends for different races

variable	Control group	Treatment group	t-test	significance
Folate	33.78363	43.49571	-17.9449	***
* p < .10 ** p < .05 *** p < .01				

Table 7: difference in serum folate concentration between between RTE cereal eaters and not RTE cereal eaters (NHANES 199/2000)

Variable	coefficient	Standard errors	Significance
Male	-0.0203873	0.0890847	
Black	-0.3593399	0.066903	***
Black_Male	0.1347435	0.0961022	
Mexican-Hispanic	-0.3088987	0.0916512	***
Male_MexicanHispanic	0.0560008	0.0881352	
Other	-0.4976317	0.0916512	***
Other_male	-0.0347966	0.1378423	
High education	0.2007299	0.0583584	***
High education_male	-0.0037099	0.0806224	
Age	-0.1141378	0.0100475	***
Age2	0.0019933	0.0002514	***
Age3	-9.79e-06	1.85e-06	***
Age_male	-0.0006241	0.0015817	
constant	0.9794879	0.1119653	***
Observations			6879
Pseudo R^2			0.0605

Table 8: Estimation of the propensity score. Probit regression (without including beta carotene concentration)

Variable	coefficient	Standard errors	Significance
Male	-0.0098765	0.0903009	
Black	-0.3555841	0.067753	***
Black_Male	0.1087147	0.097586	
Mexican-Hispanic	-0.2957586	0.0617415	***
Male_MexicanHispanic	0.037508	0.0890241	
Other	-0.4801769	0.0922293	***
Other_male	-0.0638004	0.1390184	
High education	0.1984574	0.0590015	***
High education_male	-0.0097487	0.0815827	
Age	-0.1104705	0.0102118	***
Age2	0.0018863	0.0002558	***
Age3	-9.02e-06	1.89e-06	***
Age_male	-0.00041	0.0016054	
Beta-carotene concentration	0.0016883	0.0011595	
constant	0.9264679	0.1150303	***
Observations			6733
Pseudo R^2			0.0604

Table 9: Estimation of the propensity score. Probit regression (including the beta carotene concentration as a covariate)

Sample	Treated	Controls	Difference	St.errors	T-stat
Unmatched	43.180416	33.352014	9.82840201	0.562338412	17.48
ATT	43.180416	36.5928096	6.58760639	1.50451746	4.38

Table 10: ATT after the one-to-one matching (without including concentration of beta carotene as a control)

Sample	Treated	Controls	Difference	St.errors	T-stat
Unmatched	43.180416	33.352014	9.82840201	0.562338412	17.48
ATT	43.180416	36.1465992	7.03381676	0.64743827	10.86

Table 11: ATT after the kernel matching (without including concentration of beta carotene as a control)

Sample	Treated	Controls	Difference	St.errors	T-stat
Unmatched	43.0085661	33.2782363	9.73032976	.567404932	17.15
ATT	43.0085661	36.083405	6.92516115	.652769979	10.61

Table 12: ATT after the kernel matching (including concentration of beta carotene as a control –parametrically-)

Sample	Difference	St.errors
ATT	6.608815	.3746354

Table 13: ATT after the kernel matching for each quintile of the propensity score (including concentration of beta carotene as a control –non parametrically-)

variable	sample	treated	Control	%bias	%reduct bias	t	pvalue
Black	Unmatched	.20857	.22742	-4.6		-1.64	0.100
	Matched	.20857	.20738	0.3	93.7	0.09	0.930
Male_Black	Unmatched	.10767	.10676	0.3		0.11	0.915
	Matched	.10767	.10339	1.4	-371.1	0.41	0.678
Mexican-Hispanic	Unmatched	.31849	.34711	-6.1		-2.19	0.028
	Matched	.31849	.3162	0.5	92.0	0.15	0.884
Male_MexicanHispanic	Unmatched	.16234	.1669	-1.2		-0.44	0.657
	Matched	.16234	.1569	1.5	-19.7	0.44	0.658
Other	Unmatched	.05806	.10186	-16.2		-5.55	0.000
	Matched	.05806	.05995	-0.7	95.7	-0.24	0.812
Male_other	Unmatched	.02537	.04603	-11.2		-3.80	0.000
	Matched	.02537	.0248	0.3	97.3	0.11	0.915
Male	Unmatched	.49775	.4811	3.3		1.21	0.227
	Matched	.49775	.48727	2.1	37.1	0.62	0.533
High education	Unmatched	.35738	.40842	-10.5		-3.79	0.000
	Matched	.35738	.36117	-0.8	92.6	-0.23	0.814
Male_high education	Unmatched	.16291	.18492	-5.8		-2.08	0.037
	Matched	.16291	.16212	0.2	96.4	0.06	0.949
Age	Unmatched	31.06	35.762	-19.9		-7.43	0.000
	Matched	31.06	31.082	-0.1	99.5	-0.03	0.978
Age2	Unmatched	1582.1	1775.2	-9.5		-3.55	0.356
	Matched	1582.1	1571.4	0.5	94.5	0.15	0.881
Age3	Unmatched	1.0e+05	1.1e+0	-2.5		-0.92	0.356
	Matched	1.0e+05	99766	0.8	65.9	0.24	0.813
Age_male	Unmatched	15.104	17.243	-9.1		-3.28	0.001
	Matched	15.104	14.774	1.4	84.5	0.43	0.671

Distribution of absolute bias		
statistics	unmatched	matched
5th percentile	.2935	.0951257
25th percentile	3.330224	.3036858
median	6.075608	.6970244
75th percentile	10.51226	1.382601
95th percentile	19.92101	2.09509

Sample	Pseudo R2	LR chi2	p>chi2
Unmatched	0.060	475.12	0.000
Matched	0.000	1.67	1.000

Table 14: Assessing the quality of the matching procedure (kernel matching without including concentration of beta carotene as a control)

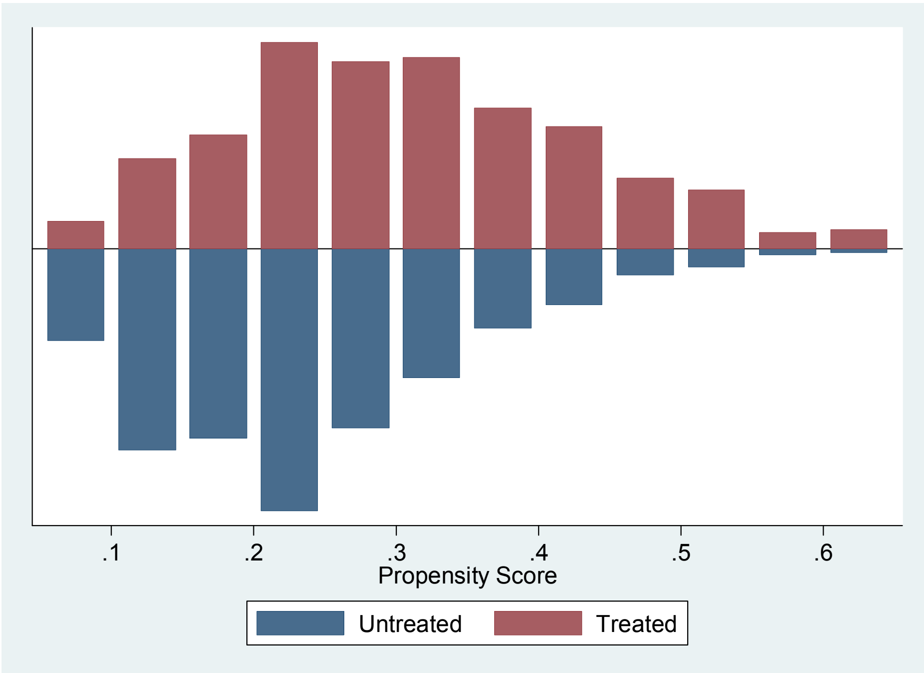


Figure 7: balance of the covariates

variable	sample	treated	Control	%bias	%reduct bias	t	pvalue
Black	Unmatched	.20624	.22731	-5.1		-1.82	0.069
	Matched	.20624	.20584	0.1	98.1	0.03	0.977
Male_Black	Unmatched	.10514	.10696	-0.6		-0.21	0.833
	Matched	.10514	.10189	1.1	-79.0	0.31	0.754
Mexican-Hispanic	Unmatched	.32467	.35146	-5.7		-2.02	0.043
	Matched	.32467	.32148	0.7	88.1	0.20	0.841
Male_MexicanHispanic	Unmatched	.16464	.16913	-1.2		-0.43	0.667
	Matched	.16464	.15859	1.6	-35.0	0.48	0.628
Other	Unmatched	.05893	.10216	-15.9		-5.40	0.000
	Matched	.05893	.06099	-0.8	95.2	-0.26	0.798
Male_other	Unmatched	.02542	.04638	-11.3		-3.79	0.000
	Matched	.02542	.02494	0.3	97.7	0.09	0.928
Male	Unmatched	.49509	.48001	3.0		1.08	0.279
	Matched	.49509	.48403	2.2	26.7	0.65	0.515
High education	Unmatched	.35586	.40664	-10.5		-3.73	0.000
	Matched	.35586	.35977	-0.8	92.3	-0.24	0.810
Male_high education	Unmatched	.16118	.18293	-5.8		-2.04	0.041
	Matched	.16118	.16063	0.1	97.5	0.04	0.965
Age	Unmatched	30.927	35.741	-20.5		-7.53	0.000
	Matched	30.927	30.991	-0.3	98.7	-0.08	0.939
Age2	Unmatched	1568.8	1772.4	-10.1		-3.71	0.000
	Matched	1568.8	1562.5	0.3	96.9	0.09	0.930
Age3	Unmatched	1.0e+05	1.0e+05	-2.9		-1.08	0.280
	Matched	1.0e+05	99200	0.6	80.3	0.16	0.873
Age_male	Unmatched	15.02	17.207	-9.3		-3.32	0.001
	Matched	15.02	14.711	1.3	85.9	0.39	0.695

Distribution of absolute bias		
statistics	unmatched	matched
5th percentile	.5895849	.0977438
25th percentile	3.017001	.2733319
median	5.76357	.674617
75th percentile	10.46614	1.055102
95th percentile	20.45502	2.211802

Sample	Pseudo R2	LR chi2	p>chi2
Unmatched	0.060	461.79	0.000
Matched	0.000	1.74	1.000

Table 15: Assessing the quality of the matching procedure (kernel matching without including concentration of beta carotene as a control)

Value of the correlation	Variance of the treatment $= V(Y_1 - Y_0)$
-1	1367.225
-0.9	1322.23
-0.8	1277.234
-0.7	1232.239
-0.6	1187.244
-0.5	1142.249
-0.4	1097.254
-0.3	1052.259
-0.2	1007.263
-0.1	962.2682
0	917.273
0.1	872.2778
0.2	827.2826
0.3	782.2875
0.4	737.2923
0.5	692.2971
0.6	647.3019
0.7	602.3067
0.8	557.3116
0.9	512.3164
1	467.3212

Variance of Y_0=369.8062 and variance of Y_1=547.4668

Table 16: Variance of the treatment

Quantile	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Quantile_1	2.497001	0.803666	3.11	0.002	0.9218453	4.072156
Quantile_2	2.951	0.778855	3.79	0.000	1.424473	4.477527
Quantile_3	3.405	0.715865	4.76	0.000	2.00193	4.808069
Quantile_4	3.405001	0.765112	4.45	0.000	1.905408	4.904593
Quantile_5	3.177999	0.758788	4.19	0.000	1.690802	4.665197
Quantile_6	3.404999	0.707915	4.81	0.000	2.017511	4.792487
Quantile_7	4.086	0.670761	6.09	0.000	2.771334	5.400667
Quantile_8	4.54	0.63928	7.1	0.000	3.287033	5.792967
Quantile_9	4.539999	0.623133	7.29	0.000	3.318681	5.761317
Quantile_10	4.993999	0.616248	8.1	0.000	3.786174	6.201823
Quantile_11	4.993999	0.615708	8.11	0.000	3.787234	6.200765
Quantile_12	4.994001	0.615954	8.11	0.000	3.786754	6.201249
Quantile_13	4.993999	0.600314	8.32	0.000	3.817406	6.170593
Quantile_14	5.221001	0.598045	8.73	0.000	4.048854	6.393148
Quantile_15	5.220999	0.596387	8.75	0.000	4.052101	6.389896
Quantile_16	5.448	0.595084	9.16	0.000	4.281657	6.614343
Quantile_17	5.220999	0.582435	8.96	0.000	4.079448	6.362549
Quantile_18	5.448002	0.588061	9.26	0.000	4.295424	6.60058
Quantile_19	5.447998	0.588945	9.25	0.000	4.293687	6.602309
Quantile_20	5.675001	0.5904	9.61	0.000	4.517838	6.832165
Quantile_21	5.674999	0.590441	9.61	0.000	4.517757	6.832242
Quantile_22	5.674999	0.583215	9.73	0.000	4.531919	6.81808
Quantile_23	5.675001	0.589845	9.62	0.000	4.518926	6.831076
Quantile_24	5.901999	0.589049	10.02	0.000	4.747484	7.056513
Quantile_25	6.356001	0.595418	10.67	0.000	5.189003	7.522998
Quantile_26	6.128998	0.593117	10.33	0.000	4.96651	7.291486
Quantile_27	6.356001	0.589801	10.78	0.000	5.200012	7.51199
Quantile_28	6.583	0.593993	11.08	0.000	5.418796	7.747205
Quantile_29	6.582998	0.596145	11.04	0.000	5.414576	7.75142
Quantile_30	6.810001	0.598474	11.38	0.000	5.637015	7.982988
Quantile_31	6.809999	0.597436	11.4	0.000	5.639047	7.980952
Quantile_32	6.809999	0.597836	11.39	0.000	5.638262	7.981737
Quantile_33	6.810001	0.60103	11.33	0.000	5.632004	7.987999
Quantile_34	7.037001	0.603069	11.67	0.000	5.855006	8.218995
Quantile_35	6.809999	0.599296	11.36	0.000	5.635401	7.984598
Quantile_36	7.037001	0.602848	11.67	0.000	5.85544	8.218561
Quantile_37	7.263998	0.600514	12.1	0.000	6.087011	8.440985
Quantile_38	7.036999	0.598487	11.76	0.000	5.863985	8.210012
Quantile_39	7.264004	0.59601	12.19	0.000	6.095845	8.432162
Quantile_40	7.036999	0.596264	11.8	0.000	5.868342	8.205655
Quantile_41	7.263998	0.594041	12.23	0.000	6.099699	8.428297
Quantile_42	7.490999	0.594714	12.6	0.000	6.325382	8.656617
Quantile_43	7.490999	0.592832	12.64	0.000	6.329069	8.652929
Quantile_44	7.491001	0.592907	12.63	0.000	6.328924	8.653078
Quantile_45	7.718	0.590622	13.07	0.000	6.560404	8.875597
Quantile_46	7.945	0.590758	13.45	0.000	6.787136	9.102863
Quantile_47	7.718	0.589076	13.1	0.000	6.563432	8.872569
Quantile_48	7.718002	0.585992	13.17	0.000	6.56948	8.866525
Quantile_49	7.718	0.59088	13.06	0.000	6.559896	8.876105

Quantile_50	7.491003	0.58931	12.71	0.000	6.335976	8.64603
Quantile_51	7.264	0.589241	12.33	0.000	6.10911	8.41889
Quantile_52	7.263996	0.588012	12.35	0.000	6.111513	8.416479
Quantile_53	7.036999	0.58731	11.98	0.000	5.885893	8.188105
Quantile_54	7.037001	0.588359	11.96	0.000	5.883838	8.190163
Quantile_55	7.264	0.587347	12.37	0.000	6.11282	8.41518
Quantile_56	7.264	0.586793	12.38	0.000	6.113907	8.414093
Quantile_57	7.036999	0.586944	11.99	0.000	5.88661	8.187387
Quantile_58	7.263996	0.587978	12.35	0.000	6.111581	8.416411
Quantile_59	7.036999	0.588505	11.96	0.000	5.883549	8.190448
Quantile_60	7.037003	0.593655	11.85	0.000	5.87346	8.200546
Quantile_61	7.036999	0.602315	11.68	0.000	5.856483	8.217514
Quantile_62	6.809998	0.607411	11.21	0.000	5.619493	8.000502
Quantile_63	6.809998	0.621017	10.97	0.000	5.592826	8.027169
Quantile_64	6.809998	0.636016	10.71	0.000	5.563429	8.056566
Quantile_65	6.810001	0.65459	10.4	0.000	5.527029	8.092973
Quantile_66	6.810001	0.673728	10.11	0.000	5.489519	8.130483
Quantile_67	6.809998	0.693224	9.82	0.000	5.451304	8.168691
Quantile_68	6.810001	0.713276	9.55	0.000	5.412007	8.207996
Quantile_69	6.810001	0.734519	9.27	0.000	5.370371	8.249632
Quantile_70	6.810001	0.76087	8.95	0.000	5.318723	8.30128
Quantile_71	6.583	0.787892	8.36	0.000	5.03876	8.127241
Quantile_72	7.491001	0.899812	8.33	0.000	5.727403	9.254599
Quantile_73	7.945	0.984905	8.07	0.000	6.014621	9.875378
Quantile_74	8.172001	1.08212	7.55	0.000	6.051085	10.29292
Quantile_75	8.399002	1.157407	7.26	0.000	6.130526	10.66748
Quantile_76	8.853001	1.207285	7.33	0.000	6.486766	11.21924
Quantile_77	9.760998	1.214163	8.04	0.000	7.381282	12.14071
Quantile_78	10.669	1.195485	8.92	0.000	8.325894	13.01211
Quantile_79	11.123	1.197546	9.29	0.000	8.775851	13.47014
Quantile_80	11.577	1.180592	9.81	0.000	9.263085	13.89092
Quantile_81	12.031	1.157616	10.39	0.000	9.762112	14.29988
Quantile_82	12.258	1.131114	10.84	0.000	10.04106	14.47494
Quantile_83	12.031	1.130733	10.64	0.000	9.814805	14.2472
Quantile_84	11.804	1.188036	9.94	0.000	9.475488	14.13251
Quantile_85	11.804	1.22916	9.6	0.000	9.394887	14.21311
Quantile_86	11.804	1.292571	9.13	0.000	9.270603	14.33739
Quantile_87	11.35	1.319315	8.6	0.000	8.764192	13.93581
Quantile_88	11.34999	1.337084	8.49	0.000	8.729358	13.97063
Quantile_89	11.577	1.390683	8.32	0.000	8.851315	14.30269
Quantile_90	11.123	1.511782	7.36	0.000	8.15996	14.08603
Quantile_91	10.442	1.567852	6.66	0.000	7.369064	13.51493
Quantile_92	11.123	1.781341	6.24	0.000	7.631637	14.61436
Quantile_93	10.669	1.940123	5.5	0.000	6.866432	14.47157
Quantile_94	11.577	1.985464	5.83	0.000	7.685557	15.46843
Quantile_95	11.577	2.036123	5.69	0.000	7.586269	15.56772
Quantile_96	11.804	2.19491	5.38	0.000	7.502057	16.10594
Quantile_97	12.712	3.41323	3.72	0.000	6.022191	19.40181
Quantile_98	13.166	4.048093	3.25	0.001	5.231884	21.10012
Quantile_99	13.393	4.500642	2.98	0.003	4.571902	22.21409

Table 17 Estimated quantile treatment effects assuming rank invariance

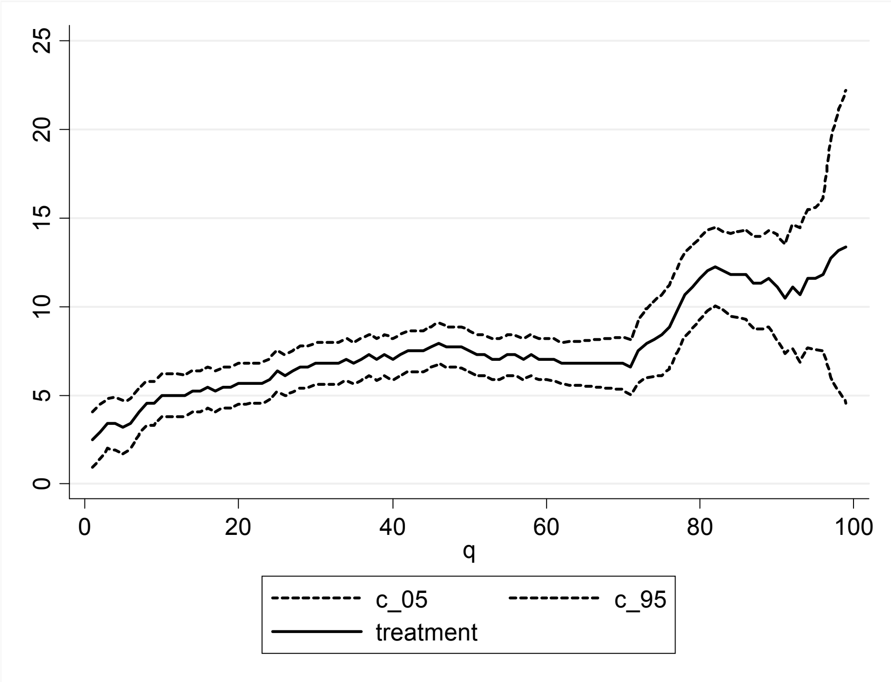


Figure 8: Quantile treatment effects (with confidence intervals) estimated using the quantile treatment effect estimator proposed by Firpo (2007)

Quantile	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
0.25	6.356001	.5894684	10.78	0.000	5.200664	7.511338
0.5	7.491003	.5893102	12.71	0.000	6.335976	8.64603
0.75	8.399002	1.157407	7.26	0.000	6.130526	10.66748

Table 18: Quantile treatment effects estimated using Firpos's estimator without controlling for dietary habits

Quantile	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
0.25	6.129002	.6026047	10.17	0.000	4.947918	7.310085
0.5	7.491003	.6065026	12.35	0.000	6.30228	8.679726
0.75	7.945004	1.13463	7.00	0.000	5.72117	10.16884

Table 19: Quantile treatment effects estimated using Firpos's estimator controlling for dietary habits (parametrically)

	without controlling for dietary habits		without controlling for dietary habits	
statistics	perfect positive dependence	perfect negative dependence	perfect positive dependence	perfect negative dependence
5th percentile	4.1768	-51.0296	4.0406	-50.8934
25th percentile	5.947399	-12.8482	5.6296	-34.7537
median	7.5364	7.5364	7.4683	7.5818
75th percentile	8.535199	27.7848	8.489799	26.8314
95th percentile	12.712	66.6018	13.5292	69.0534

Table 20: Percentiles of parameters of the impact distributions (perfect positive and perfect negative dependency)

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statistics	distribution of the 25th percentile	distribution of the median	distribution of the 75th percentile
minimum	-62.9698	-32.7334	-20.4754
25th	-36.6832	-1.770601	9.4205
50th	-4.8351	4.0406	15.1636
75th	-0.4085999	8.4898	19.6128
maximum	12.3942	24.5614	30.0094

Table 21: Percentiles of parameters of the impact distributions with a random sample of 1000 quantile permutations

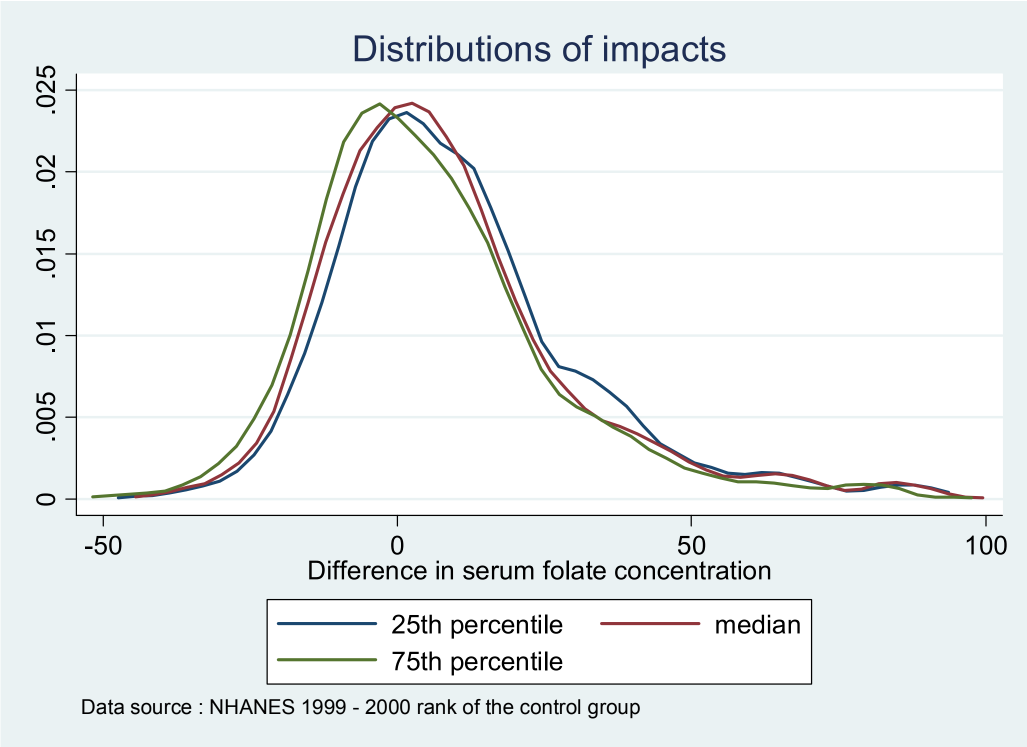

Figure 9: Distribution of the impacts assuming no correlation between the potential outcomes

Chapter 3

Obesity in Egypt: trends, socioeconomic inequalities and determinants

with Marc Suhrcke[26]

Abstract

Egypt is an example of a middle income country facing an enormous public health burden attributable to obesity. This paper sheds light on various aspects of obesity in Egypt, using data from 1992 to 2008 for women only. We start at the macro level to demonstrate that the prevalence of obesity in Egypt is significantly higher than in other countries at comparable per capita income levels. While the exceptionally high level of obesity applies to all socioeconomic groups in the country, it has thus far been the higher educated, the wealthier and the urban residents that display the largest prevalence, unlike most other countries at a similar level of economic development. Recently however a trend has emerged towards a reversal in the socioeconomic gradient.

The bulk of the increase in obesity has occurred over the 1990ies, flattening between 2000 and 2005 and modestly declining thereafter. On the whole, the high *levels* of obesity in Egypt appear to have been driven by the fairly stable, high obesity prevalence in the upper socioeconomic groups, while the observed *changes* in obesity over time are mostly driven by the changes in obesity within the lower socioeconomic groups.

A decomposition analysis of the micro data also reveals that obesity has been driven by an obesity enhancing age effect, a declining cohort effect, and a highly variable period effect, the combination of which renders the prediction of future trends very difficult.

The multivariate analysis confirms the surprising independent, positive association between education, wealth and urban residence (alongside other relevant factors) on one hand and obesity on the other hand. Year-by-year analysis shows that these effects are declining and that most recently obesity is becoming equally important in people and areas characterised by lower socioeconomic status.

Keywords: obesity, Egypt, women, socioeconomic inequalities

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3.1 Introduction

Obesity has become one of the – if not *the* – foremost public health challenges in high income countries, as current trends show no unambiguous signs of abating (Sassi et al. 2009) . The `obesity epidemic' in rich countries has been documented and analyzed in a by now enormous body of public health literature. Recently, also economists have devoted a growing interest in the topic, studying both positive and normative aspects of obesity (Philipson and Posner, 2008).

Obesity was traditionally seen as a `disease of affluence', suggesting it is `merely' a problem for the rich. This notion, however, has clearly been rejected by a still small but growing literature on the phenomenon in the developing world. Hence, public health researchers and advocates have begun to speak of obesity as a `global epidemic' (see for example Caballero, 2007; James, 2008; Prentice, 2005): `The world is fat', as the title of a recent book proclaims (Popkin, 2008).

While there is widespread agreement at least in the scientific community that obesity has become a public health problem also in the developing world, there remains a persistent, and rather fundamental shortage of data to first of all accurately measure the size and recent evolution of the problem. This is because most of the existing household surveys in low and middle income countries have at least until recently focused their attention on `traditional' developing countries' health challenges, i.e. infectious diseases, under-nutrition, maternal and child health.

This is certainly true for one of the main high quality surveys conducted in the developing world: the Demographic and Health Surveys (DHS)[27]. The DHS has become a leading source of information on a wide range of fertility and (mostly female and child) health issues in LMICs. For instance, the detailed measurement of nutritional indicators, including respondents' height and weight has allowed to capture and understand patterns and trends in short- and long-term deficits in nutrition, proxied by wasting and stunting.

Somewhat surprisingly, the available information on height and weight has rarely been used to describe the phenomenon of the overweight and obesity `surplus' side of the nutritional scale (with some notable exceptions, see for example, Monteiro et al., 2004, Nahmias, 2008). Although the data to calculate Body Mass Index (BMI) was collected in the surveys, the DHS reports that accompany the release of the data of every survey have refrained from publishing overweight data (until very recently in some countries).

Hence the DHS data potentially offers a unique and extremely valuable source to improve our understanding of overweight/obesity in the developing world. In the present paper we explore this potential using all available rounds of the DHS data for Egypt for which we have information on BMI (1992, 1995, 2000, 2005, 2008), a middle-income country facing an exceptionally large (but probably internationally under-appreciated) obesity problem. According to the latest version of the Global Prevalence of Adult Obesity database of the International Obesity Taskforce (IOTF)[28], the proportion of women classified as either overweight or obese in Egypt (79.8% in 2005) were even

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[27] see www.measuredhs.com

[28] See http://www.iotf.org/database/documents/GlobalPrevalenceofAdultObesityOctober2009v2.pdf (last accessed 20/11/2009).

higher than in the US (61.8% in 2003-4) and in England (56.4 in 2007).[29]
We use DHS data to examine the level, trends, distribution and correlates of obesity in Egypt in greater detail, and we perform a statistical analysis at the microlevel to study in deep the determinants of obesity and its changes over time. While the data focuses on a subsample of the population, i.e. ever married women who gave birth in the previous 5 years, the implications are likely to be relevant at the population level too, not least because of the size of subsample. In addition, studying married women and in particular mothers is important in light of the evidence of intergenerational transmission of health, via genetic, cultural or economic mechanisms (see, for example Ahlburg, 1998).

The first part of the analysis takes an aggregate, macro level perspective by analysing the levels and trends in obesity in Egypt, at a national level and by different socioeconomic indicators. The second part employs micro data analysis to (1) determine the age, cohort and period effects driving obesity in Egypt and (2) to assess the correlates of obesity in Egypt, using logit and quantile regression models.

The paper is organized as follows. Section 2 discusses the related literature and previously published data on obesity. Section 3 presents the data and the empirical specification. In section 4 we present the results of the analysis, the quantile regression and the APC model. Section 5 concludes.

3.2 Background

One of the most widely debated issues in the literature about obesity is the relationship between Body Mass Index (BMI) and socioeconomic status (SES),[30] which seems to explain most of the variation in obesity shares. Using American data, Baum and Ruhm (2007) claim that maternal education is a good predictor of BMI of 24-36 years old people. In fact, BMI is found to be lower in individual with high parental SES. Brunello et al. (2009) focus both on the determinants and on the consequences of the rising obesity in Europe. In line with Baum's results, they find that also in European countries the family background (proxied by parental SES and parental BMI[31]) plays a crucial role in explaining obesity. In addition, they find that there are both a significant wage differential and a significant educational attainment gap between obese people and normal range ones. All these findings may provide economic rationale for an intervention in obesity reduction.

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29 There are of course limits to the comparability of the data: the Egyptian data covers women aged 15-49, the English data refers to women older than 16 while the US data relates to women older than 20 years. It is worth noticing that in Egypt the share of obese women (46.6%) is even much higher than the overweight share (33.2%), underlining the gravity of the situation. The data presented here look different from the ones in the rest of the paper, because we focused on a subsample of mothers. Women in our sample are younger than the ones considered by IASO.

30 A new and rich systematic review on the topic is presented by McLaren (2007) and, on the more economic side, by Philipson and Posner (2008)

31 For an earlier investigation of the effect of diet and parental BMI on children's obesity, see Coate (1983)

The direct link between personal level of education and obesity status is also investigated by Kenkel et al. (2006), who perform a rich IV estimation to overcome the bias resulting from the possible endogeneity of school attainments.

Rising obesity has been interpreted also taking into account changes in the economic and social background in which food production and consumption take place. Two of the most widely cited papers in this literature are Cutler et.al.(2003) and Lakdawalla and Philipson (2002), in which the authors explain the changes in BMI by using the change in consumption of goods that experienced a bigger technological change[32]. Chou et al. (2004) also investigate the effect of environmental changes on food intake. They use microlevel data from the 1984-1999 "Behavioral Risk Factor Surveillance System" and find that the growth of the per capita number of restaurants can be a possible determinant of the rise of adiposity in the American population. The same authors find a negative effect both of education and household wealth. A similar study is the one by Rashad et al. (2006) who use NHANES data, the one by Currie et al. (2009) who use the exact geographical location of fast foods and the one by Sandy et al. (2009). On the same line, has been proven that the share of American obese children has increased thanks to their exposure to fast food advertisements on television (Chou et al, 2004). In addition, people who watch much television are more likely to report negative health measures, such as high BMI, high cholesterol, high blood pressure and smoking during adulthood (Hancox et. al. 2004).

In general, institutional and cultural factors explain most of the obesity prevalence. In fact, differences in obesity in two similar Mediterranean countries (Italy and Spain) are mainly determined by differences in nutritional habits and educational levels. However, when peer effects are taken into account, the link turned out to be much less pronounced (Costa-Font et al, Feb 2008 and Costa-Font et al, Nov 2008).

With the increasing importance of the obesity problem, in the last decade the attention has begun to shift from rich countries to developing ones[33] and, in particular, to the condition of women. According to Martorell et al. (2000), overweight is becoming more and more important also in poor areas and its prevalence has exceeded the prevalence of underweight in many countries, also when considering rural areas. In fact, in developing countries women tend to be more obese than men and, in contrast to what happens in the more developed areas, there is a highly significant positive relationship between SES and obesity. The reason of such a positive relationship can be found in the fact that in developing countries, girls are more likely to be undernourished when young, condition which exposes children to develop obesity during adulthood. In addition, at least in some cases, being overweight, particularly when considering women, is seen as a signal of a positive social status (Case and Menendez, 2007)

Despite the obvious public health importance, comparatively little research attention has been dedicated to the obesity problem in Middle East and North African

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[32] A model which explains this relationship is provided in Lakdawalla et al. (2005)

[33] See Popkin (2001)

(MENA) countries[34] and, in particular, in Egypt. In fact, according to Galal (2002), in the last 50 years Egypt experienced a major nutrition transition due to fast urbanization and increasing food availability. Asfaw (2006) argues, on the basis of his theoretical and empirical findings, that part of the transition can be explained by a decrease in food prices of energy-dense food due to the fact that the government decided to subsidize aliments such as bread, sugar and oil. In another paper the same author Asfaw (2007) investigates more in depth the relationship between the subsidization of nutrient poor commodities and obesity. The author finds that the mothers who are micronutrient deficient are significantly more likely to be obese than the ones who follow a better diet. One explanation for this fact might be that the Egyptian food subsidy program has lowered the price of energy dense and nutrients poor food.

A particularly informative contribution implicitly highlighting the exceptional location of Egypt in terms of obesity comes from a widely cited paper by Monteiro et al. (2004). The authors have collected obesity data for women between 1990 and 2002 for 37 developing countries (using data from the DHS and the Reproductive health Surveys), including Egypt, chiefly to assess how the socioeconomic gradient of obesity evolves as countries grow richer. While the paper had no specific focus on Egypt, we can use the data they made available to highlight first the exceptionally high level of obesity in Egypt already in the past decade, when compared to other countries at similar levels of economic development (Figure 1) and second, its no less extra-ordinary situation in terms of socioeconomic inequalities in obesity. Obesity in Egypt in the past decade was far more prevalent among the highest socioeconomic group (here measured by education) compared to the lowest one[35]; yet, both the lowest and highest socioeconomic groups show an obesity prevalence that is well above that found on average in other Countries of comparable per capita income levels. The issue that arises from these figures and that we seek to examine with the help of more recent data is whether the socioeconomic gradient has now reversed, as Egypt has meanwhile certainly passed the per capita income threshold when the switchover in the gradient typically does occur according to Monteiro et al (2004).

Figure 1 here

Figure 2 here

[34] Jackson (2007) compares the BMI of adolescent girls in three MENA countries (Egypt, Lebanon and Kuwait)

[35] This result has also been confirmed by Nahmias (2008) for more recent data, using DHS data from 1992 to 2005 for Egypt, and by Salazar et al (2006) who study overweight in adolescents in Mexico and Egypt. The situation in Egypt appears to differ from other countries in the MENA region. Mokhtar et al. (2001) find that in Morocco and Tunisia, which are both less wealthy then Egypt when measured by national per capita income, there is an inverse relationship between education and obesity.

An important issue, potentially explaining the greater prevalence of obesity among rich people, is whether or not Egyptian women are conscious of their being overweight and whether or not this status is considered negative. According to Harrison et al. (2000), Egyptian women are well conscious about their calory intake and they do not underreport their daily food intake. An interesting but not nationally representative[36] study by Jackson et al. (2003) shows that young girls are more willing to be thin than their mothers and that the effect is stronger in urban areas. This could be a proof of a cultural change in attitude towards obesity. A small difference between the current shape and the ideal one is also found by Ford et al (1990) in their analysis of a sample of Egyptian women highly exposed to western culture (all enrolled in the American University in Cairo). In fact, when asked to identify their preferred size, the women indicated a shape that was smaller then their current one.

In addition, it has been shown that the increase in Egyptian women's overweight is associated with an increase of chronic diseases and mortality, while the higher calories food intake (in terms of calories) is no `insurance' against some nutritional deficiencies typically associated with under-nutrition, such as anemia (see Eckhardt et al. (2008). A strong correlation between central obesity and diabetes and hypertension is also confirmed by Abolfotouh et al. (2008).

3.3 Data

The core micro data we employ in our study is from five different waves of the Egyptian Demographic and Health Survey (EDHS), a nationally representative household survey which covers many aspects of health (both communicable and non-communicable diseases), nutrition, family planning and population. We chose to use just the standard DHS surveys (disregarding the ad interim ones) to rely on a larger sample size for every year. Our research covers a time span of 15 years, considering the waves collected in 1992, 1995, 2000, 2005 and 2008[37]. The 2008 wave samples ever married women between 15 and 49 years old living in the urban governorates, in the urban and rural Lower Egypt, in the urban and rural Upper Egypt and in the frontier governorates. In order to make the sample comparable with the other waves, we disregard the frontier governorates (not sampled in 2002) and we trimmed the sample considering just the women who gave birth in the previous five years[38]. Finally, we do not consider pregnant women, since pregnancy obviously affects weight. At the end we are left with a sample size of around 33,000 observations.

Finally, we used data on population (Population prospect: The 2008 revision population database)[39] to forecast the changes in the composition of the Egyptian population due to the demographic transition the country is undergoing. Given that

[36] The sample consists in 340 girls between 11 and 19 years from the region near Cairo.

[37] We did not consider ad interim DHS collected in 1997, 1998 and 2003

[38] In the 1992 and 1995 waves just mothers were interviewed

[39] http://esa.un.org/UNPP/index.asp?panel=2

obesity is a phenomenon which affects older people, an aging population would imply an increased number of people potentially affected by this condition.

The indicator we are interested in and we use as a proxy of obesity status, is the measured[40] body mass index (BMI), which is defined as the ratio between the weight in kilos and the height squared, expressed in meters. We are aware that the body mass index is not the only measure of obesity we can consider and that it does not take into account the difference between adiposity and muscles. However, we are particularly interested in its relative change during the last 15 years and assume with some confidence that any remaining bias in BMI as a measure of true fatness is at least constant over time and hence does not affect the quality of our findings. Despite its acknowledged shortcomings, BMI also remains the single most widely used proxy for the obesity in most country-specific and cross-country analysis, a feature that is likely to remain so until superior measures (e.g. waist-to-hip ratio or waist circumference) are being routinely measured in household surveys. For our analysis we classified the women according to the WHO classification, i.e. we consider underweight women whose BMI falls below the value of 18.5, normal range those with BMI between 18.5 and 24.99, overweight the ones with BMI between 25 and 30 and obese women with a BMI above the 30 cut off.

Measuring the socio-economic status (SES) of an household is a notorious challenge that critically affects any statements about socio-economic inequalities in health. While the use of education as one important proxy of SES is widely accepted, at least three different measures are often considered for the measurement of material economic well-being: household earnings, household expenditure and wealth. While the first two present several problems due to measurement errors (misreporting, variability, home production), the third one seems to be a better measure of permanent income, which is the variable determining health status. Therefore, in order to assess the economic status of the individuals interviewed, we constructed a wealth index to proxy for household wealth. We used the widely applied methodology suggested by Filmer and Pritchett (2001), which is the standard way to compute the wealth index in the DHS surveys and since Rutstein and Johnson (2004) have shown that the index is consistent with current household consumption.

The measure we construct takes into account the number of assets owned in the household and the quality of the house (mainly floor characteristics and availability of water) which are aggregated linearly by using a set of weights derived via principal component analysis. This method allows us to capture a set of variables in a limited number of orthogonal dimensions (principal components) that describe their common characteristics. The (linear) index has been constructed by using the first component (the one that explains most of the variability) of a principal component analysis, according to the formula

$$A_j = \frac{f_1(a_{j1} - a_1)}{s_1} + \ldots + \frac{f_N(a_{jN} - a_N)}{s_N} \tag{1}$$

where a_{j1} - a_{jN} are the values of asset 1 to N in household j, a_1 - a_N are the means of the

[40]Since BMI is not self-reported, it does not create a bias due to measurement error and misreporting. This is an important advantage of the DHS survey compared to many European surveys which measure height and weight on the basis of self-reports.

value of the same assets in the population (in the same year), s_1-s_N their standard deviations and f_1-f_N are the first scoring factor of asset one to N. The index has mean zero and standard deviation equal to one and it has been computed separately for every year of the survey, in order to take into account the changes in the availability of assets in different points in time. By using the wealth index[41], we were able to divide the population in 5 different quintiles (for each year).

3.4 Methods and results

3.4.1 Aggregate analysis

In this section we take a more aggregate, country level look at obesity in Egypt. First, we document how the average BMI as well as its distribution have evolved in Egypt in most recent years, from the already high levels referred to above. Second, we disaggregate the levels and trends by socioeconomic proxies, measured in different ways. The latter serves to assess whether there are any signs that the Monteiro et al. (2004) prediction of a reversal of the socioeconomic gradient in obesity as countries become more wealthy also holds for the potentially specific case of Egypt.

Evolution of BMI

Figure 3 shows the evolution of average BMI in Egypt between 1992 and 2008. The bulk of the increase in mean BMI has occurred between 1995 and 2000, followed by a slower increase up until 2005 and a marked decline in mean BMI between 2005 and 2008, down to a BMI below the 2000 value. The mean BMI in 2008 is close to 28, and the corresponding share of obese (overweight) women is 30% (40%), illustrating the severity of the problem.[42]

Figure 3 here

Analysing the entire distribution sheds light on the dynamics of the increase in

[41] Constructing a wealth index that was consistent over time was not straightforward and our measure does not coincide perfectly with the one reported in the last (2005 and 2008) waves of DHS. In order to use the same information for every wave, we had to select only the assets and the questions which were asked in every year. Even if some proxies of wealth are present in every wave, the questions do change across years. We decided to take just a selection of the possible indicators of wealth because the index tends to be robust to the inclusion/exclusion of assets (Filmer and Pritchett 2001). The index also allows for potential differences in the importance of the single items in different periods. For each year the index assigns a weight to each variable, which reflect its relative frequency in the population.

[42] See Annex Figure 1 for the trends in obesity and overweight prevalence.

BMI (see Figure 4). Again it is evident that obesity affects a large share of the female population: only in the 1992 wave is the mode of the distribution below the value assumed as a threshold to identify overweight people (25), while it is well above this threshold in the following waves. It is worth noting that the kernel distributions of BMI prior to 2000 are positively skewed and the mass of probability is still concentrated on the left of the distribution, while, starting from 2000, the distribution seems to be more symmetric, highlighting the increasing burden of (mainly) overweight and (partly) obesity among Egyptian women, at the expense of healthy weight prevalence. In addition, the distributions of the data collected in 2000 and 2005 are slightly bimodal, with a peak around 26 and another around 30. The analysis of the kernel distributions also suggests an interpretation of the decrease in mean BMI from 2005 to 2008: the result is driven by the fall of the number of obese women and a concomitant rise in overweight prevalence.[43] Underweight, defined as a BMI below 18.5, has become essentially non-existent in Egypt after 2000.[44]

Figure 4 here

Evolution of socioeconomic inequalities in obesity

We have shown above that in the 1990ies the socioeconomic gradient in obesity was positive: obesity was far mor prevalent among the upper socioeconomic groups (measured by education) than among the lower ones. One would expect, on the basis of the Monteiro et al (2004) findings that as Egypt's economy has grown further, the gradient might have been reversed.

Figure 5 examines the question (with education as the SES proxy) by plotting the obesity prevalence in both the highest and lowest education quartile against per capita GDP in PPP in each of the relevant survey years. One the one hand, Figure 5 confirms the thrust of the Monteiro et al (2004) prediction in that the obesity "premium" of the higher SES category has continously narrowed from 2000 onwards. On the other hand, Figure 5 fails to confirm the Monteiro predictions in that even at a per capita income level of close to USD 6,000 in PPP terms – a value substantially higher the switchover threshold proposed by Monteiro et al (2004)[45] – the highest socioeconomic quartile still

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[43] See Annex Figure 2 for a bar chart representation of the distribution.

[44] Another way of capturing the evolution of the BMI distribution is by looking at the Lorentz curve of BMI (see Annex Figure 3) and by calculating the GINI coefficient (see Annex Table 1). As both the Lorentz curve and the indices remained pretty stable over time, this suggests that the increase in women's BMI was not followed by a reduction of the frequencies of the extreme values, making the problem even more serious.

[45] Monteiro et al (2004) derived a threshold GDP per capita level of about USD 2,500, although it did not become clear enough from the paper which GDP definition and hence data was used by the authors. In Figure 2 we have tried to (imperfectly) replicate the Monteiro results by using data on GNI per capita in PPP terms from the World Bank Development Indicators, finding a switchover level of about USD 4,500. Both values are well below Egypt's per capita income level in 2008.

suffers from higher obesity rates than the lowest quartile. However, the decrease in obesity at a population level that occurred between 2005 and 2008 has been driven by a fast decrease among the higher SES class compared to the lower one. If this pattern holds in the coming years, we should soon indeed see a reversal of the socioeconomic gradient in obesity within Egypt, as suggested by Monteiro et al (2004).

Figure 5 here

We examined the details and robustness of the surprising distributional finding in various ways:

(1) We scrutinise the evolution of obesity across the entire educational range and not solely in the highest and lowest level (see Annex Figure 4): it turns out from the bar charts that the dynamic of the BMI increase has been different for each educational group. The most striking difference does however appear between the lowest education category and the upper three educated group, in that the former has been the driving force of the change in BMI in the entire population. The share of obese people in the higher educated groups has remained fairly stable from 1992 to 2008, with just a modest increase between 2000 and 2005. The same can not be stated when considering the low educated population. It also results from Annex Figure 3 that the skewness of the BMI distribution observed in the first two waves is mainly caused by the low diffusion of obesity and overweight in the low educated groups.

(2) We use the wealth index as an alternative individual level SES (see Annex Figures 5 and 6): the emerging picture is very similar to the education-based one.

(3) We also compare the evolution and pattern of obesity in rural vs urban areas (see Annex Figure 7): again obesity is consistently more prevalent in urban and hence wealthier regions. Moreover, as it was observed in the education- and wealth-disaggregation, obesity has been increasing fast in rural areas, approaching the comparatively high and stable obesity levels in urban areas.

3.4.2 Micro analysis

In this sub-section we examine the pattern and distribution of obesity in Egypt in greater detail, exploiting the individual level data. We start by decomposing the BMI trend into age-, period- and cohort-effects. Subseqently, we examine the correlates of BMI and obesity, using different multivariate approaches.

Age-, period-, and cohort-model (APC model)

To develop some idea about the likely future evolution of obesity in Egypt, we need to first understand what have been the relevant drivers in the period to date. In particular, we are interested in three different time related effects: *age effects*, *cohort effects* and *period effects* (see Harding, 2009 for a discussion about the use of APC models in public health). We seek to understand if obesity is mainly due to a change in the age composition of the population (age effect), if it is due to an exogenous shock or a shift in environmental factors with a potential bearing on obesity (period effect) or if different cohorts differ in their risk of becoming obese with respect to the old ones(cohort effect), due to, for example, changes in culture, information or in technology that may have had different effects on different cohorts.

We estimate an APC model, which can be written in the following (linear) fashion (Yang et al, 2004):

$$BMI_{ij} = \mu + \alpha_i + \beta_j + \gamma_k + \varepsilon_{ij} \qquad (2)$$

where μ is the average BMI, α_i is the row age effect β_j the column period effect and γ_k the diagonal cohort effect. εij is an error term such as $E(\varepsilon_{ij}) = 0$

The model cannot be estimated by using a simple OLS procedure since the simultaneous identification of age, period and cohort effect cannot be achieved, due to the exact linear dependency between the three variables, given that *Age=year-year of birth*. In fact, the estimator $\hat{b} = (X'X)^1 X'Y$ does not exist since *X* is not full rank.

To tackle this problem two different estimators have been proposed: the *constraint generalized linear models estimator* (CGLIM), which solves the problem by putting a constraint on the parameters (e.g. two cohort effects are assumed to be equal) or the *intrinsic estimator* (IE), which still imposes a constraint on the paramenter space, derived from the design of the matrix X'X, but which appears to be much more justifiable and natural than those imposed by the CGLIM method. Constraining two coefficients to be equal is recommended only when there is a good reason for doing so. Otherwise, one would be imposing a structure on the data that could turn out to be wrong. In our case we cannot constrain two age effects to be equal since age is a very important determinant of BMI, and metabolism does change significantly with age. Nor do we have enough information to assume that two different cohorts have the same view about obesity and that they experiences the same cultural framework.

Hence we adopt the IE estimator, which has also been proved to be unbiased in a finite-time-period APC analysis for every fixed number p of time periods, more effcient than any CGLIM estimator, and asymptotically consistent as $p \to \infty$ (Theorems 1, 2, 3 in Yang et al, 2004) .

We estimated the model with the STATA by using the intrinsic estimator .

The cohorts are defined as the difference between the two other variables, so we can identify the following 12 cohorts. The graphical display of the coefficients from the APC model is given in Figure 6. The full numerical results are given in Table 1.

Figure 6 here

Table 1 here

The age effect has the expected sign: BMI is increasing quite smoothly in age, flattening somewhat after age 40. This result confirms expectations, since BMI has a bell-shape pattern and tends to decrease in later life.

The period effect is strikingly variable, with a small drop between 1992 and 1995, a sharp increase between 1995 and 2000 and a decrease between 2005 and 2008. The period effect turns positive around the year 2000, which could be interpreted to mean that Egypt has begun to face an increasingly obesogenic environment post-2000. The pattern of the period effect is similar to the general, population-wide trend already captured by Figure 3. Hence, as the age and cohort effect appear to offset each other, the extent to which environmental conditions in Egypt have been more or less conducive to obesity appears to have driven the obesity evolution in the country. The growing period effects (at least during most years of the observation period) is broadly consistent with the positive period effects found by Sassi et al. (2009) for a set of OECD countries. The temporary drop at the beginning of the observation period can probably be explained by the phasing out of the food subsidy policy between 1990 and 1994, when the food consumption decreased by 20% (Galal, 2002).

The cohort effect is decreasing, suggesting that younger cohorts have been less susceptible to obesity than older ones. The latter result is in contrast with one earlier finding that had applied the APC model to the US, finding a positive cohort effect (Reither et al 2009)[46], but it is broadly in line with recent findings for a sample of European countries that are part of the OECD sample studied by Sassi et al. (2009)[47]. These findings imply that younger cohorts share certain characteristics that expose them to an ever lower risk of obesity. One such characteristic could be increasing levels of education that materialised in particular in Egyptian women. This may have increased people's awareness of the features of a healthy lifestyle as well as their demand for health. This appears consistent with the evidence that younger Egyptian women are more concerned about their body weight than their mothers Jackson et al. (2003). (Note that some of the cohort dummies in Table 1 are not significant, but the one indicating younger women is significant at the 1% level and negative.) It is also likely that public information on healthy diets has only been actively promoted and disseminated successively throughout the observation period. Another potential explanation is rooted in the hypothesis that food and material deprivation that the fetus has been exposed to may increase the person's susceptability to obesity in older age, when deprivation has been overcome. While earlier cohorts in Egypt may well have suffered from this deprivation, more recent ones will only have done so to an ever diminishing and ultimately small extent.

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[46] Reither et al (2009) have proposed the following explanations for the negative cohort effect: the recent cohorts have been more exposed to an increasingly obesogenic environment, they are likely more willing to adopt (possibly obesity-enhancing) technological innovation, and/or they have a lower level of physical activity both in their leisure time and at work.

[47] These findings would seem to suggest that the underlying probability of obesity of successive birth cohorts, linked to factors that must have had an influence at critical stages in the life of the individuals concerned, has been declining over time, but has been increasing again since the 1960s in France, the US and Canada.

What do the results tell us about the likely future course of obesity in Egypt? Unfortunately, actual APC results have turned out too mixed to lead to unambiguous predictions. One one hand, obesity is likely to increase further due to the positive age effect we found. As Annex Figure 8 documents, the share of the most obesity susceptible women (around 40-50) will increase considerably in the coming decades. On the other hand the decreasing cohort effect could in principle compensate the effect, thus predictions on the further developments of obesity are not straightforward. In addition, the size of the period effect is not clear.

Correlates of BMI / obesity at micro level

In what follows we explore the individual level correlated of obesity/overweight in Egypt, using first a logit approach and second a quantil regression to allow for potential non-linearities of the effect of the relevant factors across the BMI scale.

Logit analysis

Since the variable of interest assumes either value zero or value one, we decide to run a discrete choice model and, in particular, we chose to use a pooled logit specification [48] both because the logit coefficients can be interpreted as the effect of a change in the covariates on the odds ratio.

In the logit specification, we estimate the following model

$$y_{it}^{*} = \alpha_i + \mathbf{x}_{it}'\beta + \varepsilon_{it} \quad (3)$$

where y_{it}^{*} is the latent variable

where

x_{it} are variables at the individual level (age and its square, education, a dummy variable that takes equals one, if the woman is currently working) , at the household level (wealth index and household location, rural or urban) and time dummies.

The existing literature provides us with some predictions about the signs of the variables we decided to include in the model. We expect that age has a positive effect on BMI, both because of biological reasons, and because younger women tend to have a more intense physical activity. We cannot know *a priori* the shape of the age effect. Even if much of the literature has shown that the relationship between weight and age is concave (see, for example, Sassi et al, 2009) for an analysis of OECD countries) so the

[48] Following Angrist and Krueger (2001) we also ran a linear pooled OLS specification, but the significance and the sign of the coefficients did not change.

decrease is likely to happen outside our sample.

It is also obvious (and evidence-based) to expect that physical activity tends to reduce the risk obesity. The only variable which in can partially proxy the level of (on the job) physical activity is the occupational status of the women. The relationship may however not be causal, since different forces are at work in different directions[49]. While one would expect that being involved in a heavy job would imply a higher level of physical activity, and thus a lower BMI, there may also be a selection process at play, according to which very obese people would find it difficult to find a job. In both cases though we expect a negative correlation between occupational status and BMI. The reverse is true once we consider underweight women, for which a low BMI is expected to reduces the odds of working. One of the habits which is usually negatively correlated with obesity is smoking (Chou et al, 2004). However, we chose to disregard it, since smoking prevalence is less than 1% among among Egyptian woman. Finally, we also had to disregard information about religion, race-ethnicity[50], end exposure to different media since this information was not present in every survey wave.

In the aggregate analysis section above we have begun to consider the influence of SES. In light of the Monteiro et al (2004) results, the relationship between obesity and SES in middle-income countries is ambiguous and is certainly changing as the countries develop. The amiguity also results from a theoretical perspective: for instance better educated people would be more informed about negative consequences of obesity (thus implying a negative coefficient), but they could be the ones who are less involved in physically demanding jobs and more willing to eat out (implying a positive coefficient). However, given the macroanalysis and considering the previous literature, we would expect a positive sign. It is worth noticing that once we consider developed countries (see, for example, Sassi et al, 2009), the relationship is negative, particularly in women.

The relationship between wealth and BMI is similarly unclear a priori. While in developed countries healthier foods are more expensive than unhealthy ones, the same is not always true in developing countries, in which the consumption of food produced at home (which is cheap and healthy) is still a common practice, especially so in rural areas. We can thus expect that fast food is an inferior good whose consumption decreases in wealth. However, richer people have access to more advanced cooking technologies (e.g. the fridge), which can lower the "price" of food (in term of time spent cooking and looking for food), as stated by Cutler et al (2003), thus increasing its demand and consumption. The same applies to people living in urban areas who have, in addition, greater access to fast foods.

We use a quite parsimonious specification of the model both because we are mainly interested in the effect of education and wealth on obesity, and because the information on other potentially relevant determinants varies from wave to wave, so we

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[49]It is worth noticing that, at least for the age group we are interested in and to the authors' knowledge, no many longitudinal studies about the determinants of overweight and obesity in developing countries have been carried out. One interesting exception is the paper by Sundquist et al. (1998) who consider just two points in time

[50] We use the variable that categorizes people according to both their race and ethnicity (DMARETHN), in order to consider both the physical and the cultural characteristics. It divides the population in non Hispanic whites, not Hispanic black, Mexican-Hispanic, other. In Nhanes there is also an indication of race (DMARACER): white, black, Hispanic of an unknown race, other or ethnicity (DMAETHNR): Mexican-American, other Hispanic, not Hispanic.

could not include them in the analysis.

Given that our dataset does not have a longitudinal structure and given the mainly descriptive purpose of our analysis, we choose to pool all the data together, since in every year we have a different set of individuals. Hence, the error terms do not contain a factor that is constant over time. This implies that, in a repeated cross sections framework, the dependence between α_i and the covariates and ε_{it} is zero by construction, since the observations are independent over time. We can therefore estimate the model by using pooled logit and by assuming that the composite error term $\alpha_i + \varepsilon_{it}$ follows a logistic distribution.

The result of the logit specification are given in Table 2, largely confirming our expectations. All variables turn out to be significant at the 1% significance level. Age has positive but decreasing impact on obesity. The dummy variable indicating a working woman enters in the regression with a negative sign, in line with the literature, even if, as stated before, we cannot assess the direction of causality. Education (at each level) has a positive effect on the dependent variable, indicating that schooling is not sufficient to prevent people from being obese. Wealth is positive for every quintile[51] even if people at the top of the wealth distribution seem to be less obese than those belonging to the middle class. The high significance of the education and wealth variable suggests that they pick up two different characteristics of the population even if, in this case, richer people show a higher level of education.

The regression analysis confirms the picture given by the earlier graphical analysis: obesity in Egypt is still affecting the cities more than the rural areas probably because the cost of food production is lower[52]. Finally all the time dummies are significant and most of them (all but the 1995) are positive, indicating a generally higher obesity level with respect to the reference year (1992). The dummy variables in the regression show that, other things equal, from 1992 to 1995 there was a decrease of the share of obese people, which can be reconnected to the beginning of the reduction of the food subsidy and the increase of the prices of some basic food as described in Galal (2002). However, we are not able to assess the causality link.

Table 2 here

We performed also a logit regression by years,[53] which confirmed our aggregate analysis, i.e. a possible change in direction of the relationship between BMI and SES: primary education turns our to be significant (and positive) from 1992 to 2005, while it looses its predictive power in the last wave. Secondary education was not significant in the first wave, but in the last one we analyze it is still correlated with obesity, even if the variable is significant just at the 10% level. Another interesting finding is that the dummy indicating one household is located in the urban area is not correlated with the

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[51] Note that the excluded category is the poorest part of the population.

[52] Both because of the technological change (better cooking facilities, fridge, less distance from the nearest water source) and because of the better availability of high calories food

[53] Results are available under request

obesity status in 2008, thus confirming a idea that high BMI is becoming a problem that affects also rural areas.

Quantile regression approach

In the last part of the multivariate analysis we employ a quantile regression approach. The choice is motivated by the heteroskedasticity of the data and because this approach sheds light on the full distribution of the variable of interest (i.e. BMI in our case) and it does not give information just about the average effect. In fact, in our analysis we are not interested just in the global trends, but we want to assess the changes in the tails of the BMI distribution, given that an extremely high and low BMI predicts higher levels of morbility. Even if the choice of the cut-offs which divide the BMI categories are well accepted, we are aware that the body mass index is a continuous variable and the shift from one category to the other is not difficult. With our logit specification we are not able to describe the situation of overweight women and we cannot identify the variables which impact positively the weight of normal range ones.

In addition, quantile regression is also more robust to the presence of outliers. Recall that in the quantile regression framework, we use a semiparametric estimator that minimizes residuals by solving the following optimization problem (see Koenker and basset, 1978 and Koenker and Hallock, 2001)

$$\min_{b \in \Re} \left[\sum_{t \in t: y_t \geq x_t b} \theta | y_t - b | + \sum_{t \in t: y_t < b} (1-\theta) | y_t - x_t b | \right] \quad (4)$$

Median regression is just a particular case of quantile regression in which $\theta = \frac{1}{2}$.

In this framework, we ran different regressions: we ran OLS and quantile regressions at different quantiles (0.25, 0.5 and 0.75) to have a first flavour of the variability of the coefficients among quantiles. Furthermore, we ran a simultaneous quantile regression (at the same quantiles) to test the equality of the regression coefficients[54]. Finally, we plot the coefficients for a better understanding.

The quantile regression results are summarised in Table 3. The estimates confirm that a quantile regression specification is preferable to OLS: Some of the coefficients do change across quantiles and they are different from the one calculated by using the OLS estimator. In addition, the Breusch-Pagan test on heteroskedasticity strongly rejects the null hypothesis[55]. In the (bootstrapped) simultaneous quantile regression (see Table 4) we estimate 3 different quantiles (and their joint variance and covariance matrix) so we are able to conduct an hypothesis testing on the equality of the coefficients across different quantiles. Interestingly the BMI levels corresponding to the first, second and third quartile we are looking at are 21, 25 and 30 respectively, the levels conventionally accepted as cutoffs for separating normal-weight, overweight and obese.

Table 3 here

Table 4 here

[54]The standard errors are bootstrapped using 100 repetitions.

[55]test statistics=642.37, p-value=0.000

A look at the graphical display of the coefficients of the quantile regression (see Annex Figure 10) provides a better description of the data. The graphs show the quantile regression estimates, the OLS counterpart and the confidence intervals at the 95% level for each estimated coefficient. It is easy to see that, for some variables, the effect changes for different quantiles, so an OLS regression would have hidden some important information. As the OLS and the logistic estimates suggests, age has a non-linear effect on BMI but follows a convex shape. However, it is worth noticing that the variable has a greater effect for high quantiles of the distribution, i.e. aging affects predominantly the women who risk being overweight or obese, as was suggested by the descriptive trend analysis. This means that if the population is becoming older, obesity will become more and more important.

The insignificance of the variable indicating the current working status hides a different message. The effect is positive (and outside the OLS confidence interval) for lower quantiles and negative for higher ones. While the first result is likely to be a symptom of a reverse causality (underweight people not being able to work), the latter can be related to the fact that increased physical activity helps reduce the risk of becoming obese. The effect of secondary education is quite flat[56], suggesting that it simply shifts the distribution to the right without altering its shape.

The effect of primary education is puzzling. In fact, not only people who own a primary school degree have a higher BMI, but the effect is more important (and significantly different) for high quantiles, indicating that primary education affects positively the prevalence of obesity[57] while is not even an `insurance' against malnutrition, since, for low quantiles, the coefficient is almost zero. The coefficients of wealth quintiles are all precisely estimated and they change with quintiles showing that income affects the obese women particularly.

The fourth wealth quintile is the best estimated, and its coefficients turn out to be significantly different also when compared to the median, the 0.25 and the 0.75 quantiles (see Table 5)[58]. The last four graphs in Annex Figure 10 confirm what we have observed in the first part of this paper. Other things equal, there is a positive time trend that shifted the distribution to the left. It is worth noticing that in 1995 the overall effect on the average was negative (with respect to the situation in 1992), but there was an increase in weight for thinner women.

Table 5 here

56The result is confirmed by the test that is not able to reject the hypothesis of equality of the coefficients

57We ran also the regressions year by year and, in the more recent datasets, education seems to loose its predictive power

58The null is the joint hypothesis H_0=[q25]coefficient-[q50]coefficient=0 and [q25]coefficient-[q50]coefficient=0

3.5 Conclusions

In this paper we have examined the trends, socioeconomic pattern and correlates of obesity in Egypt, a country that may be representative for at least some of the low or middle incomce countries in the Middle East and North Africa region, not all of which do have reliable data on obesity.

We have shown that the prevalence of obesity in Egypt is significantly higher than in other countries at comparable per capita income levels. While the exceptionally high level of obesity applies to all socioeconomic groups in the country, it has thus far been the higher educated, the wealthier and the urban residents that display the largest prevalence, unlike most other countries at a similar level of economic development. Recently however a trend has emerged towards a reversal in the socioeconomic gradient.

The bulk of the increase in obesity has occurred over the 1990ies, flattening between 2000 and 2005 and modestly declining thereafter. On the whole, the high *levels* of obesity in Egypt appear to have been driven by the fairly stable, high obesity prevalence in the upper socioeconomic groups, while the observed *changes* in obesity over time are mostly driven by the changes in obesity within the lower socioeconomic groups.

A decomposition analysis of the micro data has revealed that obesity has been driven by an obesity enhancing age effect, a declining cohort effect, and a highly variable period effect, the combination of which renders the prediction of future trends very difficult.

The multivariate analysis has confirmed the surprising independent, positive association between education, wealth and urban residence (alongside other relevant factors) on one hand and obesity on the other hand. Year-by-year analysis shows that these effects are declining and that most recently obesity is becoming equally important in people and areas characterised of lower socioeconomic status.

It is important to bear in mind that the relationships analysed in this paper do not necessarily reflect a causal mechanism. This will have to be the challenge of further research, which may have to focus on just one or two recent rounds of the DHS, where more detailed information on other relevant variables is available.

References chapter 3

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Appendix 3.1: Graphs

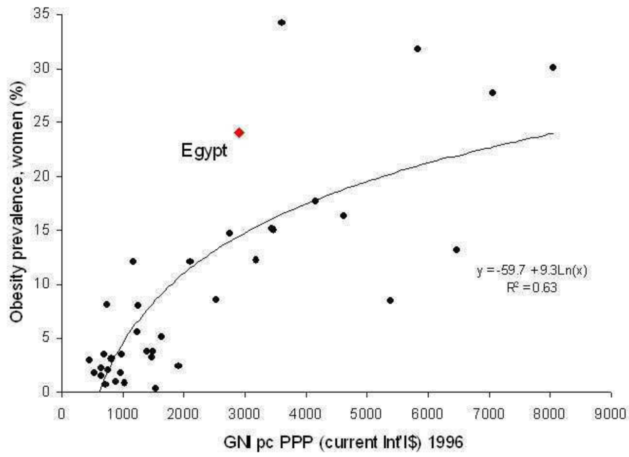

Figure 1: Obesity in women and per capita income in 37 developing countries 1992-200

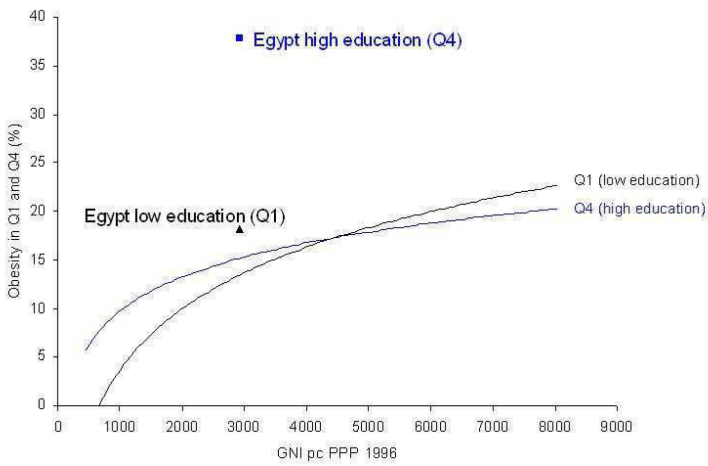

Figure 2: Obesity in women and per capita income by education in 37 developing countries 1992-200

Note: The black regression line represents the average relationship between GNP per capita and obesity prevalence in the lowest education group in all of the 37 developing countries, while the blue line shows the same for the highest education group. (We do not depict each single country point as this would overload the graph.) The crossing of these lines confirms the Monteiro et al (2004) result of the switch-over at a certain level of development, even if in our case that point is at a higher level of per capita GNP[59]. We then include the obesity prevalence for the highest and the lowest educated in Egypt.

[59] This may be due to different GNP data used by Monteiro et al. (2004). We were not able to find out from the paper which GNP exactly was used, nor whether the GNP pc was averaged over the 1992-2000 periods or not. We have used the GNP per capita for 1996 for every country

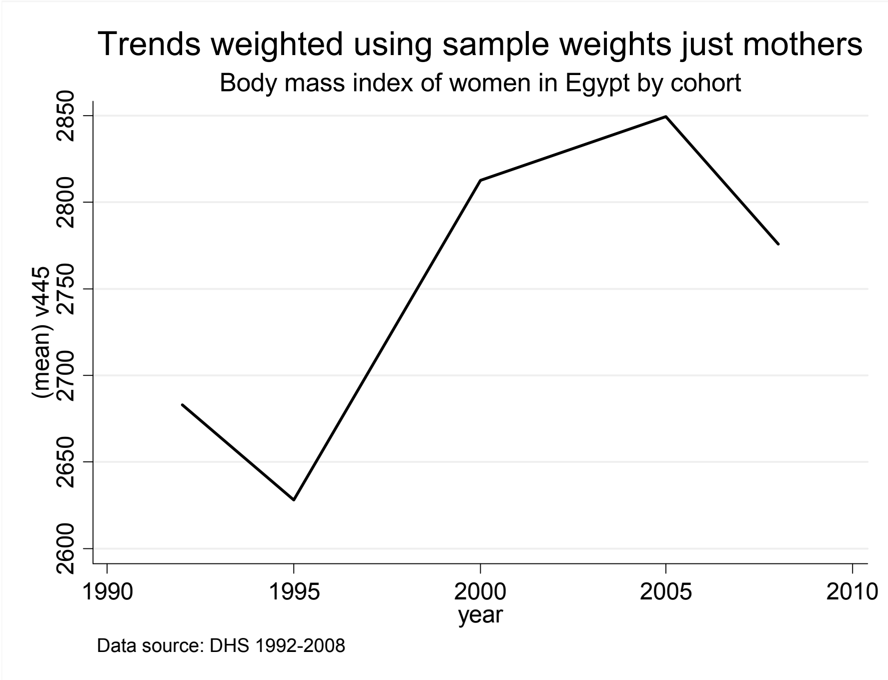

Figure 3: Mean BMI by year

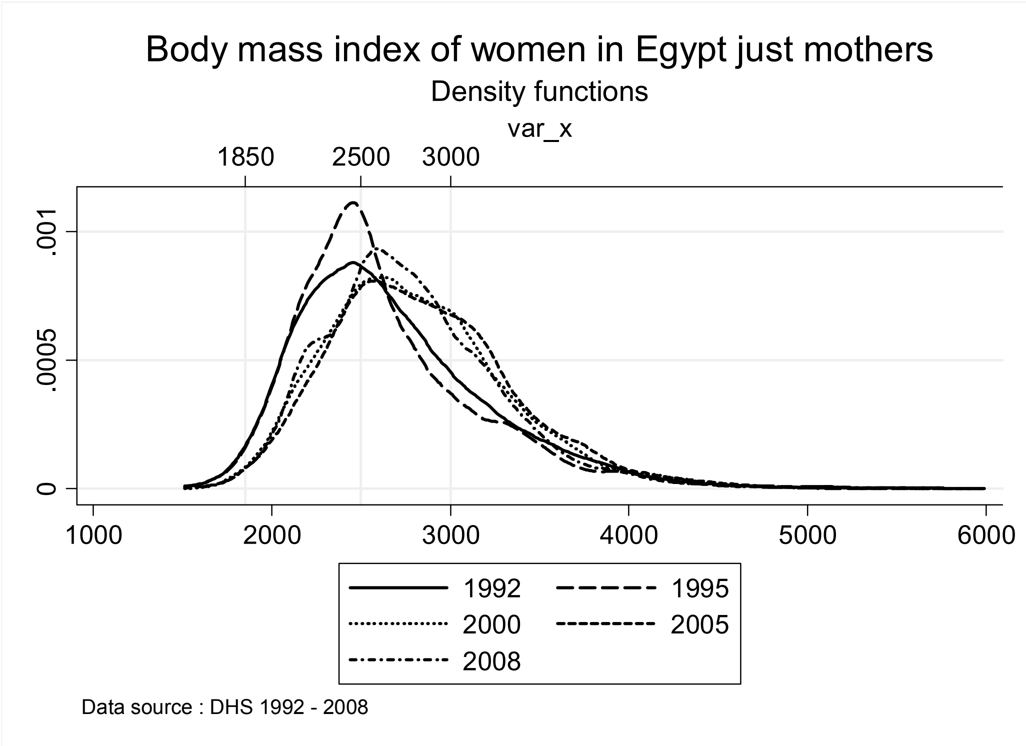

Figure 4: BMI densities

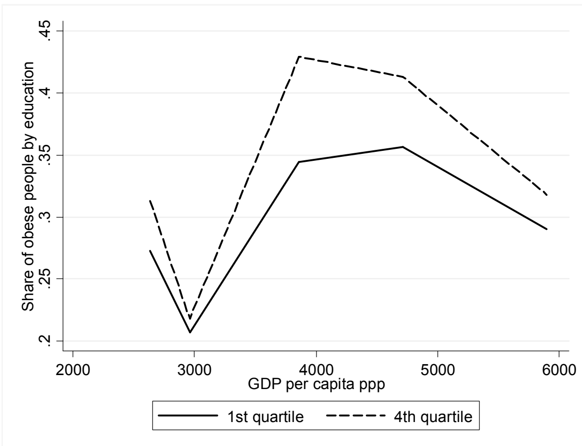

Figure 5: Share of obese people by education (highest and lowest quartile)

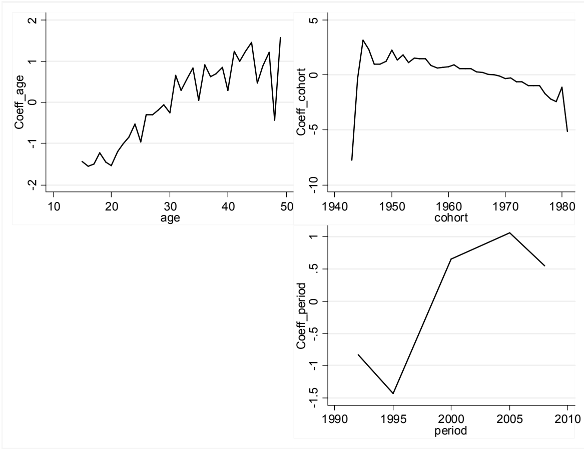

Figure 6: Estimated age, cohort and period effects

Appendix 3.2. Tables

Table 1: APC model

age_15	-1.4264		cohort_1943	-7.7419	
	(1.619)			(4.804)	
age_16	-1.5511	**	cohort_1944	-0.3397	
	(0.705)			(1.399)	
age_17	-1.5013	***	cohort_1945	3.1698	***
	(0.465)			(1.058)	
age_18	-1.2148	***	cohort_1946	2.3120	***
	(0.366)			(0.784)	
age_19	-1.4495	***	cohort_1947	0.9649	
	(0.321)			(0.614)	
age_20	-1.5426	***	cohort_1948	0.9838	*
	(0.278)			(0.542)	
age_21	-1.1986	***	cohort_1949	1.2600	**
	(0.270)			(0.533)	
age_22	-1.0057	***	cohort_1950	2.2350	***
	(0.245)			(0.496)	
age_23	-0.8496	***	cohort_1951	1.3308	***
	(0.233)			(0.478)	
age_24	-0.5320	**	cohort_1952	1.7953	***
	(0.225)			(0.445)	
age_25	-0.9681	***	cohort_1953	1.1528	***
	(0.209)			(0.428)	
age_26	-0.3010		cohort_1954	1.5034	***
	(0.212)			(0.417)	
age_27	-0.3050		cohort_1955	1.4640	***
	(0.209)			(0.402)	
age_28	-0.1950		cohort_1956	1.4608	***
	(0.208)			(0.391)	
age_29	-0.0526		cohort_1957	0.8712	**
	(0.214)			(0.375)	
age_30	-0.2553		cohort_1958	0.6397	*
	(0.210)			(0.360)	
age_31	0.6449	***	cohort_1959	0.6512	*
	(0.230)			(0.351)	
age_32	0.2934		cohort_1960	0.7350	**
	(0.230)			(0.338)	
age_33	0.5863	**	cohort_1961	0.9044	***
	(0.243)			(0.327)	
age_34	0.8274	***	cohort_1962	0.5603	*
	(0.256)			(0.314)	
age_35	0.0494		cohort_1963	0.5827	*
	(0.248)			(0.302)	
age_36	0.9068	***	cohort_1964	0.5749	**

	(0.279)			(0.291)	
age_37	0.6276	**	cohort_1965	0.3072	
	(0.285)			(0.282)	
age_38	0.6887	**	cohort_1966	0.1952	
	(0.292)			(0.274)	
age_39	0.8420	***	cohort_1967	0.0297	
	(0.316)			(0.266)	
age_40	0.2810		cohort_1968	0.0130	
	(0.304)			(0.260)	
age_41	1.2331	***	cohort_1969	-0.1367	
	(0.354)			(0.258)	
age_42	0.9902	***	cohort_1970	-0.3599	
	(0.358)			(0.256)	
age_43	1.2401	***	cohort_1971	-0.2785	
	(0.380)			(0.257)	
age_44	1.4486	***	cohort_1972	-0.6485	**
	(0.430)			(0.262)	
age_45	0.4632		cohort_1973	-0.6493	**
	(0.410)			(0.268)	
age_46	0.8760		cohort_1974	-0.9701	***
	(0.546)			(0.284)	
age_47	1.2138	*	cohort_1975	-0.9745	***
	(0.674)			(0.304)	
age_48	-0.4343		cohort_1976	-0.9591	***
	(0.741)			(0.326)	
age_49	1.5709		cohort_1977	-1.7026	***
	(1.266)			(0.396)	
1992	-0.8285	***	cohort_1978	-2.2194	***
	(0.071)			(0.506)	
1995	-1.4336	***	cohort_1979	-2.4211	***
	(0.059)			(0.784)	
2000	0.6548	***	cohort_1980	-1.1241	
	(0.054)			(1.541)	
2005	1.0583	***	cohort_1981	-5.1721	
	(0.053)			(5.120)	
2008	0.5490	***	Constant	27.2395	***
	(0.066)			(0.196)	
Observations	34881				

Standard errors in parentheses

="* p<.10 ** p<.05 *** p<.01"

Table 2: Logit regression

Logit regression				
Variable	Coefficient	Standard errors	z	pvalue
Age	0.23	0.017	13.07	***
Age square	-0.002	.0002	-8.66	***
Not working	-0.10	0.035	-2.97	***
Primary school	0.29	0.039	7.41	***
Secondary school	0.23	0.036	6.61	***
2nd wealth quintile	0.37	0.045	8.37	***
3rd wealth quintile	0.63	0.045	14.05	***
4th wealth quintile	0.95	0.048	19.65	***
5th wealth quintile	0.75	0.057	13.12	***
Urban	0.27	0.029	9.24	***
Year 2008	0.27	0.047	5.84	***
Year 2005	0.55	0.044	12.47	***
Year 2000	0.51	0.046	11.15	***
Year 1995	-0.27	0.047	-5.82	***
Constant	-6.75	0.278	-24.25	***
*$p < .10$	$p < .05$	$p < .01$		
Pseudo R^2			0.0922	
Observations			33085	

Table 3: Quantile regressions

	Quantile regression									
	OLS		Q25		Q50		Q75		BQ50	
variable	Coeff.	sign	Coeff.	sign	Coeff.	sign	Coeff.	sign	Coeff.	sign
age	0.371	***	0.251	***	0.317	***	0.405	***	0.317	***
	(0.033)		(0.036)		(0.034)		(0.053)		(0.039)	
age square	-0.003	***	-0.002	***	-0.002	***	-0.002	***	-0.002	***
	(0.001)		(0.001)		(0.001)		(0.001)		(0.001)	
working	-0.175	***	-0.049		-0.072		-0.251	**	-0.072	***
	(0.074)		(0.080)		(0.076)		(0.119)		(0.118)	
primary	0.874	***	0.445	***	0.789	***	0.983	***	0.789	***
	(0.080)		(0.087)		(0.083)		(0.129)		(0.071)	
secondary	0.740	***	0.770	***	0.824	***	0.781	***	0.824	***
	(0.072)		(0.077)		(0.074)		(0.117)		(0.080)	
2nd wealth quintile	0.817	***	0.597	***	0.716	***	0.941	***	0.716	***
	(0.082)		(0.088)		(0.084)		(0.131)		(0.100)	
3rd wealth quintile	1.481	***	1.376	***	1.432	***	1.605	***	1.432	***
	(0.085)		(0.092)		(0.088)		(0.137)		(0.077)	
4th wealth quintile	2.362	***	1.864	***	2.166	***	2.766	***	2.166	***
	(0.095)		(0.103)		(0.098)		(0.152)		(0.083)	
5th wealth quintile	1.884	***	1.572	***	1.785	***	1.976	***	1.785	***
	(0.119)		(0.129)		(0.123)		(0.190)		(0.126)	
urban	0.951	***	0.699	***	0.820	***	1.076	***	0.820	***
	(0.063)		(0.068)		(0.065)		(0.101)		(0.048)	
year 2008	0.902	***	0.930	***	1.014	***	0.848	***	1.014	***
	(0.094)		(0.102)		(0.097)		(0.151)		(0.147)	
year 2005	1.498	***	.3451	***	1.539	***	1.642	***	1.539	***
	(0.089)		(0.097)		(0.092)		(0.143)		(0.137)	
year 2000	1.416	***	1.329	***	1.540	***	1.646	***	1.540	***
	(0.094)		(0.102)		(0.097)		(0.150)		(0.139)	
year 1995	-0.717	***	-0.565	***	-0.831	***	-0.807	***	-0.831	***
	(0.091)		(0.098)		(0.094)		(0.146)		(0.117)	
constant	16.254	***	16.019	***	16.748	***	17.305	***	16.748	***
	(0.499)		(0.535)		(0.515)		(0.806)		(0.569)	

*$p < .10$ $p < .05$ $p < .01$

Pseudo R^2	0.0922
Observations	33085

Table 4: Simultaneous quantile regression

Simultaneous quantile regression								
Quantile 0.25			Quantile 0.50			Quantile 0.75		
variable	ttest		variable	ttest		variable	ttest	
age	0.2510	***	age	0.3172	***	age	0.4054	***
	(0.035)			(0.036)			(0.047)	
agesq	-0.0019	***	agesq	-0.0022	***	agesq	-0.0024	***
	(0.001)			(0.001)			(0.001)	
working	-0.0493		working	-0.0715		working	-0.2513	**
	(0.090)			(0.095)			(0.102)	
primary	0.4451	***	primary	0.7890	***	primary	0.9828	***
	(0.095)			(0.097)			(0.131)	
secondary	0.7700	***	secondary	0.8236	***	secondary	0.7814	***
	(0.070)			(0.084)			(0.107)	
2nd wealth q.	0.5972	***	2nd wealth q.	0.7163	***	2nd wealth q.	0.9412	***
	(0.090)			(0.085)			(0.133)	
3rd wealth q.	1.3760	***	3rd wealth q.	1.4323	***	3rd wealth q.	1.6053	***
	(0.084)			(0.083)			(0.121)	
4th wealth q.	1.8639	***	4th wealth q.	2.1662	***	4th wealth q.	2.7663	***
	(0.093)			(0.108)			(0.136)	
5th wealth q.	1.5722	***	5th wealth q.	1.7850	***	5th wealth q.	1.9757	***
	(0.126)			(0.125)			(0.184)	
urban	0.6991	***	urban	0.8200	***	urban	1.0765	***
	(0.069)			(0.069)			(0.093)	
2008	0.9297	***	2008	1.0141	***	2008	0.8482	***
	(0.104)			(0.106)			(0.145)	
2005	1.3451	***	2005	1.5388	***	2005	1.6419	***
	(0.100)			(0.106)			(0.138)	
2000	1.3289	***	2000	1.5400	***	2000	1.6463	***
	(0.112)			(0.101)			(0.144)	
1995	-0.5649	***	1995	-0.8314	***	1995	-0.8073	***
	(0.106)			(0.098)			(0.149)	
Constant	16.018	***	Constant	16.748	***	Constant	17.305	***
	(0.538)			(0.526)			(0.692)	
Observations	33085							

Standard errors in parentheses * $p < .10$ ** $p < .05$ *** $p < .01$"

Table 5: Tests after the simultaneous quantile regression

Tests		
variable	t-test	significance
age	6.45	***
age square	0.26	
working	2.13	
primary school	9.68	***
secondary school	0.29	
2nd wealth quintile	4.45	***
3rd wealth quintile	1.77	
4th wealth quintile	22.14	***
5th wealth quintile	2.21	*
2008	1.00	
2005	2.36	*
2000	2.89	**
1995	4.17	***
* $p < .10$	** $p < .05$	*** $p < .01$

Annex 3.1

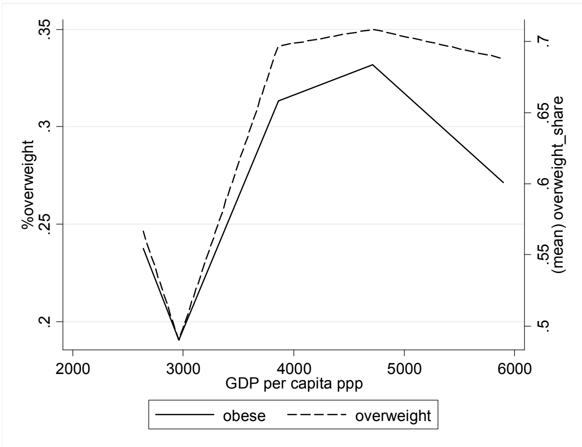

Figure A1: Prevalence of obesity and overweight

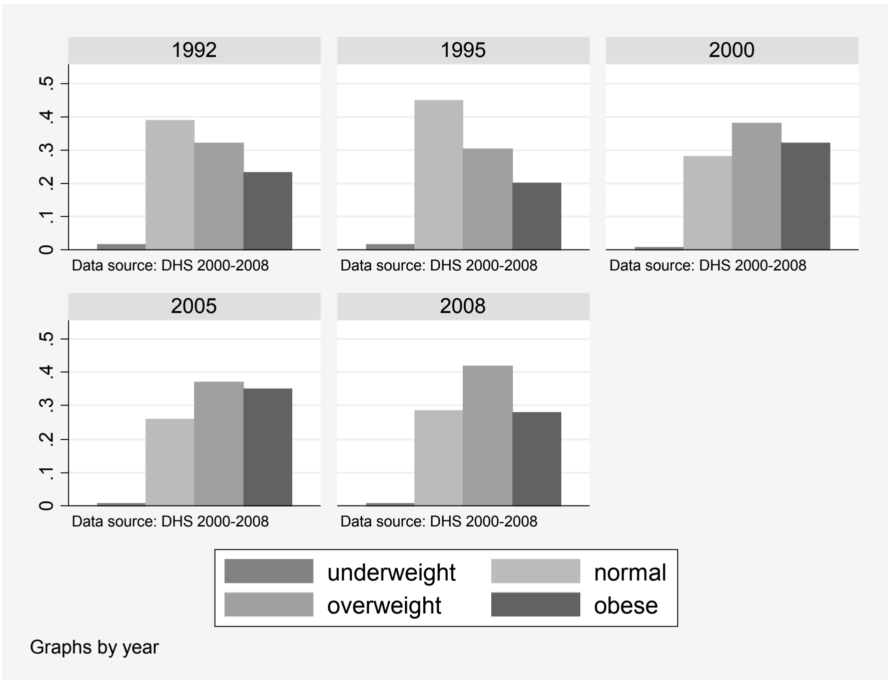

Figure A2: Body mass categories by year

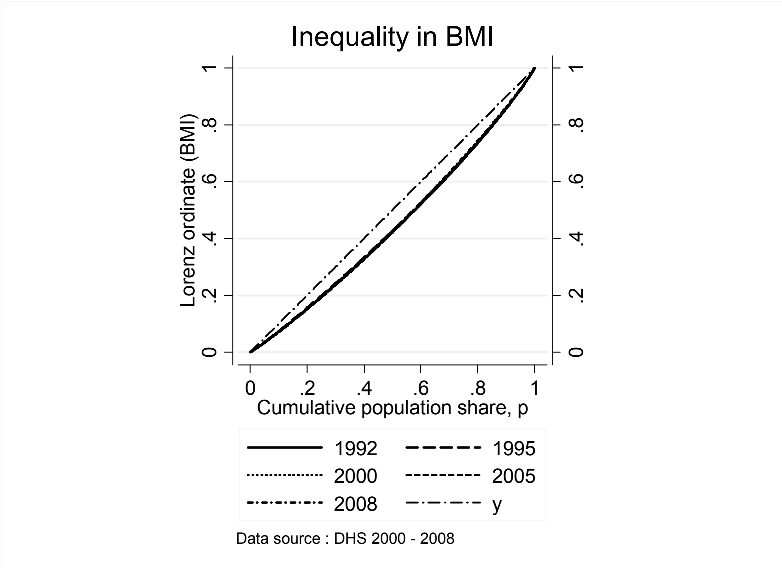

Figure A3: Inequality by year

Gini indices	
year	Gini index
year 2008	0.104
year 2005	0.110
year 2000	0.108
year 1995	0.105
year 1992	0.110

Table A1: Gini indices

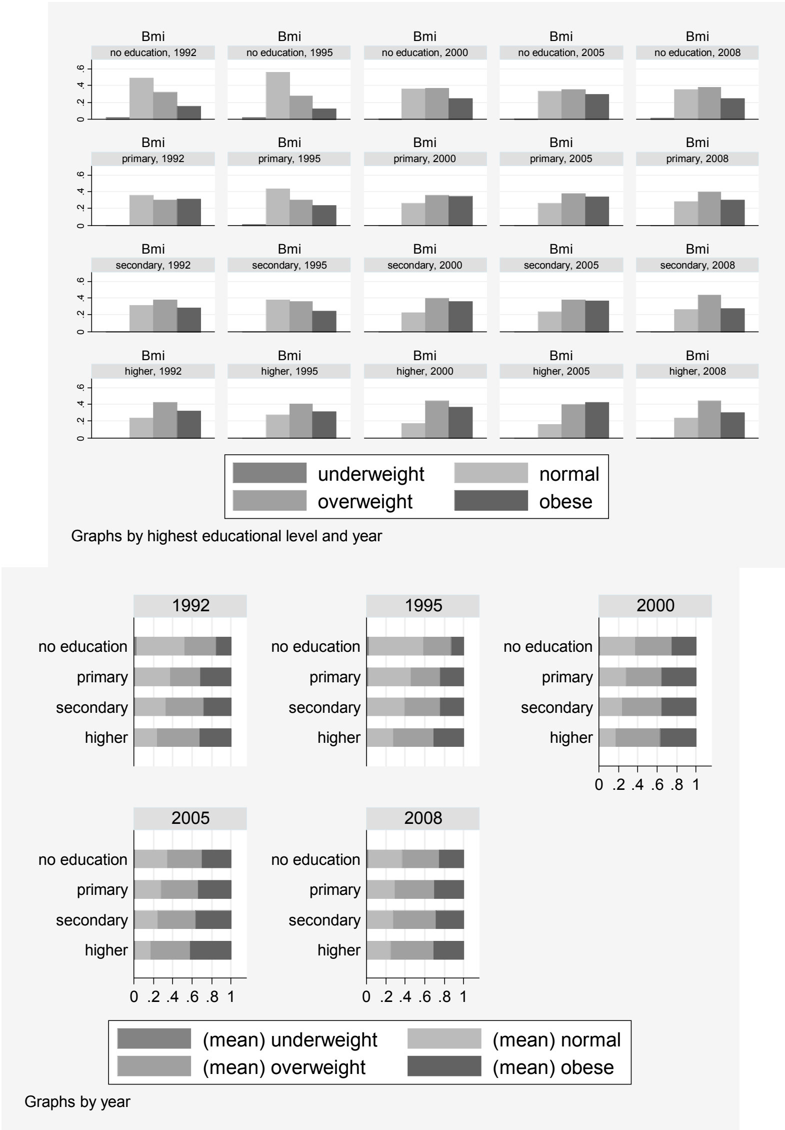

Figure A4: Body mass categories by quartiles of education

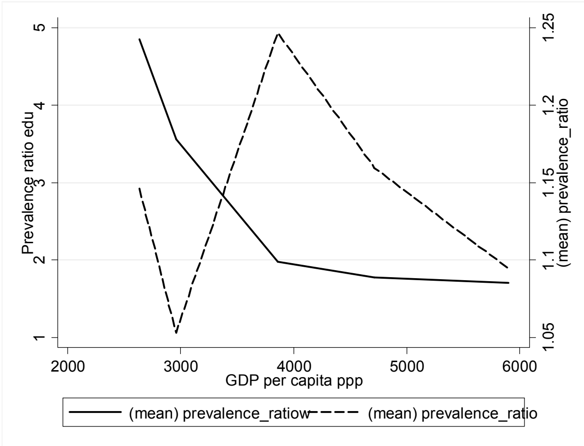

Figure A5: Ratio of of obesity by education and wealth

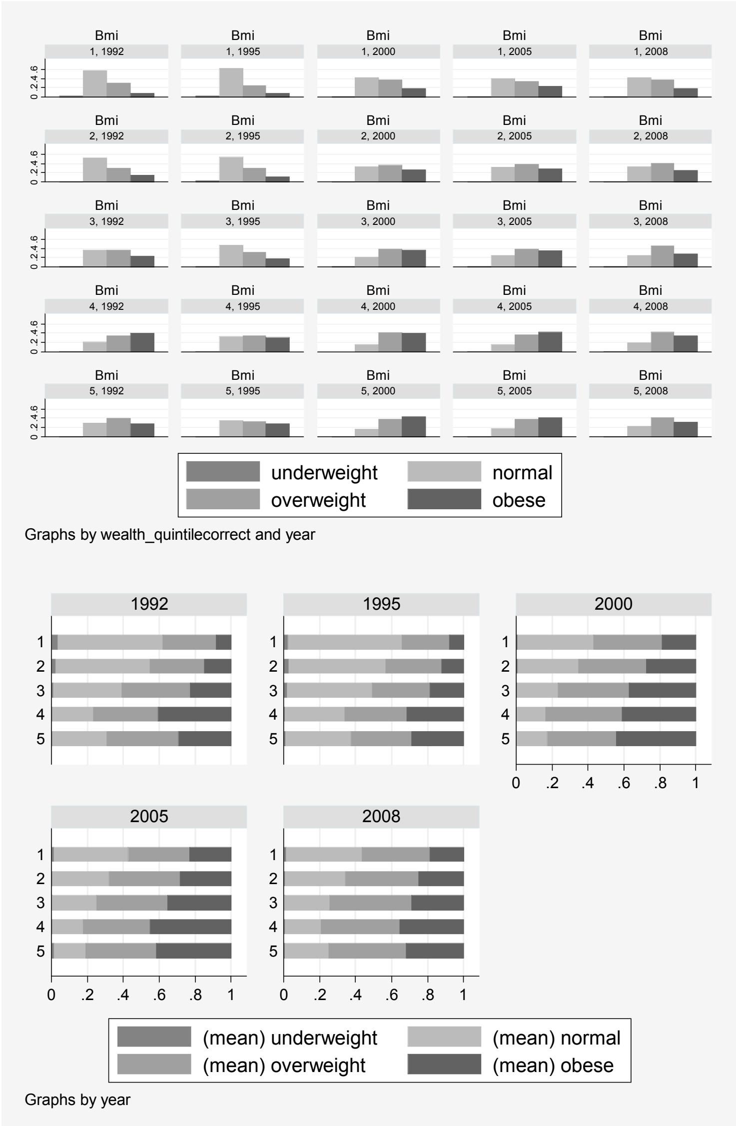

Figure A6: Body mass categories by quintiles of wealth

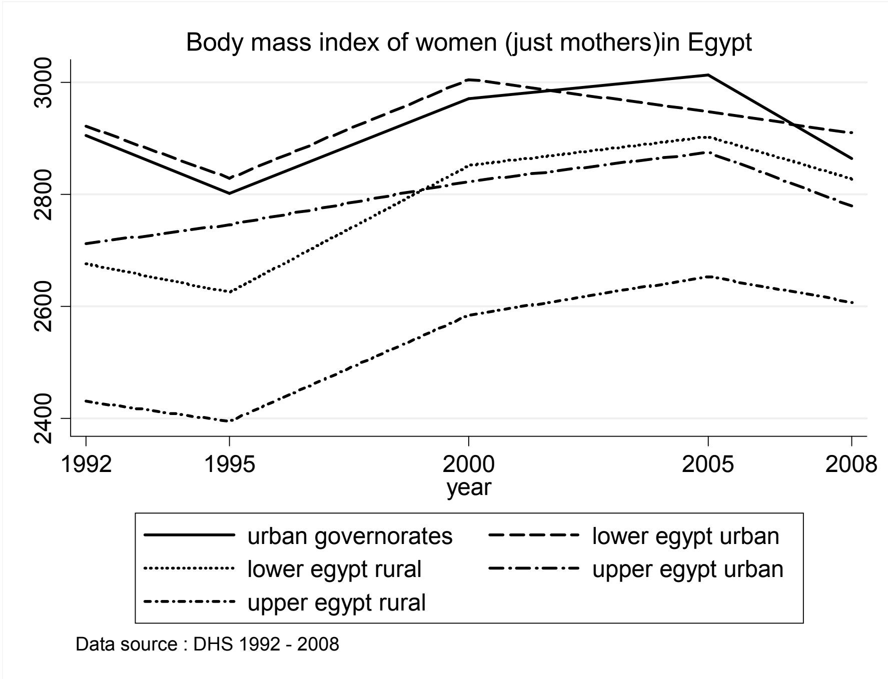

Figure A7: Body mass index by region

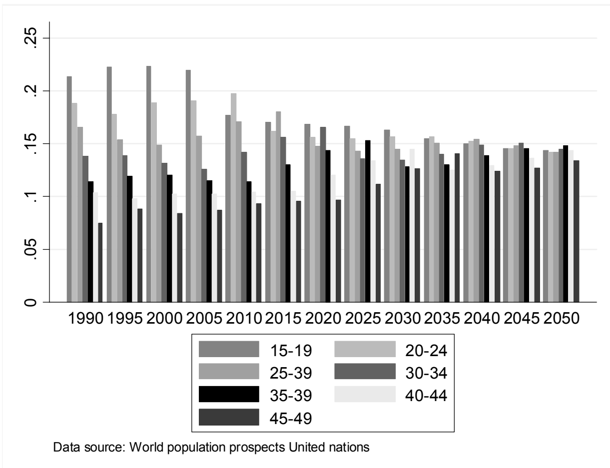

Figure A8: Percentage of women by age category in Egypt. Forecasts.

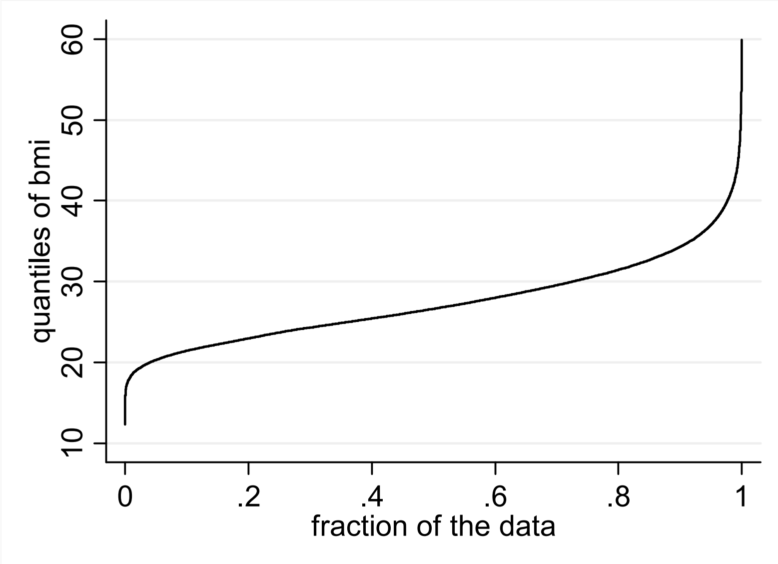

Figure A9: Quantiles of BMI

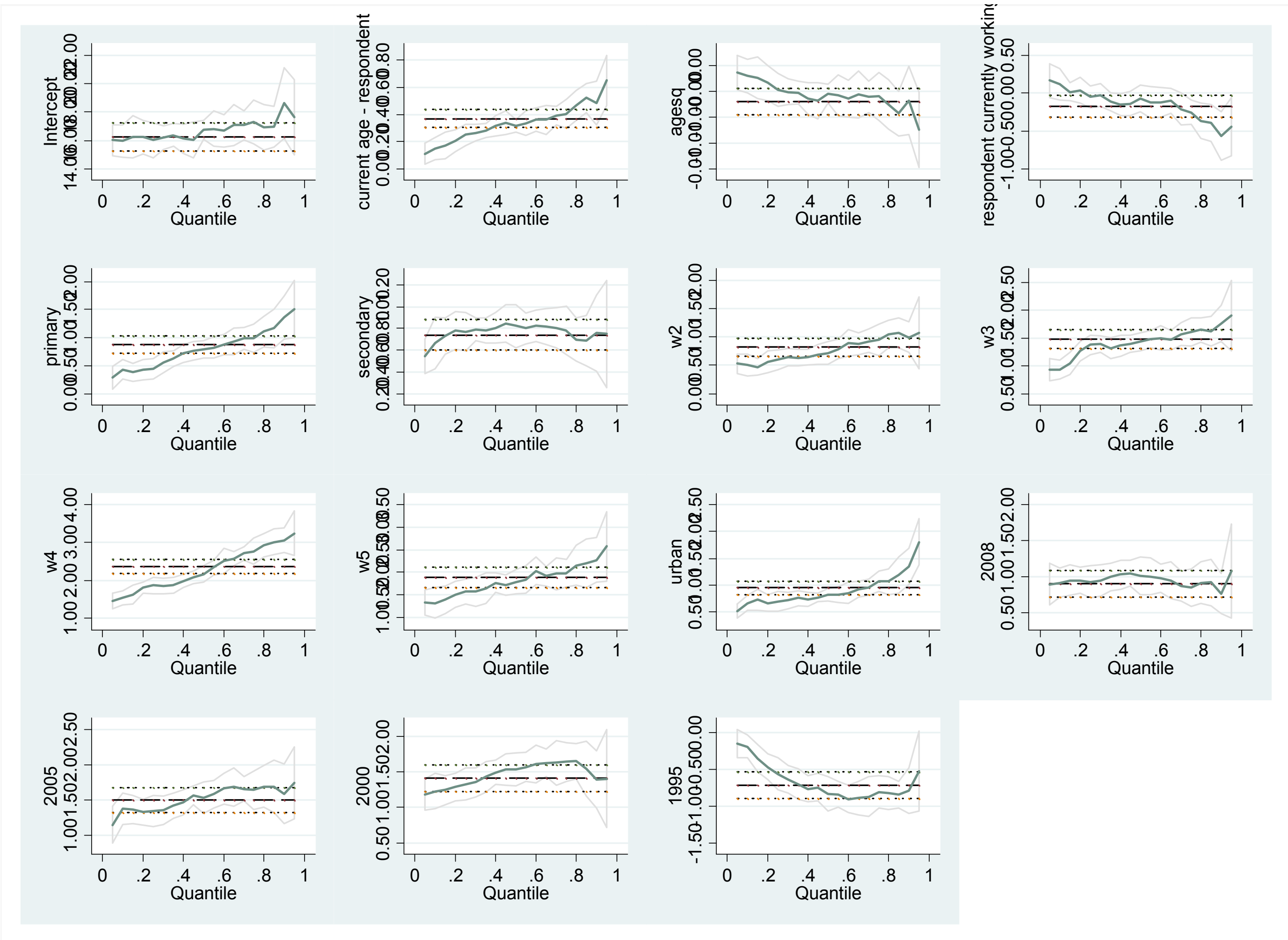

Figure A10: Graphical display of the coefficients of the quantile regression

Conclusion

The thesis analyzes three problems at the top of the political agenda in many European and not European countries. All the issues presented in the chapters have been well debated and many explanations and policy advices have been provided. However, even if these problems have been already tackled, no much work has been done by using economic tools. The idea that motivates the choice of topics such as folic acid fortification and social participation (and also obesity, even if the paper contained in this thesis in mainly descriptive) is that economics does give some of the answers that sociology and medicine can not provide. It is in this spirits that in the first chapter I model the socialization process as a result of individual choices based on both preferences and exogenous characteristics of the area in which the action takes place and, in the second chapter, I use an approach completely different from the one used in the (massive) public health literature about the topic, focusing more on the behavioural effects of the fortification (self selection and change in dietary habits). However, given the not economic nature of the topics addressed, information coming from othe disciplines has been used e.g. in identifying the instruments in the first chapter (historical facts and acts of law) and in correcting for dietary habits in the second (by considering the food composition and the commovement between vitamin C and serum folate)

The first chapter can be included in the growing literature in economics investigating social links between agents and it investigates how social participation of young children is affected by ethnic diversity. We find that segregation have a non negative effect on social participation, while fractionalization have a non positive effect. The latter is stronger when spontaneous participation is taken into account. The endogenous sorting problem is tackled by using an IV strategy.

The second chapter introduces new and well accepted econometric tools in the public health debate. It is an evaluation of the folic acid fortification of cereals in the USA. Our estimates suggest an in increase of serum folate concentration. We compute quantile treatment effect finding a variability in the impact distrubution. Finally, we correct our findings by controlling for the change in dietary patterns.

In the third chapter we analyze the prevalence of obesity in Egypt, a country which experienced a fast nutritional transition in the recent years. We find an increasing trend between 1992 and 2005 and a small decline after 2005. Our estimates show a positive correlation between high BMI and socio economic status as well as a positive age effect and a negative cohort effect.

Apart from those who commented my papers (listed before), I am grateful to Agar Brugiavini, Mario Padula and Sergio Currarini for the general supervision of the thesis. I acknowledge Jerome Adda because he made me discover health economics, Marc Suhrcke who gave me time to finish my thesis, Giacomo Pasini and Elisabetta, my living (STATA) help-on-line, Paola Ferretti and Paolo Pellizzari. And thanks to Laura, of course.

Estratto per riassunto della tesi di dottorato

L’estratto (max. 1000 battute) deve essere redatto sia in lingua italiana che in lingua inglese e nella lingua straniera eventualmente indicata dal Collegio dei docenti.

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Studente: Elena Fumagalli matricola: 955003

Dottorato: ECONOMIA

Ciclo: XX

Titolo della tesi: **Three essays in health and social participation**

Abstract:

Il primo capitolo analizza l’effetto della eterogeneita’ etnica sulla partecipazione sociale degli adolescenti. I nostri risulati mostrano che la segregazione ha un effetto non negativo sulla partecipazione sociale, mentre l’effetto della frazionalizzazione e’ non positivo. Il secondo risultato e’ piu’ charo se consideriamo la partecipazione spontanea. Il problema di endogeneita’ nella scleta dell’abitazione e’ risolto con il metodo delle variabili strumentali.
Il secondo capitolo e’ una valutazione della fortificazione con acido folico dei cereali in USA. Le nostre stime suggeriscono un aumento della concentrazione di folato nel siero. Calcoliamo inoltre i “quantile treatment effects” che dimostrano una variabilita’ dell’impatto della politica. Infine, correggiamo i nostri risultati controllando per i cambi nella dieta.
Nel terzo capitolo si analizza la prevalenza dell’obesita’ in Egitto. Riscontriamo un aumento tra il 1992 e il 2005 e una leggera diminuzione nel 2008. Le nostre stime mostrano una correlazione positiva tra un elevato indice di massa corporea e lo status socio-economico, un effetto eta’ positivo e un effetto di coorte negativo.

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Abstract:

The first chapter investigates how social participation of young children is affected by ethnic diversity. We find that segregation have a non negative effect on social participation, while fractionalization have a non positive effect. The latter is stronger when spontaneous participation is taken into account. The endogenous sorting problem is tackled by using an IV strategy.
The second chapter is an evaluation of the folic acid fortification of cereals in the USA. Our estimates suggest an in increase of serum folate concentration. We compute quantile treatment effect finding a variability in the impact distrubution. Finally, we correct our findings by controlling for the change in dietary patterns.
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Firma dello studente

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