Early Cognitive Development and Educational Assimilation of Bilingual Children

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Abstract

Immigrants come to the UK from different countries, with different resources, languages and experiences. All of these factors influence the early cognitive development and school readiness of their children. In this paper we consider how the cognitive development of young bilingual children may differ from that of their monolingual counterparts by examining children's cognitive skills for a nationally representative cohort (UK Millennium Cohort Study). The dynamic model follows children from age of 3 until 7 years and supports the notation that cognitive skill acquisition is a cumulative process. Our empirical research shows that contrary to popular believe, bilingualism has no inherent negative impact on childrens development. On the contrary, it seems to even have some cognitive advantages. While bilingual children are found to lag behind their monolingual peers at age of 3 and 5, they catch up by the time they are 7 years old by which then any language penalty has disappeared. More importantly, at 7 years of age, bilingual children showed a general superiority over their peers in a range of cognitive outcomes such as the British Ability Scale Word reading, Pattern construction and Math tests. Thus, our study facilitates the recent language education policy initiative on the value-added of speaking foreign language.

Keywords: cognitive skills production function, structural equation model, latent cognitive skills

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There is no doubt that, despite the dominance of English as a world language, the ability to speak another language - is increasingly important in our competitive and global economy. We need to be sure that in our schools, colleges, and through lifelong learning, we are building sound foundations for the sustainability of Modern Foreign Languages. (Department for Education and Employment, 2002)

1. INTRODUCTION

Learning a foreign language is a valuable skill that may help develop analytic, cognitive and communicative abilities (Saiz and Zoido, 2005). Parents who expose their children to two different language early on, may want to increase their productive skills and enable them to learn more efficiently in the future, hence, giving them an advantage over their peers.[1] Early life language acquisition is linked to better performance at later stages of schooling (Kamhöfer, 2014) and higher returns in adult life (Clifton-Sprigg, 2015).[2] However, some studies warn that bilingualism could put a child at a disadvantage and slow down cognitive development (see Bhatia and Ritchie (2008), Hakuta (1986)). The gap between second generation immigrants and other natives appears to be linked to the English-language proficiency (Bleakley and Chin, 2008). One of the earliest concerns that researchers tackled was the idea that bilingualism confused children (Genesee, 1989). These early studies conclude that native students outperformed bilingual students on a range of cognitive tasks. Bilingual children initially possess a smaller vocabulary in each of their languages, and in general they come from families where at least one parent is foreign immigrant and this may be considered as a disadvantage (Oller and Eilers, 2002). In addition, families with two foreign parents may be less proficient in the native language and may lack location-specific knowledge being essential for a child's development. These differences may play an additional role in early children's development and later life outcomes. It is therefore, theoretically ambiguous as to what the effect of growing up in a bilingual environment on early cognitive skills formation is.[3]

To economists, the issue is to what extent does bilingualism matter in early cognitive development; or put differently, is the cumulative effect of 'inputs' in a skill production function different for children being exposed to two different languages early in their life.[4] Interest in the language of immigrants has increased in part by the recent upsurge in immigration to the UK. The 2011 UK Census shows that a 13% of the UK population is foreign born, up from 7% in 1991.[5] Most of these recent immigrants are from non-English speaking countries.[6] With this raising number of immigrant families in the UK, concern has increased over the impact that growing up in a non-English speaking home environment may have on children's cognitive development and education performance.[7]

[1] To maintain the balance between two languages, the bilingual brain relies on executive functions, a regulatory system of general cognitive abilities. Because of the constant switch between languages, a bilingual child develops enhanced executive control, or the ability to effectively manage so called 'higher cognitive processes', such as problem-solving, memory and thought, or it is a phenomenon that researchers call the bilingual advantage (Bialystok et al., 2012).

[2] Numerous empirical studies suggest a positive association between English-language ability and earnings (Bleakley and Chin (2004), Chiswick (1991)). Both fluency in the language of the destination country and the ability to learn it quickly play a key role in the transfer of existing human capital to destination countries and generally increase immigrant's success (Dustmann et al. (2012), Adsera and Pytlikova (2015)). Bleakley and Chin (2004) demonstrate the role of language proficiency, as an input to the human capital is far more important than the direct effect of language on the marginal product of labour. For both social and economic reasons, language is a barrier that separates many immigrants from natives.

[3] Beyond differences in neuronal activation, bilingualism is found to affect the brain's structure. Higher proficiency in a second language, as well as earlier acquisition of that language, correlates with high gray matter volume in the left inferior parietal cortex (Mechelli et al., 2004).

[4] In contrast, there are some studies suggesting that cognitive skills remain unaffected by bilingualism (Baker, 2011).

[5] In the 2011 Census there were 7.5 million people born abroad; this compares to 4.6 million in 2001 and 3.6 million in 1991 (UK Office for National Statistics (ONS), 2011 Census).

[6] India was top of this list with 694,000 usual residents, followed by Poland with 579,000 and Pakistan with 482,000. The Polish-born population in England and Wales increased nine-fold between 2001 and 2011, more than any other country (ONS, UK, 2011 Census).

[7] Bilingualism refers to the ability to use two languages and involves both understanding and speaking.

Despite the importance of this question, not much attention has been devoted to whether cognitive development measures are themselves affected by the language spoken at home and little is known about the adaptation process that bilingual children must navigate, and educational consequences that emerge as they learn a new culture and language. The motivation for this paper stems that child development is a multi-dimensional process, and it is important to establish whether the family inputs that foreign parents have access to are associated with different cognitive development outcomes. Building on theoretical analyses of Todd and Wolpin (2003), Cunha et al. (2006) and Cunha and Heckman (2008), we estimate the cognitive skills production function of young children of immigrant parents using the UK Millennium Cohort Study (MCS).[8] The objective of our analysis is to investigate determinants of a bilingual child's development of cognitive skills over various phases of childhood, playing particular attention to early language exposure, and addressing the issue of unobserved heterogeneity and measurement error. Language exposure refers to the maintenance of the first foreign language at home. The identification strategy used in the paper follows the same spirit as Andrabi et al. (2011), who apply dynamic panel methods to evaluate the effect of private schooling on student achievement in Pakistan. To address the possibility that contemporary bilingual status and child outcomes are shaped by common past factors such as genetics, we adopt a value-added plus lagged inputs model of skill formation whereby a child's current cognitive ability depends on their previous ability and past parental home language environment inputs and socio-economic status.[9] We test the notations of so called 'self-productivity' i.e. whether more skills accumulated in the present period leads to more skills accumulated in the next period, in the transition from early to mid childhood (ages 3 to 11). The emphasis is also on the importance of parental language background and home environment defined in terms of the quality of stimulation and support available to the child. For this purpose, we estimate children's production function in a more complex approach that attempts to estimate the entire dynamic process of child development.[10] Finally, even after controlling for lagged cognitive achievement and child heterogeneity, changes in bilingual status may still be correlated with changes in time-varying component of the unobserved determinants of learning (Zhang et al., 2014). To address this concern, we employ the Arellano and Bond (1991) GMM framework.

A potential problem when estimating the skill production function is accounting for the endogeneity of parental inputs and endogeneity of language acquisition as language spoken at home is an endogenous decision made by each household.[11] The effect of speaking foreign language at home on accumulation of human capital may interact in complex ways with parental characteristics. It is possible, for instance, that families who in the 1970s were more concerned with the education of their children, tended to speak only English at home (Locay et al., 2013).[12] The reverse is also plausible. It may be the case that families place more value on their children being able to speak a second language, or have stronger loyalty to their ancestral culture. If this is the case, then we may underestimate the effect on cognitive tests scores of speaking foreign language at home. Without altering the human capital acquisition process of the main estimation model, if families are going to speak their foreign language at home even when it reduces their childrens human capital, it must be because they place some value on doing so. In our static estimation framework we account for the potential endogenity of language inputs considering that linguistic distance between migrant's origin and destination country language is expected to affect the efficiency of language learning and to raise the cost of human capital investment. The argument is that immigrants face very different costs of language

[8]We take advantage of detailed longitudinal MSC study that follows children from birth and focus on the early cognitive development of young children of immigrants, all of whom were born in the host country, thus avoiding the potential confounding role of differing experiences of the origin country environment.

[9]Models of learning achievement often assume that a child's achievement persist between grades, what child learns today largely stays in a future. The value-added model differences out the omitted endowments that might be correlated with the inputs. However, it does not difference out heterogeneity that speeds learning (Andrabi et al., 2011).

[10]One limitation of the static, cross-sectional estimates of the production function is that it overstates the importance of contemporaneous inputs measures because of their correlation with omitted historical inputs.

[11]Enodgeneity of speaking a foreign language at home and parental inputs are issues, which clearly pose a problem for the empirical identification of the parameters. The concern is that the main variables of interest may be related to some unobserved characteristic of families that negatively impacts test scores, and that we have misattributed its effects to speaking foreign language at home. We might also expect to observe children of the relatively positively selected immigrants in the UK.

[12]This raises the question of why such families wished to avoid speaking their own language in the first place.

acquisition, associated with their linguistic origin and immigrant children learn English easier and faster the linguistically closer their mother tongue to the host country language is (Isphording, 2015).[13] The result is an instrumental variable (IV) strategy using the linguistic distance as the identifying instrument. The dynamic value-added specification of cognitive skill accumulation replaces the endogenous inputs with exogenous observables and accounts for the endogenous inputs. Finally, we pay special attention on the determinants of bilingualism among children by incorporating into the analysis a dynamic random-effects decision model to further examine what determines the use of foreign language at home, accounting for both unobserved heterogeneity and initial conditions problem (Wooldridge, 2005).[14]

The question regarding the potential impact of bilingualism on children's development is of policy importance. In May 2000, the Nuffield Inquiry published its final report, summarised in the slogan 'English is not enough' (Anon, 2002), thus directly addressing the danger of the UK 'resting' on its L1 skills only.[15] The introduction of languages at Key Stage 2 is a new Government initiative, having been in place since September 2014.[16] Languages became part of the National Curriculum in England from ages 7-14, with the requirements at Key Stage 3 specifying that a modern language is taught. Thus, our study facilitates the benefits of such policy initiative on the value-added of speaking more than one language.

The rest of the paper is organized as follows. Section 2 discuses the relevant literature and Section 3 outlines a dynamic model of child development. Section 4 presents the data and the sample selection. Section 5 presents the results and section 6 concludes.

2. BACKGROUND LITERATURE

There is growing evidence across various disciplines that the environment in the early years of a child's life has a significant influence on cognitive skill formation (Knudsen et al., 2006). Family characteristics such as income and education, time spent in educational activities (reading and writing) may all influence children's cognitive and non-cognitive performance.[17]

The role of family background and culture on children's outcomes has been also recognised in migration studies. Fryer and Levitt (2006) mention that speaking Spanish at home has little effect on the initial gap of the test scores between Hispanic and non-Hispanic whites. Dustmann (2008) shows a gap in performance for first generation immigrants, relative to the native population. A lack of English proficiency is cited as a primary reason for a poor school performance among many first- and second- generation children (Rosenthal et al., 1983). Macnamara (1967) claims that the lower verbal performance among bilingual children is a result of a 'balance effect' whereby proficiency in a second language necessitated a loss in proficiency in one's first language. Thus, it is proposed that foreign speakers never reach comparable levels of linguistic proficiency as native speakers. Lambert (1977) argues that when ethno-linguistic minority children reject their own cultural values and practices for those of the prestigious, dominant group, the second language eventually replaces their native language. In contrast, immigrant ethno-linguistic minority children often do not fully develop their cognitive abilities in their native language while they must confront instruction in another language at school.[18] Studies on older immigrant youths find them to be at an academic disadvantage when compared to

[13] Isphording (2015) shows that linguistic barriers raised by language differences play a crucial role in the determination of the destination-country language proficiency of immigrants.

[14] The central econometric issue in the dynamic models used is that of unobserved heterogeneity and initial conditions.

[15] In England, all students sit nationally standardised and accredited tests in a variety of subjects (GCSE) at age 16+, and can obtain University entry qualifications (A levels) by studying a further two school years, but language study is currently not required for either GCSE or A level (Lanvers, 2011).

[16] In September 2014, a foreign language became a compulsory element of the Key Stage 2 curriculum for all English primary schools. It was introduced as one of the changes made following the Coalition Governments National Curriculum review. The Library briefing on the National Curriculum Review, SN06798, provides background. See Long and Boulton (2016)

[17] See Ermisch (2008), Blanden et al. (2007), Melhuish et al. (2008), Fiorini and Keane (2014)

[18] Lambert (1977) distinguishes between an additive and a subtractive form of bilingualism. An additive form involves both languages and cultures being complementary positive influences on overall development, which results from valuing the languages and cultures of families and communities. Thus, an additive approach to bilingualism involves acquisition of a second language at the same time that all abilities in the first language are maintained, as is the case of children from a dominant social group learning a minority language within school. A subtractive form of bilingualism, on the other hand, occurs when two languages are competing.

their native-born peers and the question of why this pattern occurs is an area of debate among researchers (Rong and Brown, 2001). Considering the extensive challenges immigrant families face while navigating a new social environment, it is not surprising that many immigrant youth struggle academically (Perreira et al., 2006).

The other strand of the literature thus strongly supports the cognitive advantages of bilingualism. Research has found that once family resources are accounted for, school-age children of immigrants often out-perform their third and higher generation peers on math and reading skills (Palacios et al., 2008). Both foreign-born and native-born youth with immigrant parents show better academic, behavioural, emotional, and health outcomes than youth with native-born parents (Coll et al., 2012). With respect to child factors, cognitive development has consistently been found to be positively associated with both pro-social behaviour and language ability (Baillargeon et al., 2011). Bilingual children also show other enhancements in their mental development. The relationship between bilingualism and concept formation is illustrative in some early studies. For instance, Bain (1974) findings support the bilingual children's superior performance on concept formation tasks. Bialystok (2001) show that bilingual children at preschool age develop executive functioning earlier than their peers who are monolingual. Yang et al. (2011) also report that four-year-old bilingual children outperformed three monolingual groups in executive functioning tasks. Feliciano (2001) shows that immigrants are less likely to drop out of school and demonstrates that bilingual youths are more likely to be bi-cultural. The strong cultural component in maintaining bilingualism which may play a role in educational success. Portes and Rivas (2011) conclude that preserving linguistic and cultural heritage is advantageous for immigrant children.

The extent of the observed difference depends crucially on the age at arrival in the country (Böhlmark, 2008) as well as the length of stay before the gap is measured (Glick and Hohmann-Marriott, 2007). The divide is also visible for second-generation immigrants but varies across countries. Dustmann et al. (2012) compare the educational attainment of second-generation immigrants with that of children born to native parents in several OECD countries and show that the average gap in test scores of children of immigrants and natives differs widely across countries, and is strongly related to achievement differences in the parent generation. The disadvantage faced by immigrant children reduces, and even disappears for some countries, once parental background characteristics are controlled for. A foreign language spoken at home is the single most important factor associated with the achievement gap. Reardon and Galindo (2009) look at development of cognitive and non-cognitive skills of Latino pre-schoolers in the U.S., and find that students with Mexican and Central American origins, particularly first and second-generation immigrants and those from homes where English is not spoken, have the lowest maths and reading skill levels at nursery entry but show the greatest achievement gains in the early years of schooling. Clifton-Sprigg (2015) presents evidence of early life performance gaps between children in foreign/bilingual and native families, using data for Scotland. Overall, children perform comparably on an array of measures, including cognitive (picture similarities), non-cognitive (strength and difficulties questionnaire) and motor development. Where the difference does emerge (vocabulary naming, speech assessment), the outcomes are likely to be related to speech and linguistic skills. The author highlights that bilingual families are heterogeneous group and children with two foreign-born parents are at a particular disadvantage at this early age. Clifton-Sprigg (2015), however, does not show a causal effects and the implications are more likely qualitative. Given the unobserved heterogeneity among children, which is crucial for their performance and correlates with the included covariates, a caution is needed when drawing conclusions. Further, there is a potential to selection issues. Amongst those who emigrate, there is a propensity to intermarry, thus forming mixed families. This positive selection may lead to bias as children of more educated parents are likely to perform better, which would close the gap between the mixed and native children.

An important contribution of this research is the connection between the level of household income, child development (Blau (1999), Dahl and Lochner (2012)) and foreign family structure.[19] Hart and Risley (1995) measure the language environment children were exposed to up to age 36 months and document that children

[19]However, a higher level of family income does not necessarily indicate a higher level of family resources being devoted to children (Del Boca et al., 2014). Differences in human capital at birth may lead to different investment by parents. Cunha et al.

of professional parents exhibited superior language development throughout the period of study. Specifically, the authors find that children of parents with welfare assistance heard about 600 words per hour, whereas children of professional parents heard almost twice as many words in the same amount of time. Rowe (2008) concludes that women in poverty and with a lower education background were simply unaware that it was important to talk to their babies.[20] Finally, it is highlighted that bilingualism on its own is unlikely to fully explain the differences in performance between native and non-English origin children.[21] Immigrant families differ from each other and, it is expected that performance of bilingual children to differ from monolingual children partly because of the different environment they are growing up in.

In the UK, a number of other studies using the Millennium Cohort Study have shown that parental inputs play a significant role in explaining child development.[22] Ermisch (2008), for example, shows that much of the difference in child development, at age of 3, by parent's socio-economic status can be explained by parental style and educational activities. Dickerson and Popli (2016) use the UK Millennium Cohort study data and find that the cognitive development test scores at age 7 years are almost 2 percentile ranks lower for children who are persistently in poverty throughout their early years, when compared to children who have never experienced poverty.[23] Girard et al. (2016) conclude that better expressive language at three years was associated with increased pro-social behaviour by five years. However, these studies do not exploit the longitudinal aspect of the data and often use restricted value-added models, where past cognitive achievement contains no information about the future gains. Despite the recent advances in the literature, little is known as to how a child's cognitive skills interact with the language spoken at home. Absent from the current research literature in the UK is estimation of dynamic panel approach in value-added approximation of the cognitive production function, which test the effects of early bilingual exposure on child's cognitive development.

Our paper differs from reviewed studies in some important aspects. First, in our analysis we focus on the early years of bilingual children's development, as reflected in their cognitive development by addressing some key empirical issues such as cognitive persistence, measurement error and endogeneity of language home inputs. Second, we exploit longitudinal aspect of the data by addressing unobserved child heterogeneity and the persistence in the cognitive achievement. We consider a longer time horizons by examine children's cognitive development at age of 3, 5, 7 and 11 years. This allows us to include a period when the children have been attending school.[24] We test the notions of self-productivity in the transition from early to middle childhood.

3. CONCEPTUAL FRAMEWORK AND EMPIRICAL SPECIFICATION

3.1. Conceptual framework

With the respect of the mechanism through which the bilingualism operates in child cognitive skills formation, it could be both different levels of family language inputs are combined with different production functions.[25] We consider migrant families are bound to be different in many respects, not just the fact that

(2010) quantify the importance of four main determinants of early investment in children, namely the budget constraints that parents face, differences in the child's characteristics, differences in beliefs about the technology of skill formation, and differences in preferences. The authors argue that this quantification is important because the different channels have distinct implications about what public interventions should be implemented to foster human capital formation. They find that heterogeneity in parental preferences and beliefs plays an important role in explaining the gap in early investment.

[20]The study indicates that child-directed speech relates to socio-economic status as measured by income and education, and the relation between socio-economic status and child-directed speech is mediated by parental knowledge of child development.

[21]Baker (2011) provides an extensive overview of the impact of bilingualism on cognitive outcomes in children reflecting mainly ideas from sociological and linguistic literature. However, the linguistic studies are usually based on experimental runs on relatively selected samples since participation is voluntary.

[22]See Ermisch (2008), Kiernan and Huerta (2008), Hernández Alava and Popli (2013), Schoon et al. (2012).

[23]It has been documented in the literature, however, that poverty alone does not explain variation in educational outcomes or behavioural patterns of immigrant children (Rumbaut, 1995).

[24]Children's cognitive development during each period is driven by different environmental inputs.

[25]These two alternatives are not mutually exclusive and it is not possible to separately identify them in a model in which both were allowed.

different language is spoken at home. The diversity of origins and resources available in the homes of children of immigrants and natives may all impact subsequent development. Even those from the same country may originate from diverse linguistic backgrounds and economic origins. We expect that bilingual children have particular environments that may be associated with low social economic circumstances, constrained early learning opportunities, parents who have experienced their own educational difficulties and this limits responses to the cognitive skill tests assessment. We also expect that a child who grows up in a family where the parents are fluent in English, but nevertheless speak foreign language at home, will become fluent in English more slowly. This will result in lower cognitive test scores. In a household where the parents are not fluent in English, the alternative to speaking foreign language may be to speak very poor English, which in turn will lower the rate at which a child becomes fluent in English. Presumably such a household would be foreign-speaking one. The effect of speaking foreign language at home on the accumulation of human capital, therefore, may interact in complex ways with parental characteristics (Locay et al., 2013).

Unfortunately, our data set does not include measures of the English fluency of the parents. However, it does include their level of education, whether they were born abroad, their age at arrival in the UK, and their country of origin, all of which we believe are correlated with their degree of fluency in English, and consequently with their probability to speak English language at home. Parental schooling should be directly related to the other productivity parameters, and indirectly related in the production of human capital to speaking foreign language at home. Specifically, there are several ways parental schooling can impact the accumulation of human capital and therefore cognitive test scores of the children. First, parental schooling is likely to be correlated with the innate ability of the parents and thus with their children's inherited abilities (Locay et al., 2013). Second, parents with high levels of education are likely to have higher income, which will be associated with better opportunities and other inputs into the human capital accumulation process. Finally, better educated parents are more likely to be fluent in English and this can affect the growth rate of English language directly as well as through its interaction with the foreign language spoken at home.

Another factor influencing the ability to learn a new language and the degree of English language proficiency is the age at arrival of the parent, given that this determines the ability to acquire the new language. Immigrant parents arriving in young ages pick up the destination language almost effortlessly and reach a near native level of proficiency (Isphording, 2014).[26] Finally, parents of bilingual child also vary according to the current linguistic use and their ability or efficiency in acquiring the destination language.[27]

Our main interest lies in investigating the various determinants of skill formation with a particular focus on whether being bilingual has an effect on children's cognitive skills development. We adopt and educational production function approach and consider children's cognitive acquisition as cumulative process that depends on child's current and past endowment of cognitive capacity and a history of family inputs (Todd and Wolpin (2003) and Todd and Wolpin (2007)). Let A_{ijt} denote the cognitive achievement for a child i, which is the level of observation, residing in household j at time t; and the vector of family inputs $\mathbf{F}_{ijt}$ is a function of time, as the family investment differs depending on the age of the child:

$$A_{ijt} = A_t[\mathbf{F}_{ij}(t), \mathbf{X}_{ij}(t), \mu_{ij0}, \epsilon_{ijt}] \tag{1}$$

The vector of family inputs includes parental investment at different age along the linguistic abilities - passing the second language on to the child i - the variable of most interest; $\mathbf{X}_{ijt}$ includes various additional child and mother controls. Included are regional dummies, ... Here μ_{ij0} denotes child's mental capacity ('ability') or capacity for cognitive achievement, and the term $\epsilon_{i,t}$ captures measurement error in the cognitive test scores. The empirical implementation of this production function, however, is difficult for three main

[26]Some early studies have documented that mother tongue development facilitates the acquisition of second language, and thus argue that the first step in learning English should be mastery of the mother tongue (Cropley, 1983). These authors explain that poor immigrant children are more likely to receive limited linguistic support at home, and therefore need more support in school to acquire the mother tongue.

[27]In the U.S, for example, the majority of homes in which a non-English language is spoken include at least one person who speaks English well. However, a substantial minority of immigrant children live in homes in which no one speaks English well and children raised in such environment likely benefit from exposure to two languages (Hernandez, 2004).

reasons which will be discussed below: (i) inheritable endowments are unobservable; (ii) datasets on inputs are incomplete (i.e. have incomplete input histories and/or missing inputs); and (iii) inputs may be chosen endogenously with respect to unobserved endowments and/or prior achievement (Todd and Wolpin, 2003).

3.2. Value-Added models

To set up the idea we define the child life cycle as constituting of distinct time periods indexed by t, not necessarily equivalent to a year. Following Todd and Wolpin (2007) and Andrabi et al. (2011), we model the cumulative production function of cognitive achievement as a dynamic process as follows:

$$y_{it}^{*} = \sum_{s=0}^{t} (\mathbf{X}_{is}\alpha_{t-s} + \theta_{t-s}\mu_{is}) \tag{2}$$

where y_{it}^{*} is true cognitive achievement for a child i at end of period t, measured without error, and μ_{is} is the unobserved determinants (both inputs and endowments) affecting child is learning in period s; α_{t-s} and θ_{t-s} correspond to, respectively, the impacts of the observed and unobserved factors applied $t-s$ periods prior to the time of assessment on child's cognitive achievement.[28] We aggregate all inputs applied to child i in periods s, including our main variable of interest, foreign language spoken at home, into a single vector $\mathbf{X}_{is}$ and exclude interactions between past and present inputs.

Estimating equation (2) is in general impossible because we do not observe the full set of inputs, past and present. Adding and subtracting $\lambda y_{i,t-1}^{*}$, normalizing θ_1 to unity and assuming that all input coefficients, both observed and unobserved, decline geometrically at the same rate λ, i.e., ($\alpha_{t-s-1} = \lambda\alpha_{t-s}$ and $\theta_{t-s-1} = \lambda\theta_{t-s}$) $\forall$ $s \leq t-1$, we can obtain a value-added specification that relates a child's current achievement to his/her lagged achievement and the contemporaneous inputs as:

$$y_{it}^{*} = \lambda y_{it-1}^{*} + \mathbf{X}_{it}\alpha_0 + \mu_{it} \tag{3}$$

The basic idea behind value-added specification (3) is that lagged achievement y_{it-1}^{*} is a sufficient statistic and captures the contribution of all previous inputs and any past unobservables, and is linked to current cognitive achievement through the persistence parameter λ.[29] However, the estimation of eq.(3), faces two additional issues, as discussed in Andrabi et al. (2011). First, lagged achievement only captures individual heterogeneity in level $t-1$, but gifted children may accumulate knowledge faster. If this is the case, the error term μ_{it} may include child-level heterogeneity in learning (i.e., $\mu_{it} \equiv \eta_i + v_{it}$, where η_i reflects the unobserved individual-level heterogeneity in the average accumulation process and v_{it} is the time-varying deviation in the unobserved individual-level accumulation process that has a zero mean across time for the same child). Since this unobserved heterogeneity enters in each period, cov $(y_{it-1}^{*}, \mu_{it}) > 0$ and λ will be biased upward. Second, the cognitive achievement test scores are inherently a noisy measure of latent cognitive achievement: $y_{it} = y*_{it} + e_{it}$, where e_{it} is independently distributed across both children and time periods. Replacing latent cognitive achievement with their observed measures, we can rewrite eq.(3) in terms of observables and the error term now will include measurement error:

$$y_{it} = \lambda y_{it-1} + \mathbf{X}_{it}\alpha_0 + \eta_i + \varphi_{it} \tag{4}$$

where $\varphi_{it} = v_{it} + e_{it} - \lambda e_{it-1}$. To address child-level heterogeneity in cognitive accumulation progress, we can difference eq. (4) as follows:

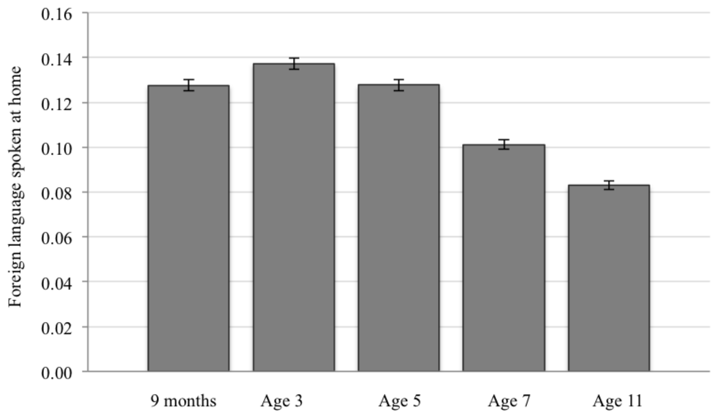
$$\Delta y_{it} = \lambda \Delta y_{it-1} + \Delta\mathbf{X}_{it}\alpha_0 + \Delta\varphi_{it} \tag{5}$$

[28] This starting point assumes that an input applied at age t has the same effect on that age scores as an input applied at age $t+1$ has on $t+1$ achievement scores. See Andrabi et al. (2011).

[29] We refer to α as the input coefficient and λ as the persistence coefficient, parameter that links cognitive achievement across periods. Imposing the restriction that $\alpha = 1$ yields the restricted value-added or gain-score model, which asserts that past cognitive achievement contains no information about future gains: $y_{it}^{*} - y_{it-1}^{*} = \alpha' \mathbf{x}_{it} + \mu_{it}$.

where the differenced model eliminates the unobserved fixed effect η_i; and $\Delta\varphi_{it} = v_{it} - v_{it-1} + e_{it} - (1 + \lambda)e_{it-1} + \lambda e_{it-2}$. Identification of λ and α is achieved by imposing Arellano and Bond (1991) linear moment conditions.[30] In the dynamic panel model, without measurement errors, Arellano and Bond (1991) propose instrumenting Δy_{it} with two or more lags of y_{it}, such as $y_{i,t-2}$ if the unobserved child-level, time-varying shocks v_{it} are serially uncorrelated. The lags are uncorrelated with the error term but are correlated with the change in lagged cognitive achievement, provided $\lambda < 1$. The input coefficient, in our case the contribution of foreign language spoken at home, is primarily identified from the set of children who switch between bilingual status in the observation period.[31] At age of 3, children exposed to foreign language at home comprise 13% of the overall sample, and as Figure 1 shows children change their language status over time. By age 11 (sweep 5), less than 9% of the them are exposed to foreign language at home.

Figure 1: Change in bilingual status over time



Source: MCS data. Notes: Full sample. Unweighed data. Author's calculations.

The implementation of the GMM approach depends on the precise assumptions about inputs. We consider two cases: strictly exogenous and predetermined inputs. Strictly exogenous inputs assumes that past disturbances do not affect current and future inputs, ruling out feedback effects. In our context, this is a strong assumption, as a delay in child development may cause parents to change their preferences and switch to English language spoken at home. The assumption of strictly exogenous inputs allows us to use changes in time-varying characteristics, e.g., bilingual status, child age, poverty status, and family characteristics, as exogenous controls (included instruments) in the difference equation. We also consider the case where inputs are predetermined but not strictly exogenous. The predetermined inputs case assumes that inputs are uncorrelated with present and future disturbances but are potentially correlated with past disturbances. This also assumes that lagged cognitive achievement is uncorrelated with present and future disturbances. Compared to strict exogenous case, this approach uses only lagged inputs as instrument; specifically, we instrument with time varying characteristics such as lagged bilingual status, strengths and difficulties indicator and children's age.

[30] See for more details Arellano and Bond (1991), Andrabi et al. (2011).

[31] Presumably, this always goes in one direction. Children begin being bilingual and then switch to being monolingual, that is switching doesn't occur in the opposite direction.

3.3. Addressing Measurement error

In addition measurement error in cognitive test scores can also bias our parameters of interest.[32] In the context of value-added estimation, measurement error attenuates the coefficient on lagged cognitive achievement and can bias the input coefficient in the process. The dynamic panel estimators do not address measurement error in their own. If we replace true cognitive achievement with observed achievement in the standard Arellano and Bond (1991) setup,equation (6) becomes

$$\Delta y_{it} = \alpha' \mathbf{\Delta x}_{it} + \beta \Delta y_{i,t-1} + [\Delta v_{it} + \Delta \epsilon_{i,t} - \beta \Delta \epsilon_{i,t-1}] \tag{6}$$

The standard potential instrument, $y_{i,t-2}$ is uncorrelated with Δv_{it}, but is correlated with $\Delta \epsilon_{i,t-1} = \epsilon_{i,t-1} - \epsilon_{i,t-2}$ by construct. The solution is to use either three-period lagged test scores or alternate subjects as instruments. In the dynamic panel model as discussed, correcting for measurement error using additional lags requires four years of data for each child, a difficult requirement in most longitudinal datasets, including ours. We correct for measurement error analytically using reliability estimates obtained from Item Response Theory.[33] See Andrabi et al. (2009).

3.4. Decision of speaking foreign language at home

A model of the determinants of destination language proficiency has been developed and used for analyses of adult immigrant linguistic adjustment (Chiswick and Miller, 2007). The model of language attainment is based on the assumption that language skills are form of investment in human capital and builds on three conceptual variables: exposure to the destination language, efficiency in language acquisition, and economic incentive for immigrant language acquisition. Similar approach is applied here for the determinants of bilingualism among children in the UK. The emphasis, however, is on the variables related to exposure, as the efficiency and economic incentive effects so dominant in analyses for adult immigrants are assumed to play a minor role for childhood bilingualism. If the parents really want to ensure that their children become fluent in the foreign language, they will exclusively speak the foreign language only at home.

Specifically, we model parental decision to speak foreign language at home in a limited dependent variable framework, where $I_{it} = 1$ if foreign language was spoken at home in time t for a child i. As such, $I_{it} = 1\ (I^*_{it} > 0)$ where 1(.) is the indicator function taking a value of unity if the expression in parenthesis is true and zero otherwise. To control for unobserved individual effects while also including explanatory variables that affects a family's tastes for speaking foreign language at home, we introduce specification that takes the form of a Chamberlain-Mundlak Random Effects Model (Mundlak (1978), and Chamberlain (1984)):

$$I^*_{it} = \beta_0 + \beta X_{it} + \bar{x}_i + a_i + u_{it} \tag{7}$$

where $\bar{x}_i$ and a_i represent unobserved individual heterogeneity, and the $\bar{x}_i$ is the part of the unobserved individual heterogeneity correlated with the X_{it}. While certain observable characteristics are assumed to affect a family's tastes for speaking foreign language at home, propensity to speak foreign language may persist for other reasons. Unobserved heterogeneity, such as parental attitudes and tastes, might affect the propensity of maintaining foreign language at home. The latter refers to a causal relationship between past and current bilingual status. In short, a parent who does not speak foreign language in year $t-1$ will behave differently in year t to otherwise identical parent who speaks foreign language in year $t-1$. This might result from an individual changing preferences due to past child's achievements. To facilitate examination of the effect having spoken foreign language in year $t-1$ on propensity to speak foreign language in year t and thereby consider the effect of persistence, a dynamic random effects probit model (including lagged dependent

[32]The randomness in testing means that classifying children as high or low ability on the basis of a single test is liable to be subject to error since achieving a relatively high or low score on a given day is likely to be followed by a less extreme score in they were tested on another day (Dickerson and Popli, 2016). Instead of having the true measures we have a range of imperfect measures of cognitive skills and parental investment.

[33]Item Response Theory (IRT) provides the standard error for each score from the inverse Fisher information matrix after ML estimation of the IRT model.

variable and correction term for initial conditions while also controlling for unobserved heterogeneity) is considered (Orme (1996), Wooldridge (2005), Arulampalam et al. (2000)). The model is specified as follows:

$$I_{it}^{*} = \beta_0 + \beta X_{it} + \gamma I_{i,t-1} + a_1 \bar{X}_i + \delta e_i + a_i + u_{it} \tag{8}$$

where a vector of contemporaneous individual and household characteristics is indicated by X_{it}; $I_{i,t-1}$ is a lagged dependent variable representing the bilingual status in the previous year; the a_i represents unobserved individual heterogeneity, it is individual specific and time-invariant random component; the idiosyncratic error term is u_{it}; the $\bar{x}_i$ the time-varying explanatory variable, of individual i over time is included to pick-up possible correlation between the time-varying regressors and any unobservable heterogeneity (following Chamberlain (1984), Mundlak (1978) and outlined in Arulampalam et al. (2000)); and δe_i signifies the 'initial condition' correction term.

In dynamic panel modelling, with a limited number of time periods, correlation between a_i (unobserved heterogeneity) and the initial observation may result in inconsistent results (Hsiao, 2014).[34] To correct for this a correction term is added into the specification. In the spirit of Heckman's standard selection model, a reduced form equation for the initial condition is modelled (Heckman (1981), Orme (1996)). This process involves two main steps. First, an estimator of a reduced form model for initial observation I_{i1}. This includes vector z, all the explanatory variables including time varying means but also additional 'pre-sample information'. The reduced form model is specified as follows:

$$I_{i1}^{*} = \lambda' z_{i1} + \eta_i \quad \text{where } i = 1, 2...N;\ t = 1 \tag{9}$$

From the reduced form equation, a generalised probit error, correction term e_i is generated, which is used as an additional regressor in the dynamic model to account for the correlation between the initial condition and unobserved heterogeneity.

We believe that parental factors, such as age, sex, and occupation, may influence initial bilingual status, but not subsequent changes. To prevent our identification from relying solely on functional forms, we need to have some variables that affect familys choice to speak foreign language at home, but do not directly affect the cognitive test scores. The difficulty in learning a destination language depends in part on the person's origin language Chiswick and Miller (2007). A Chinese speaker would find it more difficult than a Spanish speaker to learn English because the differences in languages are so much greater. That is, the 'linguistic distance' between Chinese and English is greater than between Spanish and English. If English is linguistically closer to Western European languages, such as Spanish, French, and German, than it is to East Asian languages, such as Korean or Japanese, it would be expected that Western European immigrants in the UK would attain a higher level of proficiency in English sooner than immigrants from East Asia or Arab countries (Chiswick and Miller, 2004). Hence, the cost of acquiring the host country language depends on the distance of the migrants mother tongue from the dominant majority language, in our case English (Dustmann et al., 2003). We adapt Chiswick and Miller (2004) scalar of the linguistic distance between English and a set of other languages (linguistic indices), where the lower the scores, the greater is the distance between reported languages and English. Linguistic scores and the main languages are reported in Appendix Table 2 for a wide range of languages that are spoken by mothers country of origin. In the analysis the linguistic distance (LD) is measured as the inverse of the linguistic score (LS) in Table A1, that is LD = 1/LS, where the range is from a low score (easier to learn) of 0.33 for Afrikaans, Norwegian and Swedish and a high score (harder to learn) of 1.00 for Japanese. The index for French is 0.40 and for Chinese/Mandarin and Arabic 0.67. These scores suggest a ranking of linguistic distance from English among these languages: Japanese

[34] Previous research in parametric, dynamic nonlinear models has focused on three different ways of handling initial conditions. The first approach is to treat the initial conditions for each cross-sectional unit as non-random variables. However, this assumption is very strong as non-randomness of initial conditions implies that the observed outcome is independent of unobserved heterogeneity. A better approach is to allow initial conditions to be random, and then to use joint distribution of all outcomes on the response, including that in the initial time period, conditional on unobserved heterogeneity and observed strictly exogenous variables.The main complication with this approach is specifying the distribution of the initial condition given unobserved heterogeneity (Wooldridge, 2005). Heckman (1981) proposes approximating the conditional distribution using the full set of sample observations allowing cross-correlation between the main and initial period equations.

being the most distant, followed by Chinese and Arabic and then Afrikaans, Norwegian and Swedish as the least distant.

4. Description of data

4.1. Millennium Cohort Study

The data used in this analysis come from the UK Millennium Cohort Study (MCS) following a large sample of around 19,000 babies born in 2000-2001.[35] It covers the four countries of the UK, with over-representation of those living in the smaller countries, and it also over-represents those born in disadvantaged areas and in areas of England with relatively high proportions of those from minority ethnic groups. Unlike earlier birth cohort studies, the sample covers those born across a full year, rather than a specific week. The sample was selected from Child Benefit records, and selected from 400 areas of the UK. When appropriately weighted the sample is representative of children born in the UK across the period (late 2000-2001 in England and Wales and to early 2002 in Scotland and Northern Ireland).

The main unit of observation of the survey is the cohort member (the child), but information is collected both on cohort members and their parents. The study tracks children through their early childhood years and collects information on diverse aspects of their lives, including behaviour, cognitive development, health, schooling, housing and parents' employment and education, income and poverty; housing, neighbourhood and residential mobility; and social capital and ethnicity.[36] Specifically, child cognitive assessments are collected directly from the child by trained interviewers, whilst questions about the cohort members socio-emotional behaviour were asked to one of the parent, typically the mother. The five surveys of cohort members conducted so far - at ages 9 months and 3, 5, 7 and 11 years - have built up a uniquely detailed portrait of children's development.[37] This study uses information from all the waves of the survey collected so far.

To our knowledge, the UK MCS data has not been used in economics to study the effect of language background on early cognitive development. The singular exception to this is Girard et al. (2016), but their study focusses on the expressive language ability, defined from the British Ability Scale on child's pro-social behaviour and their study does not consider immigrant children. We focus our attention on a set of children who were all born in the UK and whose mother or father were born overseas. For our analysis, we use two sub-samples of the data: all children, with both native and foreign-born parents, who were tested over time, and children for whom at lest one parent is foreign-born. We draw the conclusion from both sub-samples, but our main focus and dynamic analysis is drawn from a selected sample of second-generation immigrant children for whom at least one parent is born overseas (for sake of brevity, we will refer to this sample as "immigrant" sample). In this way, we drop from analysis the children who are not exposed to the language setting we are interested in.[38] We use information on language spoken at home to categorize children at each wave into the following three language categories: (i) children whose parents speak foreign language only (FL) at home; (ii) children who speak about half English and half other language at home; and (iii) children who use only English at home. We merged the first two categories and use it as a treatment group and (iii) serves as controls.[39] The final sample we use in the dynamic empirical strategy is comprised of 2,877 second-generation children.[40]

[35] We restrict our analysis to first born child.

[36] The data are collected via both direct interview and by self-completion. For the sample analysed in this paper, 98% of the main respondents are biological mothers or fathers of the children.

[37] The first sweep took place in 2001-2002 when these babies were, on average, around 9 months old. The second sweep took place when the children were around 3 years old, whereas the third sweep was administered when the children had reached age 5 years and had started school. Finally, the forth and the fifth sweeps were undertaken in 2008 and 2012 when the children were 7 and 11 years old respectively.

[38] For the purposes of this paper someone born outside the UK is defined as immigrant. We have 1,556 mothers and 1,596 fathers in the sample who were born overseas.

[39] The question asked to the main respondent is: "Is English the language spoken at home?" and responses "Yes- English only", "Yes-mostly English and sometimes other language" are used to identify child monolingual status, while responses "Yes-about half English and half other language", "No - mostly other, sometime English" and "No-other languages only" are used to identify child being bilingual.

[40] To balance the need for a consistent sample of children across time with the need for statistical power, we do not restrict our sample to children with non-missing information for all of the outcomes that we examine in a given age group of assessment.

4.2. Child outcomes: Cognitive test scores

The dataset provides different measures of cognitive abilities. Cognitive ability of a child at age 9 months is captured using the Denver Development Screening Test (DDST), which is an assessment widely used for examining the development of children from birth until age 6 years (Frankenburg and Dodds, 1967).[41] The test assesses children on 125 items grouped into four different areas. The MCS uses a subset of the items covering three areas: fine motor functioning: eye/hand co-ordination, and manipulation of small objects; gross motor functioning: motor control, e.g. sitting, walking, standing and other movements; and communicative gestures: Dex and Joshi (2004). Following Dickerson and Popli (2016) we classify a child as having a delay in a particular functioning if he or she cannot perform a task that 90% of the children of their age can do. The classification is based on answers from the main respondent of the survey.

The data also records several standard tests of cognitive development at ages 3, 5, 7 and 11 years, administrated to the children themselves. We focus on the children's performance across all of these tests since each of them reflect different cognitive abilities and educational performance. The set of measures comes from a widely used age-varying test from the British Ability Scales (BAS) which includes the BAS Naming Vocabulary Test, the BAS Word Reading Test, the BAS Verbal Similarities Test, the BAS Picture Similarity Test and the BAS Pattern Construction Test Elliott et al. (1996).[42] The second measure of cognitive skill available in MCS is an adapted version of the National Foundation for Educational Research Progress in Maths Test (NFER).

At age 3 and 5 childrens cognitive abilities are evaluated with the BAS Naming Vocabulary (BAS-NV) which assesses childs expressive spoken vocabulary and consists of a set of coloured pictures of objects shown to the child one by one and asked to name. Successful performance depends on the childs previous knowledge of a vocabulary of nouns.[43] In addition, at age of 3, the Bracken School Readiness Assessment (BSRA) is used to assess the conceptual development of young children across a wide range of categories (see Bracken (2002)). When the child is 5 years old, cognitive abilities are measured by the BAS Naming Vocabulary Test, as at age 3, together with the BAS Picture Similarity and the BAS Pattern Construction. The Picture Similarity Test measures childrens problem solving abilities by showing a row of 4 pictures and asking the child to choose another picture most similar to one of those. In addition, at age of 5, cognitive abilities are measured by the BAS Pattern Construction test (BAS-PC) and BAS Picture Similarity test (BAS-PS). The BAS Pattern Construction test asks the child to constructs a design by putting together flat squares or solid cubes. This assessment tests child accuracy, speed and spatial awareness, but can also be used to observe dexterity and coordination, as well as traits like perseverance and determination. The BAS Picture Similarity test (BAS-PS) measures childrens reasoning and problem solving abilities by showing a row of 4 pictures and asking the child to choose another picture most similar to one of those.

At age 7 cognitive abilities are assessed with three tests, the BAS Pattern Construction test which is the same as at age 5, the BAS Word Reading test (BAS-WR), and the National Foundation for Educational Research Progress in Maths Test (PiM). The BAS-WR test asks the child to read aloud a series of 90 words presented on a card, to assess childrens English reading ability.[44] The PiM maths test assess children's numerical and analytical skills by providing a range of tasks covering number, shape, space, measures and data Finally, at age 11, new measures of memory, strategic thinking, decision making and risk taking

[41] It is difficult to measure cognitive development at that early age since there are no tests for cognitive ability for children that young Dickerson and Popli (2016). We can only measure their development, i.e. the physiological and psychological functioning, and whether they have reached particular age-specific development that most children at that age can do. However, it might be argued that the items in the DDST might be capturing other concepts, not just cognitive development.

[42] The British Ability Scales (BAS) are a set of standard age-appropriate individually administered tests of cognitive abilities and educational achievements suitable for use with children and adolescents aged from 2 years 6 months to 7 years 11 months. Hansen (2010) provide the relevant information on this subsection.

[43] The Naming Vocabulary scores reflect expressive language skills; vocabulary knowledge of nouns; ability to attach verbal labels to pictures; general knowledge; general language development; retrieval of names from long-term memory; and level of language stimulation.

[44] Different test was carried out in Wales. The parents of children living in Wales were asked to select either an English reading test (BAS II Word Reading) or a Welsh reading test (called Our Adventure) for their child. In our selected sample we disregard the Welsh cohort members undertaking the 'Our Adventure' test as it is not comparable with the English reading test.

were introduced. Combined, these measures provide a comprehensive picture of the childrens cognitive development at this age. We focus on the BAS Verbal Similarities Test, which evaluates verbal reasoning and verbal knowledge with the interviewer who reads out three words to the child who must recognize the similarities among them. All the raw scores are adjusted using a set of standard adjustment tables to take account of the age of the child and the difficulty of the item set administrated.

As in Dickerson and Popli (2016), for each of these tests, we use the age-standardized scores and construct the child's percentile ranking across all children in the MCS who completed the test and we consider the differences in scale and dispersion between the tests. The percentile rankings record on a scale of 0-100 the percentage of children in the sample completing the test who are ranked below the child's score. Thus a child's ranking of 90 on a particular test indicates that 90% of children scored lower in the test; the child is thus in the top 10% of the specific test score distribution. Percentile rankings provide a convenient metric against which to record the influence of being bilingual on the different cognitive skills that are assessed in each of the tests. For ease of interpretation all tests are converted into z-scores, with mean 0 and standard deviation of 1.

It is traditional in the literature to combine several measures into a single latent factor that captures cognitive ability (see e.g. Jensen (1998), Heckman et al. (2006)).[45] The assumption that one factor captures cognitive ability test scores might be not ideal in our context where a wide range of cognitive tests are considered and differences in reading and mathematical abilities of bilingual children are expected.[46] However, the dynamic panel setup analysis requires at least three years of data on consistent cognitive outcome for each child, a difficult requirement if we use alternate subjects measured at each age. It also gives us a better understanding of the child's general cognitive ability.[47] Therefore, a composite score of general cognitive ability following Heckman et al. (2006) is also constructed from the test scores by means of principal factor analysis. For instance, at age 5 we carried out a factor analysis of three subsets - picture similarities, naming vocabulary and pattern construction. For the general cognitive ability factor in our data, the underlying factor explains 78%, 56% and 62% of the trace of cognitive test score correlation matrix at ages 3, 5 and 7, respectively. We saved g scores for each child, based on the first unrotated factor. The scores indicating general cognitive ability (g) were standardized to a mean of 100 and a standard deviation of 15. Table 1 shows the pairwise Spearman rank correlation matrix of the cognitive measures used in the analysis.

Verbal skills were assessed using a subset of the British Ability Scales II (BAS II), which is a battery of cognitive abilities and educational achievement tests suitable for use from ages 2 years 6 months to 17 years 11 months. The individual subscales are widely validated, age appropriate, can be analysed separately, and have been shown to predict later child cognitive performance.17 Data were available on the BAS II Naming Vocabulary Subscale (age 3 and 5 years) which measures vocabulary and expressive reasoning, the Word Reading subscale (age 7 years) involving verbal reasoning, and the Verbal Similarities subscale (age 11) assessing childrens verbal reasoning and verbal knowledge18 The subscale scores used in this study are standardized to mean 50 and standard deviation 10 and are adjusted for both item difficulty and age.

4.3. Other covariates

A major advantage of the MCS data is that it includes a large set of covariates, which makes the assumption of selection on observables more credible. The set of controls we include draws partly from the human capital formation literature, that accounts for parental inputs as one of the major determinants. To control for differences in the starting developmental position of children, we use birth weight, age of the mother at birth and level of education of the mother.[48] Mothers education at birth is included to capture

[45] The most convincing evidence for a single general intelligence model is that there is a high positive correlation between different tests of cognitive ability.

[46] Gardener's theory of multiple intelligences, for example, suggests that there are linguistic, musical, spatial, bodily, interpersonal, and logico-mathematical forms of intelligence (Gardner, 2013)

[47] The factor analysis helps us to understand the underlying structure of a set of correlated variables, and to reduce the dataset to a more manageable size while retaining as much of the original information as possible (Dunteman, 1989).

[48] Birth weight is included as a proxy for genetic endowment (Del Bono et al., 2012), and mother's age and education are included to capture any disadvantage that the child might face (Hernández Alava and Popli, 2013).

the finding in the literature that educated parents, especially mothers, tend to systematically spend more time with their child. Other variables included in the model are ethnic background, age of the child at the assessment, household size, poverty indicator, indicator of whether a child had regularly attended some form of formal childcare (e.g.preschool, nursery) prior to starting school. We also include controls for young immigrant parent as consistent with the research on linguistic acquisition, people who received their first exposure to English at an earlier age attain a higher level of English proficiency than those who received in later and we expect it determines the propensity of speaking Englsih language at home.[49] Age at arrival affects not only the language proficiency but also cultural assimilation. Older arrivals likely differ from younger arrivals along non-language dimensions that could affect the outcomes of interest. To address this concern, we introduce a dummy variable for mother coming from a non-English-speaking country.[50]

When cohort members were approximately 3, 5 and 7 years old, parents were asked to complete the Strengths and Difficulties Questionnaire (SDQ). The SDQ is a validated tool which has been shown to compare favourably with other measures for identifying hyperactivity and attention problems. The SDQ asks questions about five domains of behaviour, namely: conduct problems, hyper- activity, emotional symptoms, peer problems and pro-social behaviour. Scores from the conduct problems, hyperactivity, emotional symptoms and peer problems sub-scales are summed to construct a total difficulties score.

Parental investment at 9 months is measured using the mother's attitudes toward child rearing. Responses to four questions about the importance for development of talking to the baby, cuddling the baby, stimulating the baby and having regular sleeping and eating time for the baby are used. Furthermore, responses of the mother to a wide range of questions are used at the age of 3, 5 and 7 to measure parental investment. The questions cover a wide range of activities parents may carry out with their children. For example, when children are age of 3, mothers are asked about the frequency their child is helped with the alphabet. [51]

For the purpose of comparison, Table 3 presents the characteristics on a selected sample of second-generation immigrant children restricted to those children with at least one parent being a foreign immigrant (for sake of brevity, we will refer to this sample as "immigrant" sample).[52] This sample is split into the two categories (i) bilingual: children whose parents speak foreign language or mix it with English at home; (ii) monolingual: children whose parents speak only English at home. Of the individuals in 'immigrant' sample at child's age 3, 47.6% report to speak English only at home. We have 726 children with a foreign born mothers reporting that they only speak English at home.

There are pronounced differences in socio-economic and demographic characteristics between the two groups. Bilingual children score much lower than their monolingual counterparts in the Bracken School Readiness test and Naming Vocabulary exercise at both age 3 and 5, and the same can be said about the Picture Similarities scores measured at age 5. The gap between the two groups tend to decline with age and is found insignificant in the BAS-Word Reading test score measured at age of 7. Children whose parents speak foreign language at home come mainly from none white ethnic background and less educated households, are less likely to attend child care facilities, and around 50% of them live below the poverty line. Parents also differ in terms of their home parental inputs. Parental investment at 9 months, as measured by mother's

[49] We define mother's age at arrival as a difference between year of arrival in the UK, available in the dataset, and mother's year of birth. Those who arrived up to age of 10 are considered as young arrivals. We drop the latter arrivals thus; the range of year of arrival for the mothers is therefore 1954-1995.

[50] The MCS data allows us to identify mother country of birth. We used The World Almanac and Book of Facts, 2005 to determine whether English was official language or predominant language in each country of origin. We classify as English-speaking countries those mothers who come from Australia, Canada, Barbados, Bermuda, Dominica, Ethiopia, Ghana, Guyana, Hong Kong, India, Ireland, U.S., Jamaica, Kenya, New Zealand, Nigeria, Saint Lucia, Saint Vincent and the Grenadines, Seychelles, Singapore, Trinidad and Tobago, Zambia. Mothers from non-English speaking countries who arrive young (up to around age of 10) attain English-language skills comparable to those immigrant mothers from English speaking countries. Upon arrival in the UK, immigrants originating from English-speaking countries encounter everything that immigrants from non-English countries encounter except the language. Thus, any difference in childrens outcome between young and old arrivals from non-English speaking countries that is over and above the difference from English-speaking countries can plausibly be attributed to language Bleakley and Chin (2004).

[51] We tried different specification, where following Melhuish et al. (2008), a summative home environment investment index has been considered and the idea was to capture child's general home environment. However, we found home activities questions not consistent over time and keep the variables clear.

[52] We do not show the descriptive statistics of the overall sample but they are available on request.

attitudes toward child rearing, is found to be significantly different between bilingual and monolingual mothers. On the four questions about the importance for development of talking to the baby, cuddling, stimulating the baby and having regular sleeping and feeding habits, foreign speaker mothers show higher scores. However, at age of 3, compared to a monolingual mother, a foreign speaker mother score lower on the parental activities scale and favour less a firm discipline parental style.[53] The means of the answers to these questions change over time suggesting that perenting styles are not persistent over time. At age of 5 and 7, bilingual parents spend more time helping their child with reading and writing suggesting that these parents

5. Results

5.1. Baseline estimates from cross-section data

Before presenting our estimates of the bilingual effect, we provide some evidence for the cognitive effect of being exposed to a foreign language at home using cross-sectional evidence. These results do not take advantage of the more sophisticated dynamic specifications above but nevertheless provide initial evidence that the value-added of bilingual effect is evident. We provide the estimates on both the entire sample of children including the native speakers and on the 'immigrant' sample consisting of children for whom at least one parent was born overseas.[54] Tables 4 to 11 present results for a cross-section regression of cognitive achievement on child and household characteristics at different ages and across the two samples. The IV specifications of the production function address the issue of endogenous language inputs. The dependent variable in each regression is the standardized cognitive test score corresponding to that age. Our discussion will be limited mainly to the primary variable of interest, namely, speaking foreign language at home.

Turning to the variable of most interest, it is found that for the same level of development, at age 3 years, children who speak a foreign language at home tend to score lower in the two cognitive tests when compared to monolingual children. Speaking foreign language at home when child was 9 months reduces the Bracken school readiness measured at age of 3 and the effect is found significant at 10% significance level once we fully control for child and family characteristics. Overall, adding a comprehensive set of controls reduces the estimated coefficient on the main variable of interest and in some specifications the effects being statistically insignificant at conventional levels. In particular, the bilingual childs Bracken School Readiness and BAS-Naming Vocabulary, once controlled fully for child and household characteristics is expected to be 0.102 standard deviations (SDs) (3 percentile ranks) and 0.283-SDs (8 percentile ranks) below the cognitive scores of a monolingual child, respectively.[55] For both OLS and IV we find that bilingualism negatively affects child cognitive skills, however, this effect is statistically insignificant in the IV specifications. Children with gross and fine motor development delay measured at 9 months perform worse at age of 3 in both Bracken School Readiness and BAS-Naming Vocabulary. Mother education has a significant and positive association across all specifications. Also, higher mothers age at the time of birth, having mother with higher qualification, and being white ethnic background are all associated with higher cognitive development at age of 3 years, though the effect of white ethnicity is insignificant in school readiness IV specification. We see that child poverty exerts a statistically significant negative influence on child cognitive performance measured at age of 3 years. Specifically, a child who has been in poverty can be expected to be 0.275-SDs below the School Readiness score of the child who has never been in poverty. A negative association between lower socio-economic status is consistent with the existing literature (see Dickerson and Popli (2016) who report that a child who is in poverty is associated with seven percentile ranks (0.263 SDs) lower cognitive ability at age 3 years.). The effect of having parents arrived at younger age translates into a significant increase in

[53] Parenting style is a construct and may correlate with the socio-economic disadvantage. In particular, the extent to which parents monitor their children decreases with disadvantage (Cobb-Clark et al., 2016).

[54] The 'immigrant' sample allows for homogeneity of the two groups, both composed of children born in the UK with at least one foreign-born parent. This sample restriction is necessary, given that foreign-language speakers are much more likely to come from foreign-born families and foreign -born children differ substantially from those of native-born parents. Moreover, the native children are not exposed to the same language home environment.

[55] The percentile rank changes are calculated by multiplying the observed standard deviations changes in the cognitive variables by the standard deviations of the underlying measures; all the test scores have an SD of around 28.5.

the cognitive development at age of 3. Specifically, children whose parents arrived in the UK at early age score over 0.112-SDs in School readiness and 0.153-SDs in Naming Vocabulary test. Finally, children who struggle at 9 moths, as measured by the strengths and difficulties index, are also likely to do worse at age 3 (see Table 4).

At age of 5, the penalty of not speaking English language at home has disappeared once we fully control for observable characteristics, with the effects being statistically insignificant at conventional levels for the BAS-Picture Similarities and BAS-Pattern construction test scores. The association is found significant and negative only for the BAS-Naming Vocabulary test, where bilingual children continue to score on average lower when compared to their monolingual counterparts. Other things being equal, the results suggest that a bilingual child scores 0.219-SDs (6 percentile ranks) below the monolingual child (see Table 5). This is suggestive that bilingual children at age of 5 continue to fall behind in their expressive language and knowledge of names.[56] The significant result does not hold for the IV specification, where we cannot reject the null hypothesis of exogeneity of the linguistic distance instruments using a Sargan test and conclude that overidentifying restriction is valid (p-value=0.314).[57] Across all three specifications, we note that there is presence of self-productivity, thus a child developing well at age of 3 years is also likely to be doing well at age 5.[58] A 1-SD higher cognitive score in the BAS-Naming Vocabulary at age of 3 years is associated with a 0.290-SD higher score in the same test at age 5 years; this is equivalent to 8 percentile ranks; similarly a 1-SD higher score in Bracken School Readiness at age of 3 years translates to a 0.247-SD higher cognitive score in the BAS-Naming vocabulary at age of 5, equivalent to 7 percentile ranks. Parental inputs, as measured by the frequencies with which the mother and father read to the child and library visits are found to predict significantly the BAS-Naming Vocabulary outcome.

However, at age of 7 other things being equal, the BAS-Word reading, Pattern construction and Maths test scores for bilingual children are found almost 5 to 7 percentile ranks higher than for children who only use one language at home (see Table 6).[59] The results hold in both the entire sample of children and 'migration' sample. This finding is in line with Mumtaz and Humphreys (2001) who show that bilingual children were better at reading regular words, non-words and irregular words compared to their monolingual counterparts.[60] At age of 11, turning to the variable of most interest, speaking foreign language at home reduces the tests scores in the basic specifications, and the disadvantage faced by foreign speaker in Verbal similarity standard score disappear once we fully control for child and parental characteristics (Table 7). There is self-productivity effects, the cognitive test scores, namely, the Word reading, Pattern construction and Maths, as measured at age of 7, predict the outcome significantly. At age of 11, we include as additional variable the number of hours teacher spent teaching English language per week, but it is found insignificant in our specification and not reported here.[61] Interesting, significant advantage effect at age 11 is found for

[56] Recall that for this exercise, the child was shown a series of pictures presented in the stimulus booklet and asked to say what it was, e.g. a picture of a shoe, chair or pair of scissors. There were in total 36 pictures, but the number of items distributed to a child depended on his/her performance. There were different starting and stopping points dependent upon age and performance, on the whole, the better they did, the more items they were administered. These were teaching items. The interviewer provided specific feedback, i.e., yes, thats right, etc, but also gave the correct response if the child had not answered correctly or had not understood the question. Parsons (2006).

[57] The null hypothesis of over-identifying restriction test is that all the including instrumental variables are jointly exogenous. A test on excluding our potential instruments from the reduced form equation, yields an F-statistics of 66.27 and partial R^2 of 0.046. Both of these compare favourably with those reported in Bound et al. (1995). Further, the Durbin-Wu-Hausman test leads to rejection of the null hypothesis that speaking foreign language is exogenous in this specification.

[58] This is consistent with Cunha and Heckman (2008) and Dickerson and Popli (2016).

[59] Recall that in the BAS-Word reading test, child has to correctly pronounce words within locally accepted standards, with emphasis on the correct syllable or syllables.

[60] Mumtaz and Humphreys (2001) study bilingual reading and show that it may be possible to transfer general language and literacy skills from the first language to reading skills in the second language. They investigate the impact of Urdu as a first language on learning to read in English as second language. Their study involved 60 bilingual Urdu-English speaking students and 60 monolingual English-speaking students. All students were tested individually over a period of eight weeks. The bilinguals were also found to have an advantage in phonological awareness at the earliest stages of reading as compared to the monolinguals. This investigation demonstrates a possible transfer of first language literacy skills to development of reading in a second language, and also supports that bilingual reading development may have an increased effect on the acquisition of certain literacy skills such as phonological awareness and memory, and regular-word reading.

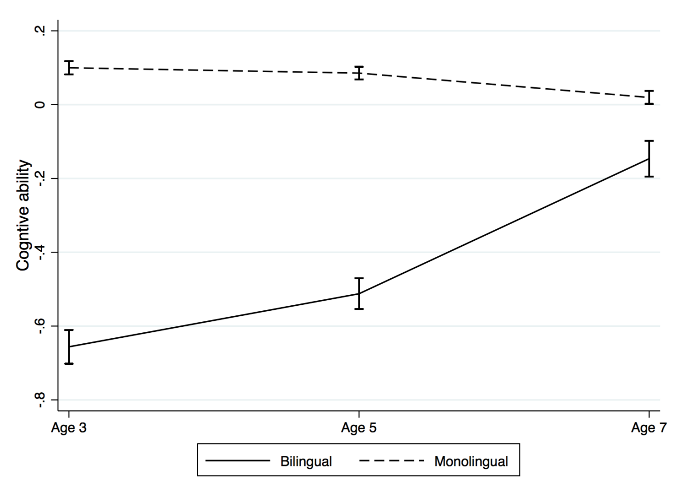
[61] We tried to include several additional variables such as whether the child receive additional English support but the size of

children with young migrant parents.

Next, we discuss the results for the 'immigrant' sample, where as before we present results from both the OLS and IV specifications (Table 8 to Table 11). As before, we focus our discussion to the variable of most interest, and note these results do not differ much between the one found in the overall sample of children. Thus we find evidence for significant cognitive advantage at age 7, after controlling fully for individual and family characteristics (see Table 10). Speaking foreign language at home when child was 5 years increases the Word reading ability, Pattern construction and Maths cognitive outcomes at age of 7 and the effects are found significant at 5% significance level. Other things being equal, the cognitive test scores for bilingual children are almost 5to 7 percentile ranks higher than for children whose parents only speak English at home. The results hold for both the OLS and IV specifications. We note that the magnitude of coefficients increases for the IV specifications. Increasing the cognitive skills at age 5 is associated with a higher level of cognitive skills at age 7. Again, the difference between bilingual and monolingual children in the Verbal similarity test is insignificant at age 11.

Figure 2 plots cognitive levels, as constructed by factor analysis over three years interval.[62] There is clear evidence of a convergence in the cognitive functioning for the two groups over time.

Figure 2: Evolution of cognitive composite score by bilingual status



Notes: Vertical bars represent 95 percent confidence intervals around the group means. Composite cognitive ability indicator derived from factor analysis. Full sample of children.

5.2. Dynamic Panel value-added estimates

Table 12 presents our main value-added results. All estimates include the full set of controls. For brevity, we only report the main coefficients of interest. In columns 1 to 3, we start with the simple linear estimation of a canonical restricted version of equation 5, assuming perfect persistence in cognitive achievement ($\lambda = 1$) and exogeneity of the change in bilingual status. That is, for composite cognitive score, we regress the difference in test score changes on the change in bilingual status, which is summarized by the dummy indicator. For the main variable of interest, the estimated bilingual effect in the restricted model that assumes $\lambda = 1$ is positive and significant, suggesting that bilingualism is associated with an increase in test score of 0.298 SDs, compared to having English language only at home. By comparison, the dynamic panel estimate,

the main variable of interest was unaffected.

[62] To create a unique and more comprehensive measure of cognitive ability across time we combine the cognitive scores available at ages 3, 5, and 7 using factor analysis.

assuming strictly exogenous inputs is insignificant. Adding levels equation, using the assumption that levels are uncorrelated with the omitted effects, reduce the bilingual effect but it is still significant and positive. The point estimate drop to 0.125 SDs.

5.3. Determinants of speaking foreign language at home

Since we are now treating speaking foreign language at home as endogenous variable, the first stage results are briefly discussed. Table ?? reports the average marginal effects derived from the probit, random probit and Wooldridge conditional maximum likelihood (CML) estimates. The standard probit model that assumes equi-correlated errors over periods 1 to T is estimated to keep the illustration simple. Column [1] reports the pooled probit estimates. Having spoken foreign language at home in $t-1$ strongly increases the probability of speaking foreign language in time t. Having spoken foreign language at home at $t-1$ strongly increases the probability of speaking other than English at t. Having a mother from a non-English background increases the probability that a child will speak a language other than English at home by about 2%. Those who arrived in the UK before age of 10 are less likely to keep foreign language at home. Parental education is an important determinant of bilingualism among children and it is found to reduce the probability of speaking other than English language at home. Other variables the same, the greater the linguistic distance, the more likely is the child to speak other than English language at home. Column [2] gives the standard random effect probit estimates, treating lagged bilingual as exogenous. The coefficient on lagged dependent variable I_{t-1} is significantly reduced relative to the pooled probit estimates. However, the random effects probit and pooled probit models involve different normalizations.[63] The propensity to speak foreign language at home seems to reduce significantly with mother education, and with having at least one young migrant parent.

The corresponding estimates from the Wooldridge estimator are given in column [3] which contains x_{it} (child age and poverty status) for all time periods. The model also includes the correction term to adjust for initial conditional problem. The coefficient for the lagged dependent variable representing state dependence is still positive and statistically significant indicating persistence in bilingualism effect. Holding everything else equal, the marginal effect of those who have spoken other than English language in $t-1$ is 2% more likely not to speak English in year t. The degree of persistence however is not high, indicating that those who speak other than English language at home tend to switch. The Wooldridge estimates of the elements of β corresponding to child's characteristics, mother education and family composition are fairly similar to those from the random effects models, thought slightly reduced in magnitude relative to the pooled probit and random effect probit models. Despite controlling for both unobserved effects and state dependence, with the inclusion of lagged dependence variable, the effect of mother education is still significant suggesting that over and above speaking foreign language at home last year (year $t-1$), education matter and significantly reduce the propensity to speak other than English at home. Compared with those with no education, the probability of having foreign language at home reduces by 6% for those child whose mother has diploma in higher education, 4% for those with O-level. Although gender is discussed as a very important determinant of bilingualism in the literature, the estimated effect is not significant, which is not surprising as the decision to speak foreign language at home depends on the characteristics of the parents, and not necessarily on a child's gender. Those children who lived in bellow the poverty line are more likely to be exposed to other than English language at home.

Overall the negative effect of mother's education and having a parent who migrated at younger age remain robust across the three specifications. Other things equal, parents who came to the UK from non-English speaking countries tend to maintain their foreign language at home. We are not able to distinguish, however, whether this finding is due to the parents more likely to value their children being able to speak a second language and have stronger loyalty to their ancestral culture, or because of their low level of English fluency. We believe that whether English is spoken at home depends more on the level of fluency of the parent. Presumably, parents who are from non-English background countries are more likely to have poorer English language skills (Locay et al., 2013). Since we are already controlling for non-English background in the

[63] To compare the coefficients, those from the random effects estimator need to be multiplied by an estimate of $\sqrt{1-\rho}$, where ρ is the constant cross-period error correlation given by $\rho = \sigma_\alpha^2/(\sigma_\alpha^2+1)$ (see Arulampalam (1999)).

cognitive test score equations, we saw no reason to be concerned about this indicator variable having direct effect on cognitive scores.

[Table 13 about here]

6. Conclusion

This paper uses longitudinal data from the Millennium Cohort Study to estimate a dynamic model of bilingual children's cognitive development in the UK. We show that migrant children lag behind the native children at age of 3 but they catch up by the time they are 5 years old and by age of 7 they actually have higher cognitive development scores. The OLS results reveal significant evidence of self-productive effect in childrens cognitive development higher levels of cognitive development at time t foster higher levels of cognitive development at age t+1. Parental investment is found to significantly increase the cognitive ability of children, but this declines as children enter formal schooling. This finding suggests that efforts to promote assimilation of migrant children should concentrate towards the home environment in the very early years and in particular to concentrate on the changes in parental investment at different development stages.

This shows an adjustment process similar to that documented in the immigrant literature (Chiswick et al., 2008).

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7. Appendix

Table 1: Pairwise Spearman rank correlation matrix

	BSR	BAS-NV	BAS-NV	BAS-PC	BAS-PS	BAS-PC	BAS-WR	Math Score
BSR (age of 3)	1							
BAS-NV (age of 3)	0.6558	1						
BAS-NV (age of 5)	0.5691	0.6700	1					
BAS-PC (age of 5)	0.3644	0.3125	0.3526	1				
BAS-PS (age of 5)	0.2705	0.2385	0.2991	0.3792	1			
BAS-PC (age of 7)	0.3847	0.3031	0.3732	0.5537	0.3227	1		
BAS-WR (age of 7)	0.3794	0.2329	0.2971	0.2865	0.2166	0.3399	1	
Math score (age of 7)	0.3976	0.3050	0.3958	0.3636	0.3011	0.4688	0.5100	1
VS (age of 12)	0.2872	0.3225	0.3990	0.2091	0.1855	0.2343	0.2890	0.3171

Table 2: Mother's country of birth and linguistic distance

Mothers' country of birth	Language	Distance to English (LS)	LD=1/LS
Afghanistan	Dari/Pashto	2.00	0.50
Algeria	Arabic	1.50	0.67
Angola	Portuguese	2.50	0.40
Argentina	Spanish	2.25	0.44
Aruba	Dutch/(English, Spanish, French)	2.75	0.36
Australia	English	3.00	0.33
Austria	German	2.25	0.44
Bangladesh	Bengali	1.75	0.57
Barbados	English	3.00	0.33
Belgium	Dutch/ French/German	2.50	0.40
Bermuda	English	3.00	0.33
Brazil	Spanish	2.25	0.44
Bulgaria	Bulgarian	2.00	0.50
Canada	English	3.00	0.33
Chile	Spanish	2.25	0.44
China	Chinese/Mandarin	1.50	0.67
Croatia	Croatian	2.00	0.50
Cyprus	Turkish	2.00	0.50
Czech	Czech	2.00	0.50
Denmark	Danish	2.25	0.44
Dominica	English	3.00	0.33
Egypt	Arabic	1.50	0.67
Equador	Spanish	2.25	0.44
Ethiopia	English	3.00	0.33
France	French	2.50	0.40
Gambia	English	3.00	0.33
Germany	German	2.25	0.44
Ghana	English	3.00	0.33
Greece	Greek	1.75	0.57
Guadeloupe	French	2.50	0.40
Guyana	English	3.00	0.33
Hong Kong	Chinese/English	1.50	0.67
Hungary	Hungarian	2.00	0.50
India	Hindu/English	1.75	0.57
Indonesia	Indonesian	2.00	0.50
Iran	Arabic	1.50	0.67
Iraq	Arabic	1.50	0.67
Ireland	English	3.00	0.33
Italy	Italian	2.50	0.40
Jamaica	English/Creole	3.00	0.33
Japan	Japanese	1.00	1.00
Kenya	English/Bantu Swahili	2.75	0.36
Lebanon	Arabic	1.50	0.67
Libya	Arabic	1.50	0.67
Macedonia	Macedonian	2.00	0.50
Malawi	English/Chichewa	1.50	0.67
Malaysia	Malaysian	1.75	0.57
Malta	Maltese	2.75	0.36
Mauritius	English/French	2.50	0.40
Montserrat	English	3.00	0.33
Morocco	Arabic	1.50	0.67
Nepal	Nepali	1.75	0.57
Netherland	Dutch	2.75	0.36
New Zealand	English	3.00	0.33
Nigeria	English	3.00	0.33
Norway	Norwegian	3.00	0.33
Pakistan	Urdu/English	2.75	0.36
Philippines	English/Filipino	2.75	0.36
Poland	Polish	2.00	0.50
Portugal	Portuguese	2.50	0.40
Romania	Romanian	3.00	0.33
Saint Lucia	English	3.00	0.33
Saint Vincent and the Grenadines	English	3.00	0.33
Seychelles	English	3.00	0.33
Serbia and Montenegro	Serbian	2.00	0.50
Singapore	English	3.00	0.33
Somalia	Somali, Arabic	1.50	0.67
South Africa	English/Afrikaans	3.00	0.33
Spain	Spansih	2.25	0.44
Sri Lanka	Sinhala/Tamil/English	1.75	0.57
State of Palestine	Arabic	1.50	0.67
Sweden	Swedish	3.00	0.33
Switzerland	French/German/Italian/Romansh	2.50	0.40
Syrian Arab Republic	Arabic	1.50	0.67
Taiwan	Twai	2.00	0.50
Tanzania	Swahili/English	2.75	0.36
Trinidad and Tobago	English	3.00	0.33
Tunisia	Arabic	1.50	0.67
Turkey	Turkish	2.00	0.50
Uganda	Bantu/Swahili/English	2.75	0.36
Unated States of America	English	3.00	0.33
Uruguay	Spanish	2.25	0.44
Vietnam	Vietnamese	1.50	0.67
Western Sahara	Arabic	1.50	0.67
Yemen	Arabic	1.50	0.67
Zambia	English	3.00	0.33
Zimbabwe	English/Shona	3.00	0.33

Table 3: Baseline Characteristics of bilingual sample children

	Bilingual*		Monolingual*			
Measures of cognitive ability:	Mean	SD	Mean	SD	Difference	t-stat
9 months: Communicative gestures delay	0.45	[0.50]	0.43	[0.50]	0.02	(0.03)
9 months: Fine motor development delay	0.13	[0.33]	0.14	[0.34]	-0.01	(0.02)
9 months: Gross motor development delay	0.15	[0.35]	0.12	[0.32]	0.03	(0.02)
Age 3: Bracken school readiness	38.32	[29.39]	55.89	[27.68]	-17.58***	(1.57)
Age 3: BAS-Naming Vocabulary	26.66	[25.19]	54.81	[27.82]	-28.15***	(1.48)
Age 5: BAS-Naming Vocabulary	29.15	[26.16]	55.32	[27.62]	-26.18***	(1.34)
Age 5: BAS-Picture Similarity	47.74	[29.17]	54.03	[27.56]	-6.29***	(1.41)
Age 5: BAS-Pattern Construction	43.67	[28.24]	52.62	[28.78]	-8.95***	(1.42)
Age 7: BAS-Pattern Construction	42.2	[29.18]	50.01	[29.00]	-7.81***	(1.49)
Age 7: BAS-Word Reading ability score	55.52	[28.75]	56.37	[28.07]	-0.85	(1.46)
Age 7: Maths test score	45.95	[30.38]	54.55	[28.37]	-8.59***	(1.5)
Age 11: Verbal Similarity standard score	45.14	[31.47]	56.62	[26.95]	-11.47***	(2.19)
Measure of parental investment and style:						
9 months: Importance of simulating the baby	0.54	[0.67]	0.34	[0.56]	0.20***	(0.03)
9 months: Importance of talking to baby	0.30	[0.54]	0.14	[0.37]	0.16***	(0.02)
9 months: Importance of cuddling baby	0.22	[0.49]	0.12	[0.36]	0.10***	(0.02)
9 months: Importance of regular sleeping/eating for baby	0.70	[0.78]	0.61	[0.73]	0.09**	(0.04)
Parental style (=1 if firm discipline & lots of fun)	0.33	[0.47]	0.49	[0.50]	-0.16***	(0.02)
Age 3: Frequency parent reads to the child	2.76	[1.30]	3.42	[0.93]	-0.65***	(0.06)
Age 3: Frequency taken to the library	0.45	[0.75]	0.58	[0.78]	-0.13***	(0.04)
Age 5: Frequency parent reads to the child	2.52	[0.85]	2.70	[0.57]	-0.17***	(0.04)
Age 5: Frequency taken to the library	0.68	[0.72]	0.73	[0.64]	-0.04	(0.03)
Age 5: Frequency child helped with maths	2.59	[0.56]	2.56	[0.59]	0.03	(0.03)
Age 5: Frequency child helped with writing	2.64	[0.54]	2.57	[0.59]	0.07**	(0.03)
Age 7: Frequency parent reads to the child	2.36	[1.48]	2.03	[1.62]	0.33***	(0.09)
Age 7: Frequency taken to the library	0.82	[0.72]	0.75	[0.64]	0.07*	(0.04)
Age 7: Frequency child helped with maths	2.78	[0.88]	2.34	[0.90]	0.44***	(0.07)
Age 7: Frequency child helped with writing	2.85	[0.86]	2.66	[0.89]	0.19***	(0.07)
Age 3: Strengths and Difficulties index	10.95	[5.76]	8.58	[4.90]	2.36***	(0.29)
Age 5: Strengths and Difficulties index	8.25	[5.28]	6.69	[4.63]	1.56***	(0.25)
Age 7: Strengths and Difficulties index	8.17	[5.22]	6.74	[5.09]	1.43***	(0.26)
Initial conditions						
Child gender (=1 if male)	0.5	[0.50]	0.49	[0.50]	0.01	(0.03)
Child ethnic background (=1 if white)	0.14	[0.35]	0.83	[0.38]	-0.68***	(0.02)
Birth weight (kg)	1.02	[0.17]	0.95	[0.14]	0.07***	(0.01)
Mother's age at birth	28.44	[5.34]	30.68	[5.36]	-2.23***	(0.30)
HH size	4.83	[1.72]	3.89	[1.07]	0.94***	(0.08)
Child attends registered care service at 9 months	0.06	[0.25]	0.15	[0.35]	-0.08***	(0.02)
Child attends registered care service age of 3	0.05	[0.22]	0.17	[0.38]	-0.12***	(0.02)
Mother's highest academic qualification measured when child is 9 months						
Higher degree	0.07	[0.25]	0.08	[0.27]	-0.01	(0.01)
First degree	0.16	[0.36]	0.24	[0.43]	-0.08***	(0.02)
Diplomas in higher education	0.06	[0.24]	0.11	[0.31]	-0.05***	(0.02)
A- level (A / AS / S levels)	0.09	[0.29]	0.11	[0.31]	-0.02	(0.02)
O - level (GCSE grades A-G)	0.29	[0.45]	0.37	[0.48]	-0.08***	(0.03)
Other academic qualifications	0.11	[0.31]	0.01	[0.12]	0.09***	(0.01)
No qualification	0.23	[0.42]	0.08	[0.27]	0.15***	(0.02)
Mother married	0.97	[0.16]	0.80	[0.40]	0.18***	(0.02)
Mother with non-English background	0.64	[0.48]	0.22	[0.41]	0.42***	(0.02)
Young migrant (mother or father arrived before age 10)	0.43	[0.49]	0.77	[0.42]	-0.35***	(0.02)
Below 60% of the median UK household income:						
at 9 months	0.43	[0.50]	0.18	[0.38]	0.26***	(0.02)
at age of 3	0.48	[0.50]	0.15	[0.35]	0.34***	(0.02)
at age of 5	0.54	[0.50]	0.19	[0.39]	0.35***	(0.02)
at age of 7	0.47	[0.50]	0.14	[0.35]	0.33***	(0.02)

Notes: *Bilingual (=1 if both foreign and English language spoken at home);** Monolingual (=1 if English language only spoken at home). Cells contain means, brackets contain standard deviations, parentheses contain t-statistics. Standard errors for the difference between bilingual and monolingual are clustered at the household level. *Difference is statistically significant at the 10% level. **Difference is statistically significant at the 5% level. ***Difference is statistically significant at the 1% level. Frequency parent reads to the child is coded as (0) not at all (1) less often; (2) once/twice a week (3) every day. Parental investment attitudes toward child rearing variables measured at 9 months are coded as discrete values ranging from 0=strongly agree; 1=agree; 2=neither agree nor disagree; 3=disagree; 4=strongly disagree;

Table 4: Cognitive abilities at age 3 and bilingual status, Sample of all children

	Bracken School Readiness			BAS-Naming Vocabulary		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV	OLS	OLS	IV
Bilingual status$_{t-1}$	-0.373***	-0.102*	-0.098	-0.732***	-0.283***	-0.292
	(-5.20)	(-1.95)	(-0.55)	(-11.21)	(-5.65)	(-1.63)
Child's age in months	0.010**	0.024***	0.026***	0.004	0.015***	0.015***
	(1.97)	(5.56)	(7.73)	(0.91)	(3.98)	(4.51)
Gross motor development delay$_{t-1}$		-0.131***	-0.134***		-0.188***	-0.171***
		(-4.59)	(-5.44)		(-6.54)	(-6.94)
Fine motor development delay$_{t-1}$		-0.062**	-0.052**		-0.096***	-0.080***
		(-2.34)	(-2.17)		(-3.67)	(-3.34)
Communication gesture delay$_{t-1}$		-0.050**	-0.042**		-0.060***	-0.065***
		(-2.51)	(-2.57)		(-2.84)	(-3.90)
Weight		-0.304***	-0.369***		-0.301***	-0.264***
		(-3.36)	(-5.16)		(-3.99)	(-3.67)
Below 60% of the median UK household income$_{t-1}$		-0.275***	-0.256***		-0.228***	-0.217***
		(-10.55)	(-11.76)		(-8.83)	(-9.91)
Male		-0.187***	-0.202***		-0.231***	-0.228***
		(-10.30)	(-12.72)		(-13.33)	(-14.33)
White		0.122**	0.161		0.301***	0.370***
		(2.25)	(1.64)		(6.56)	(3.77)
Mother with higher degree$_{t-1}$		0.575***	0.535***		0.298***	0.345***
		(10.38)	(10.62)		(5.50)	(6.83)
Mother with first degree$_{t-1}$		0.489***	0.472***		0.379***	0.373***
		(11.83)	(13.45)		(8.91)	(10.60)
Mother with higher diploma$_{t-1}$		0.299***	0.314***		0.257***	0.279***
		(7.64)	(8.55)		(5.75)	(7.57)
Mother with A level$_{t-1}$		0.268***	0.256***		0.225***	0.221***
		(6.29)	(7.11)		(5.26)	(6.13)
Mother with O-level$_{t-1}$		0.109***	0.101***		0.127***	0.128***
		(3.46)	(3.85)		(3.96)	(4.87)
Mother with other degree$_{t-1}$		0.121	0.098		-0.002	-0.001
		(1.40)	(1.32)		(-0.02)	(-0.02)
Mother age		0.008***	0.007***		0.006***	0.006***
		(3.79)	(3.94)		(2.90)	(3.75)
Married		0.080***	0.063***		0.042*	0.032
		(3.58)	(2.92)		(1.73)	(1.47)
HH size		-0.130***	-0.118***		-0.090***	-0.091***
		(-13.35)	(-15.93)		(-9.01)	(-12.23)
Young migrant (mother or father arrived before age 10)		0.112***	0.120***		0.153***	0.147***
		(3.07)	(3.64)		(4.29)	(4.45)
Mother with non-English background		-0.128**	-0.098		-0.212***	-0.193***
		(-2.36)	(-1.47)		(-4.43)	(-2.89)
Importance of stimulating the baby$_{t-1}$		-0.025	-0.022		-0.052***	-0.054***
		(-1.41)	(-1.38)		(-2.73)	(-3.43)
Importance of talking to the baby$_{t-1}$		-0.021	-0.027		-0.025	-0.009
		(-0.81)	(-1.06)		(-0.81)	(-0.36)
Importance of cuddling the baby$_{t-1}$		0.001	0.008		0.016	0.006
		(0.05)	(0.33)		(0.59)	(0.25)
Importance of regular sleep/feeding time$_{t-1}$		-0.020	-0.022**		-0.000	-0.009
		(-1.53)	(-1.98)		(-0.02)	(-0.84)
Strengths and Difficulties index (standardised)$_{t-1}$		-0.140***	-0.141***		-0.125***	-0.112***
		(-14.35)	(-16.26)		(-11.29)	(-12.84)
N	11956	11956	11956	11956	11956	11956
R2	0.0093	0.2351	0.2302	0.0347	0.2015	0.2164
F-test first of excluded instruments:			67.98			67.98
Partial R2			0.0437			0.0437
Sargan statistic overidentification test			6.456			1.942
p-value			0.4877			0.963
Durbin-Wu-Hausman chi-sq test (p-value):			0.869			0.976

Notes: ***, ** and * denote significance at the 1%, 5% and 10% level respectively. Test scores are standardized. Specifications additionally control for urban/rural indicator and child attending childcare service.

Table 5: Cognitive abilities at age 5 and bilingual status, Sample of all children

	BAS-Picture Similarity			BAS-Pattern Construction			BAS-Naming Vocabulary		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	OLS	IV	OLS	OLS	IV	OLS	OLS	IV
Bilingual status$_{t-1}$	-0.032	0.020	0.106	-0.170***	0.047	0.150	-0.651***	-0.219***	0.054
	(-0.64)	(0.32)	(0.55)	(-3.88)	(1.00)	(0.80)	(-10.57)	(-4.84)	(0.34)
Child's age in months	-0.012***	-0.011***	-0.012***	-0.051***	-0.051***	-0.052***	-0.009**	-0.008***	-0.007***
	(-2.70)	(-2.79)	(-3.98)	(-11.98)	(-13.92)	(-17.09)	(-2.39)	(-2.92)	(-2.71)
BAS-Bracken school readiness$_{t-1}$		0.175***	0.165***		0.221***	0.204***		0.247***	0.233***
		(11.91)	(14.09)		(16.92)	(17.93)		(20.41)	(24.13)
BAS-Naming Vocabulary$_{t-1}$		0.084***	0.078***		0.083***	0.090***		0.290***	0.297***
		(5.90)	(6.32)		(6.31)	(7.49)		(24.84)	(29.00)
Below 60% of the median UK household income$_{t-1}$		0.014	-0.029		-0.003	-0.026		-0.063***	-0.080***
		(0.54)	(-1.21)		(-0.09)	(-1.11)		(-2.65)	(-4.04)
Male		-0.005	-0.033*		-0.062***	-0.059***		0.092***	0.098***
		(-0.21)	(-1.81)		(-3.05)	(-3.35)		(4.83)	(6.56)
White		-0.031	0.024		0.125***	0.174		0.096**	0.273***
		(-0.57)	(0.21)		(2.65)	(1.52)		(2.13)	(2.80)
Mother with higher degree		0.253***	0.207***		0.184***	0.133**		0.311***	0.248***
		(3.94)	(3.65)		(3.00)	(2.41)		(6.47)	(5.28)
Mother with first degree		0.117**	0.090**		0.232***	0.175***		0.242***	0.228***
		(2.44)	(2.34)		(4.90)	(4.68)		(6.36)	(7.13)
Mother with higher diploma		0.069	0.065		0.175***	0.113***		0.206***	0.180***
		(1.35)	(1.60)		(4.17)	(2.87)		(5.44)	(5.38)
Mother with A-level		0.099**	0.091**		0.173***	0.123***		0.092**	0.086***
		(2.07)	(2.31)		(3.84)	(3.19)		(2.41)	(2.62)
Mother with O-level		0.018	0.005		0.100***	0.078***		0.085***	0.084***
		(0.47)	(0.16)		(2.89)	(2.72)		(3.12)	(3.48)
Mother with other degree		0.003*	0.024		0.002	0.116		0.004***	0.058
		(1.68)	(0.31)		(0.99)	(1.55)		(3.15)	(0.90)
Mother age		-0.008	0.002		0.028	0.002		0.045**	0.004**
		(-0.34)	(1.29)		(1.17)	(0.99)		(2.20)	(2.55)
Married		0.018	-0.007		0.002	0.015		0.029**	0.018
		(1.27)	(-0.30)		(0.15)	(0.68)		(2.52)	(0.93)
Frequency reading to the child $_{t-1}$		0.001	0.008		-0.007	-0.000		0.036***	0.039***
		(0.09)	(0.79)		(-0.60)	(-0.01)		(3.86)	(4.73)
Frequency taken to the library $_{t-1}$		0.018	0.023*		0.002	0.022*		0.029**	0.033***
		(1.27)	(1.85)		(0.15)	(1.83)		(2.52)	(3.15)
Young migrant (mother or father arrived before age 10)		0.005	0.011		-0.009	0.008		0.020	0.032
		(0.12)	(0.31)		(-0.28)	(0.22)		(0.61)	(1.05)
Mother with non-English background		0.094*	0.078		0.024	0.007		-0.101**	-0.158**
		(1.84)	(1.04)		(0.39)	(0.09)		(-2.30)	(-2.55)
Strengths and Difficulties index (standardised)$_{t-1}$		-0.075***	-0.068***		-0.100***	-0.094***		-0.024***	-0.021***
		(-6.85)	(-6.85)		(-9.50)	(-9.77)		(-2.66)	(-2.62)
N	11055	11055	11055	11055	11055	11055	11055	11055	11055
R^2	0.0012	0.0982	0.0959	0.0246	0.1575	0.1494	0.0348	0.3561	0.3517
F-test first of excluded instruments:			66.270			66.270			66.270
Partial R^2			0.046			0.046			0.046
Sargan statistic overidentification test			3.033			5.444			8.215
p-value			0.882			0.606			0.314
Durbin-Wu-Hausman chi-sq test (p-value):			0.788			0.579			0.060

Notes: ***, ** and * denote significance at the 1%, 5% and 10% level respectively. Test scores are standardized. Specifications additionally control for urban/rural indicator.

Table 6: Cognitive abilities at age 7 and bilingual status, Sample of all children

	Words Reading Ability score			BAS-Pattern Construction			PiM Maths		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	OLS	IV	OLS	OLS	IV	OLS	OLS	IV
Bilingual status$_{t-1}$	0.099**	0.264***	0.939***	-0.309***	0.143***	0.755***	-0.217***	0.074	0.566**
	(2.10)	(5.05)	(3.22)	(-6.54)	(3.14)	(2.76)	(-3.58)	(1.42)	(1.98)
Child's age in months	0.032***	0.035***	0.040***	0.003	0.033***	0.034***	0.041***	0.050***	0.047***
	(7.85)	(9.57)	(12.33)	(0.82)	(9.79)	(11.08)	(9.63)	(13.02)	(14.74)
BAS-Picture Similarity$_{t-1}$		0.051***	0.037***		0.123***	0.113***		0.137***	0.134***
		(4.69)	(3.68)		(11.04)	(11.76)		(10.31)	(13.37)
BAS-Pattern Construction$_{t-1}$		0.156***	0.147***		0.475***	0.469***		0.268***	0.250***
		(14.52)	(14.31)		(45.51)	(48.71)		(22.53)	(24.86)
BAS-Naming Vocabulary$_{t-1}$		0.239***	0.259***		0.073***	0.091***		0.208***	0.225***
		(21.44)	(19.70)		(6.52)	(7.38)		(15.25)	(17.44)
Below 60% of the median UK household income$_{t-1}$		-0.089***	-0.108***		-0.051*	-0.047*		-0.062**	-0.074***
		(-2.65)	(-4.18)		(-1.90)	(-1.95)		(-2.04)	(-2.93)
Male		-0.064***	-0.063***		0.048**	0.027		0.141***	0.135***
		(-3.33)	(-3.42)		(2.39)	(1.58)		(7.02)	(7.48)
White		-0.211***	0.160		0.224***	0.555***		0.013	0.266
		(-4.10)	(0.95)		(4.24)	(3.48)		(0.23)	(1.60)
Mother with higher degree		0.395***	0.412***		0.242***	0.267***		0.235***	0.210***
		(6.63)	(7.71)		(4.76)	(5.32)		(3.86)	(4.01)
Mother with first degree		0.356***	0.427***		0.199***	0.280***		0.195***	0.239***
		(8.02)	(10.41)		(5.17)	(7.27)		(4.15)	(5.94)
Mother with higher diploma		0.161***	0.252***		0.116**	0.200***		0.066	0.135***
		(3.37)	(5.49)		(2.47)	(4.63)		(1.30)	(2.99)
Mother with A-level		0.266***	0.314***		0.138***	0.189***		0.116**	0.156***
		(5.30)	(7.39)		(3.26)	(4.74)		(2.33)	(3.74)
Mother with O-level		0.109***	0.165***		0.047	0.127***		0.036	0.079**
		(2.79)	(4.42)		(1.33)	(3.62)		(0.85)	(2.17)
Mother with other degree		0.064	0.012		0.050	-0.017		0.194**	0.146*
		(0.79)	(0.16)		(0.84)	(-0.24)		(2.31)	(1.96)
Mother age		0.005***	0.002		0.002	0.002		-0.001	-0.000
		(2.86)	(1.36)		(1.28)	(1.24)		(-0.57)	(-0.26)
Married		0.011	0.001		0.012	-0.020		-0.003	-0.022
		(0.35)	(0.04)		(0.43)	(-0.74)		(-0.12)	(-0.77)
Frequency taken to the library$_{t-1}$		0.032*	0.028*		-0.003	-0.023		0.018	-0.008
		(1.94)	(1.81)		(-0.19)	(-1.54)		(1.12)	(-0.50)
Frequency reading to the child$_{t-1}$		0.031*	0.036**		-0.040**	-0.007		-0.007	0.012
		(1.79)	(2.48)		(-2.35)	(-0.51)		(-0.43)	(0.84)
Young migrant (mother or father arrived before age 10)		0.008	0.063		0.006	0.038		0.030	0.083*
		(0.26)	(1.40)		(0.18)	(0.91)		(0.92)	(1.89)
Mother with non-English background		-0.017	-0.139*		0.039	-0.091		-0.005	-0.099
		(-0.34)	(-1.82)		(0.77)	(-1.27)		(-0.09)	(-1.31)
Strengths and Difficulties index (standardised)$_{t-1}$		-0.159***	-0.153***		-0.053***	-0.054***		-0.111***	-0.110***
		(-12.27)	(-14.86)		(-4.91)	(-5.53)		(-10.32)	(-10.90)
N	9031	9031	9031	9031	9031	9031	9031	9031	9031
R^2	0.0106	0.2624	0.2296	0.0078	0.3551	0.3296	0.0189	0.2852	0.2572
F-test first of excluded instruments:			23.89			23.89			23.89
Partial R^2			0.0208			0.0208			0.0208
Sargan statistic overidentification test			9.284			6.837			3.631
p-value			0.233			0.446			0.821
Durbin-Wu-Hausman chi-sq test (p-value)			0.005			0.013			0.063

Notes: ***, ** and * denote significance at the 1%, 5% and 10% level respectively. Test scores are standardized. Specifications additionally control for urban/rural indicator.

Table 7: Cognitive abilities at age 11 and bilingual status, Sample of all children

	Verbal similarity test		
	(1)	(2)	(3)
	OLS	OLS	IV
Bilingual status$_{t-1}$	-0.189**	-0.043	0.127
	(-2.23)	(-0.67)	(0.52)
Child's age in months	-0.018***	-0.019***	-0.019***
	(-7.86)	(-8.97)	(-11.29)
BAS-Word reading ability$_{t-1}$		0.156***	0.155***
		(9.92)	(12.50)
BAS-Pattern Construction$_{t-1}$		0.081***	0.081***
		(6.76)	(7.43)
PiM Maths test$_{t-1}$		0.123***	0.124***
		(7.88)	(10.05)
Below 60% of the median UK household income$_{t-1}$		-0.139***	-0.142***
		(-4.43)	(-4.79)
Male		0.115***	0.115***
		(5.25)	(6.01)
White		-0.007	0.084
		(-0.12)	(0.62)
Mother with higher degree		0.566***	0.570***
		(9.23)	(9.89)
Mother with first degree		0.447***	0.455***
		(9.39)	(10.86)
Mother with higher diploma		0.292***	0.303***
		(5.74)	(6.60)
Mother withA_level		0.304***	0.312***
		(5.59)	(6.95)
Mother with O_level		0.167***	0.177***
		(4.30)	(4.83)
Mother with other degree		0.171**	0.141*
		(2.29)	(1.70)
Mother age		0.009***	0.009***
		(3.92)	(4.75)
Married		0.022*	0.022**
		(1.77)	(2.16)
Frequency reading to the child$_{t-1}$		0.006	0.006
		(0.92)	(0.91)
Frequency taken to the library$_{t-1}$		0.022	0.021
		(1.01)	(1.33)
Young migrant (mother or father arrived before age 10)		0.084**	0.097**
		(2.05)	(2.42)
Mother with non-English background		-0.067	-0.098
		(-1.34)	(-1.51)
Strengths and Difficulties index (standardised)$_{t-1}$		-0.044***	-0.044***
		(-3.19)	(-4.11)
N	8288	8285	8285
R^2	0.0141	0.2167	0.5729
F-test first of excluded instruments:			49.23
Partial R^2			0.0456
Sargan statistic overidentification test			14.626
p-value			0.041
Durbin-Wu-Hausman chi-sq test (p-value):			0.473

Notes: ***, ** and * denote significance at the 1%, 5% and 10% level respectively. Test scores are standardized. Specifications additionally control for urban/rural indicator.

Table 8: Cognitive abilities at age 3 and bilingual status, Sample of bilingual children (at least one parent is foreign immigrant)

	Bracken School Readiness			BAS-Naming Vocabulary		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV	OLS	OLS	IV
Foreign language vs mixed English and foreign$_{t-1}$	-0.576***	-0.095	0.063	-0.901***	-0.199**	-0.114
	(-5.20)	(-0.96)	(0.32)	(-9.48)	(-2.47)	(-0.61)
Child's age in months	0.014	0.024**	0.026***	-0.018*	-0.003	0.005
	(1.29)	(2.11)	(2.63)	(-1.82)	(-0.31)	(0.55)
Gross motor development delay$_{t-1}$		-0.190**	-0.148**		-0.225***	-0.200***
		(-2.24)	(-2.04)		(-2.60)	(-2.95)
Fine motor development delay$_{t-1}$		-0.081	-0.012		-0.127*	-0.042
		(-0.99)	(-0.17)		(-1.82)	(-0.63)
Communication gesture delay$_{t-1}$		-0.051	-0.003		-0.052	-0.039
		(-0.94)	(-0.06)		(-0.91)	(-0.85)
Weight		-0.099	-0.216		-0.106	-0.089
		(-0.42)	(-1.07)		(-0.56)	(-0.47)
Below 60% of the median UK household income$_{t-1}$		-0.143*	-0.113*		-0.109	-0.145**
		(-1.81)	(-1.67)		(-1.53)	(-2.29)
Male		-0.200***	-0.170***		-0.137**	-0.096**
		(-3.69)	(-3.53)		(-2.40)	(-2.13)
White		0.177*	0.320***		0.481***	0.587***
		(1.84)	(2.71)		(6.64)	(5.31)
Mother with higher degree		0.642***	0.572***		0.352**	0.345***
		(4.65)	(4.70)		(2.51)	(3.02)
Mother with first degree		0.636***	0.623***		0.520***	0.539***
		(5.60)	(6.27)		(4.93)	(5.78)
Mother with higher diploma		0.223	0.291**		0.352***	0.416***
		(1.57)	(2.49)		(3.13)	(3.80)
Mother with A-level		0.286**	0.296***		0.435***	0.441***
		(2.38)	(2.76)		(4.05)	(4.40)
Mother with O-level		0.092	0.096		0.148*	0.177**
		(1.04)	(1.15)		(1.70)	(2.26)
Mother with other degree		0.165	0.079		0.107	0.027
		(0.99)	(0.61)		(0.67)	(0.22)
Mother age		0.009	0.009*		0.013**	0.011**
		(1.52)	(1.65)		(2.40)	(2.21)
Married		-0.029	-0.073		0.050	0.011
		(-0.29)	(-0.91)		(0.61)	(0.14)
HH size		-0.104***	-0.071***		-0.083***	-0.055***
		(-4.15)	(-3.67)		(-4.23)	(-3.01)
Young migrant (mother or father arrived before age 10)		0.191***	0.231***		0.203***	0.203***
		(3.39)	(3.87)		(3.09)	(3.62)
Mother with non-English background		-0.104*	-0.099		-0.193***	-0.189***
		(-1.68)	(-1.46)		(-3.39)	(-2.98)
Importance of stimulating the baby$_{t-1}$		-0.029	-0.033		-0.035	-0.012
		(-0.54)	(-0.70)		(-0.62)	(-0.27)
Importance of talking to the baby$_{t-1}$		0.029	0.009		0.010	-0.024
		(0.35)	(0.12)		(0.14)	(-0.37)
Importance of cuddling the baby$_{t-1}$		-0.005	0.021		0.086	0.056
		(-0.07)	(0.30)		(1.11)	(0.87)
Importance of regular sleep/feeding time$_{t-1}$		-0.068**	-0.058*		-0.080*	-0.057*
		(-2.09)	(-1.77)		(-1.88)	(-1.85)
Strengths and Difficulties index (standardised)$_{t-1}$		-0.113***	-0.126***		-0.106***	-0.100***
		(-3.65)	(-4.87)		(-3.35)	(-4.13)
N	1381	1381	1381	1381	1381	1381
R^2	0.0684	0.2724	0.2787	0.1648	0.3543	0.3913
F-test first of excluded instruments:			25.92			25.92
Partial R^2			0.1343			0.1343
Sargan statistic overidentification test			5.039			2.104
p-value			0.6552			0.9538
Durbin-Wu-Hausman chi-sq test (p-value)			0.545			0.564

Notes: ***, ** and * denote significance at the 1%, 5% and 10% level respectively. Test scores are standardized. Specifications additionally control for urban/rural indicator.

Table 9: Cognitive abilities at age 5 and bilingual status, Sample of bilingual children (at least one parent is foreign immigrant)

	BAS-Picture Similarity			BAS-Pattern Construction			BAS-Naming Vocabulary		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	OLS	IV	OLS	OLS	IV	OLS	OLS	IV
Bilingual status$_{t-1}$	-0.174***	-0.004	0.141	-0.294***	0.054	0.298	-0.781***	-0.147*	0.073
	(-2.67)	(-0.05)	(0.70)	(-5.01)	(0.73)	(1.51)	(-8.72)	(-1.85)	(0.45)
Child's age in months	-0.015	-0.020*	-0.010	-0.053***	-0.059***	-0.059***	-0.002	-0.011	-0.006
	(-1.31)	(-1.77)	(-1.11)	(-5.48)	(-6.63)	(-6.74)	(-0.19)	(-1.44)	(-0.85)
Bracken school readiness$_{t-1}$		0.120***	0.144***		0.235***	0.221***		0.167***	0.189***
		(3.24)	(4.37)		(7.25)	(6.85)		(5.35)	(7.09)
BAS-Naming Vocabulary$_{t-1}$		0.091**	0.089**		0.122***	0.100***		0.348***	0.335***
		(2.43)	(2.43)		(3.47)	(2.80)		(10.49)	(11.38)
Below 60% of the median UK household income$_{t-1}$		0.023	0.005		0.053	0.076		-0.018	0.013
		(0.32)	(0.07)		(0.72)	(1.11)		(-0.30)	(0.23)
Male		0.074	-0.004		-0.055	-0.104**		0.078*	0.064
		(1.39)	(-0.08)		(-1.16)	(-2.09)		(1.71)	(1.55)
White		0.094	0.134		0.178**	0.327***		0.083	0.210**
		(1.11)	(1.05)		(2.00)	(2.63)		(1.02)	(2.04)
Mother with higher degree		-0.102	0.034		0.122	0.169		0.317**	0.283***
		(-0.70)	(0.27)		(0.78)	(1.34)		(2.28)	(2.70)
Mother with first degree		-0.280**	-0.187*		-0.026	0.078		0.229**	0.257***
		(-2.27)	(-1.87)		(-0.20)	(0.79)		(2.44)	(3.17)
Mother with higher diploma		-0.274*	-0.159		0.012	0.064		0.323***	0.325***
		(-1.89)	(-1.35)		(0.10)	(0.56)		(3.03)	(3.43)
Mother with A-level		-0.147	-0.040		0.234**	0.163		0.119	0.042
		(-1.12)	(-0.37)		(2.15)	(1.55)		(1.15)	(0.48)
Mother with O-level		-0.262**	-0.162*		-0.017	0.059		0.154**	0.166**
		(-2.35)	(-1.89)		(-0.16)	(0.71)		(2.14)	(2.39)
Mother with other degree		-0.161	0.001		0.054	0.230*		0.207*	0.183*
		(-0.99)	(0.01)		(0.38)	(1.86)		(1.81)	(1.79)
Mother age		-0.005	-0.003		0.001	-0.004		-0.001	0.001
		(-1.01)	(-0.68)		(0.12)	(-0.90)		(-0.12)	(0.34)
Married		0.084	0.017		0.166*	0.146*		0.029	0.000
		(1.20)	(0.23)		(1.79)	(1.93)		(0.36)	(0.01)
Frequency reading to the child$_{t-1}$		0.032	0.021		0.007	-0.004		0.058**	0.055***
		(1.10)	(0.84)		(0.24)	(-0.18)		(2.44)	(2.70)
Frequency taken to the library$_{t-1}$		0.017	0.031		-0.004	0.026		0.043	0.043
		(0.46)	(0.93)		(-0.09)	(0.80)		(1.30)	(1.59)
Young migrant (mother or father arrived before age 10)		-0.001	-0.003		0.045	0.077		0.082	0.122**
		(-0.02)	(-0.06)		(0.84)	(1.27)		(1.19)	(2.43)
Mother with non-English background		0.072	0.034		0.047	-0.019		-0.087*	-0.128**
		(1.14)	(0.47)		(0.69)	(-0.27)		(-1.83)	(-2.18)
Strengths and Difficulties index (standardised)$_{t-1}$		-0.152***	-0.103***		-0.111***	-0.112***		-0.104***	-0.078***
		(-5.02)	(-3.70)		(-3.60)	(-4.09)		(-3.46)	(-3.46)
N	1350	1350	1350	1350	1350	1350	1350	1350	1350
R2	0.0098	0.1133	0.1027	0.0451	0.2201	0.1911	0.1358	0.4552	0.4697
F-test first of excluded instruments:			34.570			34.570			34.570
Partial R2			0.175			0.175			0.175
Sargan statistic overidentification test			3.428			4.445			7.717
p-value			0.843			0.727			0.358
Durbin-Wu-Hausman chi-sq test (p-value)			0.543			0.286			0.150

Table 10: Cognitive abilities at age 7 and bilingual status, Sample of bilingual children (at least one parent is foreign immigrant)

	Word Reading Ability score			BAS-Pattern Construction			Maths		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS	OLS	IV	OLS	OLS	IV	OLS	OLS	IV
Bilingual status$_{t-1}$	-0.053	0.163**	0.785***	-0.274***	0.247***	0.558***	-0.273***	0.191**	0.528**
	(-0.80)	(2.29)	(3.64)	(-3.75)	(3.26)	(2.66)	(-3.33)	(2.30)	(2.39)
Child's age in months	0.031***	0.034***	0.033***	0.000	0.031***	0.028***	0.032***	0.035***	0.029***
	(2.91)	(3.59)	(3.87)	(0.03)	(3.16)	(3.36)	(2.95)	(3.54)	(3.35)
BAS-Picture Similarity$_{t-1}$		0.066**	0.065**		0.108***	0.101***		0.133***	0.130***
		(2.25)	(2.52)		(4.09)	(4.00)		(4.22)	(4.91)
BAS-Pattern Construction$_{t-1}$		0.183***	0.174***		0.463***	0.444***		0.239***	0.215***
		(6.39)	(6.54)		(16.45)	(17.14)		(6.54)	(7.89)
BAS-Naming Vocabulary$_{t-1}$		0.196***	0.234***		0.141***	0.152***		0.227***	0.260***
		(6.30)	(7.86)		(4.95)	(5.23)		(6.99)	(8.52)
Below 60% of the median UK household income$_{t-1}$		-0.121*	-0.177***		-0.087	-0.060		-0.142**	-0.141**
		(-1.86)	(-2.83)		(-1.33)	(-0.98)		(-2.00)	(-2.20)
Male		-0.022	-0.023		0.064	0.066		0.184***	0.210***
		(-0.41)	(-0.49)		(1.10)	(1.44)		(3.42)	(4.36)
White		-0.204***	0.009		0.190***	0.290***		-0.005	0.106
		(-3.02)	(0.08)		(2.70)	(2.87)		(-0.07)	(0.99)
Mother with higher degree		0.320***	0.338***		0.059	0.076		0.161	0.070
		(3.38)	(2.86)		(0.41)	(0.66)		(1.08)	(0.58)
Mother with first degree		0.165*	0.348***		0.143	0.309***		0.234**	0.297***
		(1.72)	(3.48)		(1.46)	(3.18)		(1.98)	(2.90)
Mother with higher diploma		-0.070	0.153		-0.070	0.074		-0.020	0.054
		(-0.63)	(1.31)		(-0.57)	(0.65)		(-0.16)	(0.45)
Mother with A-level		0.145	0.382***		-0.030	0.108		0.231*	0.293***
		(1.34)	(3.64)		(-0.29)	(1.06)		(1.67)	(2.72)
Mother with O-level		-0.036	0.108		-0.094	0.051		0.047	0.100
		(-0.46)	(1.26)		(-0.98)	(0.62)		(0.45)	(1.14)
Mother with other degree		-0.090	-0.036		-0.138	-0.061		0.088	0.177
		(-0.84)	(-0.34)		(-1.23)	(-0.58)		(0.62)	(1.60)
Mother age		0.004	0.007		0.001	0.006		0.008	0.013***
		(0.82)	(1.47)		(0.10)	(1.32)		(1.61)	(2.63)
Married		0.062	-0.028		0.028	0.030		0.048	0.022
		(0.79)	(-0.32)		(0.29)	(0.36)		(0.65)	(0.25)
Frequency taken to the library$_{t-1}$		0.051	0.036		-0.026	-0.012		0.039	-0.010
		(1.21)	(1.06)		(-0.74)	(-0.35)		(0.93)	(-0.29)
Frequency reading to the child$_{t-1}$		0.024	0.043		-0.020	-0.027		-0.005	0.025
		(0.65)	(1.20)		(-0.57)	(-0.76)		(-0.14)	(0.69)
Young migrant (mother or father arrived before age 10)		-0.094	0.003		0.004	0.061		0.041	0.072
		(-1.57)	(0.05)		(0.07)	(1.00)		(0.67)	(1.12)
Mother with non-English background		-0.114*	-0.165***		0.010	-0.023		-0.028	-0.074
		(-1.89)	(-2.59)		(0.17)	(-0.38)		(-0.43)	(-1.14)
Strengths and Difficulties index (standardised)$_{t-1}$		-0.154***	-0.152***		-0.040	-0.077***		-0.127***	-0.143***
		(-5.64)	(-5.76)		(-1.49)	(-2.99)		(-5.09)	(-5.26)
N	1306	1306	1306	1306	1306	1306	1306	1306	1306
R2	0.0103	0.2834	0.2486	0.0172	0.3888	0.3588	0.0257	0.3365	0.2981
F-test first of excluded instruments:			19.1			19.1			19.1
Partial R^2			0.1078			0.1078			0.1078
Sargan statistic overidentification test			8.270			5.695			2.435
p-value			0.309			0.576			0.932
Durbin-Wu-Hausman chi-sq test (p-value):			0.004			0.084			0.086

Table 11: Cognitive abilities at age 11 and bilingual status, Sample of bilingual children (at least one parent is foreign immigrant)

	Verbal similarity test		
	(1) OLS	(2) OLS	(3) IV
Bilingual child vs monolingual$_{t-1}$	-0.295***	-0.009	0.050
	(-2.96)	(-0.10)	(0.25)
Child's age in months	-0.008	-0.007	-0.007*
	(-1.43)	(-1.39)	(-1.69)
BAS-Word reading ability$_{t-1}$		0.151***	0.150***
		(4.06)	(4.67)
BAS-Pattern Construction$_{t-1}$		0.058	0.058**
		(1.56)	(2.08)
Maths test$_{t-1}$		0.106***	0.107***
		(3.14)	(3.42)
Below 60% of the median UK household income$_{t-1}$		-0.305***	-0.305***
		(-4.34)	(-4.38)
Male		0.107*	0.109**
		(1.91)	(2.16)
White		0.116	0.140
		(1.58)	(1.39)
Mother with higher degree		0.556***	0.560***
		(3.61)	(4.32)
Mother with first degree		0.402***	0.410***
		(3.30)	(4.15)
Mother with higher diploma		0.133	0.145
		(0.99)	(1.24)
Mother withA_level		0.235*	0.242**
		(1.73)	(2.18)
Mother with O_level		0.161	0.172*
		(1.56)	(1.89)
Mother with other degree		0.048	0.039
		(0.35)	(0.32)
Mother age		0.007	0.007
		(1.12)	(1.35)
Married		0.051	0.051
		(1.24)	(1.39)
Frequency reading to the child$_{t-1}$		0.040**	0.039**
		(2.30)	(2.43)
Frequency taken to the library$_{t-1}$		0.066	0.065*
		(1.61)	(1.71)
Young migrant (mother or father arrived before age 10)		-0.106	-0.095
		(-1.48)	(-1.44)
Mother with non-English background		-0.127**	-0.134**
		(-2.09)	(-2.18)
Strengths and Difficulties index (standardised)$_{t-1}$		-0.003	-0.004
		(-0.11)	(-0.12)
N	1238	1238	1238
R2	0.023	0.2563	0.5709
F-test first of excluded instruments:			21.87
Partial R^2			0.1274
Sargan statistic overidentification test			5.946
p-value			0.546
Durbin-Wu-Hausman chi-sq test (p-value):			0.755

Table 12: Value Added model estimates of cognitive score and bilingual status

	Static Estimates			Difference GMM	Levels and Difference SGMM		Levels GMM (proxy)
	Restricted value-added (perfect persistence, OLS)	Lagged value-added (no measurm. error, OLS)	Lagged value-added (with measurm. correction, 2SLS)	Differenced dynamic, Strictly Exogenous Inputs (GMM)	Predetermined Inputs, Constantly correlated Effects (GMM)	Predetermined Inputs, Uncorrelated Effects (GMM)	Predetermined Inputs, Uncorrelated Effects, Proxy, Weakly Stationary (GMM)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Bilingual status	0.298***	0.158***	0.216***	0.100	0.007	0.125***	0.220***
	(6.18)	(3.65)	(3.18)	(1.1)	(0.09)	(2.68)	(3.11)
Lagged achievement	-	0.509***	0.562***	0.160**	0.334***	0.392***	0.511***
		(27.24)	(22.82)	(2.42)	(5.65)	(6.83)	(6.91)
Child's age in months	0.009*	0.003	0.037***	0.011***	0.002	0.002	0.034***
	(1.74)	(0.66)	(4.57)	(4.51)	(0.34)	(0.38)	(4.1)
Frequency taken to the library	0.046*	0.083***	0.092***	0.091**	0.082*	0.092***	0.115***
	(1.78)	(3.56)	(2.61)	(2.05)	(1.92)	(3.84)	(3.29)
Frequency reading to the child	0.054***	0.016	-0.001	0.030	0.082***	0.033*	0.078***
	(3.06)	(1.01)	(-0.04)	(1.2)	(2.71)	(1.83)	(5.2)
Higher degree	0.022	0.294***	0.273**		0.396***	0.359***	0.192
	(0.35)	(4.55)	(2.56)		(4.04)	(4.82)	(1.61)
First degree	-0.097*	0.187***	0.297***		0.285***	0.255***	0.245**
	(-1.88)	(3.47)	(3.48)		(3.44)	(3.94)	(2.58)
Higher diploma	-0.091	0.083	0.082		0.140	0.125*	0.046
	(-1.56)	(1.33)	(0.85)		(1.59)	(1.78)	(0.44)
A-level	0.014	0.163***	0.273***		0.218***	0.198***	0.218***
	(0.25)	(2.84)	(3.11)		(3.10)	(3.17)	(2.28)
O-level	-0.052	0.003	-0.015		0.009	0.016	-0.068
	(-1.20)	(0.07)	(-0.21)		(0.17)	(0.34)	(-0.85)
Poverty	-0.006	-0.104***	-0.144**		-0.033	-0.127***	-0.188***
	(-0.15)	(-2.66)	(-2.32)		(-0.50)	(-3.06)	(-3.06)
N	2873	2873	2873	2873	2873	2873	2873
Hansen's J				41.99	59.61	80.42	13.21
				0.000	0.000	0.000	0.280

Notes: ***, ** and * denote significance at the 1%, 5% and 10% level respectively. Cells contain estimates for the main parameter and standard errors. Hansen's J represents the X^2 and associated p-values. Model (1) assumes perfect persistence in cognitive development and no or uncorrelated heterogeneity. Model (2) assumes no measurement error and no effects, model (3) assumes no effects and uncorrelated measurement errors across test scores. The difference strictly exogenous model (4) assumes no feedback effects (inputs: 1...T, score: 1...t-2). The predetermined input model (5) assumes effects have constant correlation with inputs (instruments: Δ Inputs: 1...t). The predetermined model with uncorrelated effects (6) assumes effects are uncorrelated with inputs (random effects). Model (7) assumes effects are uncorrelated with inputs (random effects) and scores are conditionally mean stationary (instruments: Inputs: 1...t; Δ Score: t-1).

Table 13: Determinants of speaking foreign language at home

	Probit	RE Probit	Wooldridge
Foreign language spoken at home$_{t-1}$	0.084***	0.055***	0.018**
	(0.010)	(0.012)	(0.008)
Linguistic distance	0.024***	0.024***	0.020***
	(0.003)	(0.003)	(0.003)
Foreign language spoken at home (0)	-	-	0.034***
	-	-	(0.005)
Child age	-0.013***	-0.013***	-0.010***
	(0.001)	(0.001)	(0.001)
Ever Lone parent	-0.002	-0.002	-0.006
	(0.014)	(0.014)	(0.012)
Male	-0.003	-0.0027	-0.002
	(0.005)	(0.005)	(0.004)
White child	-0.028***	-0.029***	-0.028***
	(0.006)	(0.008)	(0.007)
Birth weight	0.006***	0.006**	0.005**
	(0.002)	(0.002)	(0.002)
Mother's age at birth	-0.001***	-0.001***	-0.001***
	(0.000)	(0.001)	(0.001)
Young migrant (mother or father arrvived before age 10)	-0.034***	-0.032***	-0.027***
	(0.006)	(0.005)	(0.005)
Mother with non-English backgound	0.018***	0.021**	0.015**
	(0.006)	(0.008)	(0.007)
HH size	0.001	0.001	0.0004
	(0.001)	(0.001)	(0.001)
Below 60% of the median UK household income	0.061***	0.0481***	0.046***
	(0.008)	(0.006)	(0.007)
Higher degree	-0.011	-0.012	-0.013
	(0.010)	(0.012)	(0.011)
First degree	-0.022***	-0.025**	-0.024**
	(0.006)	(0.009)	(0.008)
Diplomas in Higher educ	-0.042***	-0.072***	-0.061***
	(0.005)	(0.015)	(0.013)
A-level	-0.015**	-0.018*	-0.017*
	(0.007)	(0.009)	(0.008)
O-level GCSE grades A-G	-0.037***	-0.042***	-0.036***
	(0.005)	(0.007)	(0.006)
Other academic qualf	-0.002	-0.002	-0.002
	(0.007)	(0.007)	(0.006)
rho		0.015	0.156
		(0.055)	(0.052)
log L	-1670.513	-1670.470	-1646.670
Likelihood-ratio test of rho=0		0.080	8.750
		0.386	0.002