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Initial Risk Matrix, Home Resources, Ability Development and Children's Achievement

Dorothea Blomeyer
Katja Coneus
Manfred Laucht
Friedhelm Pfeiffer

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Dorothea Blomeyer
ZI Mannheim

Katja Coneus
ZEW Mannheim

Manfred Laucht
ZI Mannheim and University of Potsdam

Friedhelm Pfeiffer
ZEW Mannheim, University of Mannheim and IZA

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

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ABSTRACT

Initial Risk Matrix, Home Resources, Ability Development and Children's Achievement*

This paper investigates the role of self-productivity and home resources in ability formation from infancy to adolescence. In addition, we study the complementarities between basic cognitive, motor and noncognitive abilities and social as well as academic achievement. Our data are taken from the Mannheim Study of Children at Risk (MARS), an epidemiological cohort study following the long-term outcome of early risk factors. Results indicate that initial risk conditions cumulate and that differences in basic abilities increase during development. Self-productivity rises in the developmental process and complementarities are evident. Noncognitive abilities promote cognitive abilities and social achievement. There is remarkable stability in the distribution of the economic and socio-emotional home resources during the early life cycle. This is presumably a major reason for the evolution of inequality in human development.

JEL Classification: D87, I12, I21, J13

Keywords: initial conditions, home resources, intelligence, persistence, social competencies, school achievement

Corresponding author:

Friedhelm Pfeiffer
Centre for European Economic Research
P.O. Box 103443
D-68034 Mannheim
E-mail: pfeiffer@zew.de

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1 Introduction

Economists and psychologists share a common interest in research on ability and health development (Heckman, 2007, 2008). Deep-seated skills are formed in a dynamic interactive process starting in early childhood, and research that is based on only a subset of relevant factors may contain some bias. The relationship between initial risk conditions (both from the organic and the psychosocial perspective) investments and ability development is analyzed to gain an understanding of competence formation in childhood.

Our contribution to this burgeoning multidisciplinary literature on individual development is twofold. First, we employ unique data from a developmental psychological approach to study economic models of ability formation for the first time. The data are taken from the Mannheim Study of Children at Risk (MARS[1]), an epidemiological cohort study that follows 384 children from birth to adulthood (Laucht et al., 1997, 2004). MARS provides detailed psychometric assessments and medical and psychological expert ratings on various child outcome measures. We utilize data from infancy to adolescence with variables on initial risk conditions, on basic cognitive and motor abilities as well as on persistence, a noncognitive ability. Second, we analyze the relationship between economic and socio-emotional home resources and the formation of basic abilities, and between these and the children's achievements in social and academic life. This should deepen the understanding of basic ability formation (Cunha and Heckman, 2007) in the early life cycle from both an economic and a psychological perspective.

There is a great deal of stability in the economic and socio-emotional home resources over time. This is presumably a major reason for the increase of inequality in development. Our findings are related to literature on the stability of personality traits in development (Mischel et al., 1988, among others). We contribute to this literature through the use of expert rather than maternal assessments of children's abilities in an economic framework. The stability of personality traits in development also seems to be in part the result of the stability of home resources. Disadvantages from adverse home environments cumulate during the developmental stages. In early childhood, the development of basic cognitive and motor abilities is hindered. This disadvantage continues, thus impairing noncognitive ability formation at school age. These children are again

[1] MARS has been derived from the German title: **MA**nnheimer **R**isikokinder **S**tudie.

hindered during the transition to a higher-track secondary school, when low economic home resources constitute an additional barrier.

2 MARS: Initial risk matrix, home resources, the development of basic abilities, and children's achievement

MARS aims at following infants at risk for later developmental disorders in order to examine the impact of initial adverse conditions on the probability of negative health and socio-economic outcomes (Laucht et al. 2004). It includes first-born infants, growing up with German-speaking parents in a West German urban conglomeration (the Rhine-Neckar region) of medium size. Infants were rated according to the degree of "organic" risk and the degree of "psychosocial" risk. Each risk factor was scaled as no risk, moderate risk or high risk. Organic risk factors include conditions such as preterm birth or neonatal complications, while psychosocial risk factors are defined as being born into adverse home environments such as parents of low education, early parenthood or parents with a mental disorder.

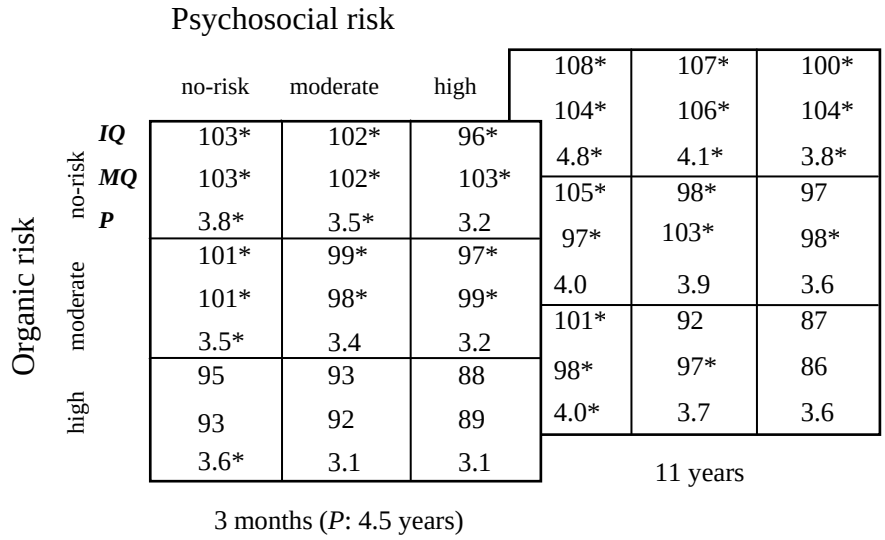
According to this rating, children were assigned to one of the nine groups resulting from the two-factor 3x3 design. All groups have about equal size with a slight oversampling in the high-risk combinations and with sex distributed evenly in all subgroups.[2]

Psychometric assessments of cognitive and motor abilities, standardized *IQ* and *MQ*, were conducted at infancy (3 month), toddlerhood (2), preschool age (4.5), elementary school age (8) and secondary school age (11 years), representing significant stages of child development (see Figure 1). Our main dimension of noncognitive abilities is related to goal shielding in the presence of distractors and obstacles, defined as *persistence*, *P*.

Assessments are based on behaviour observations, parent interviews and expert ratings also starting at the age of 3 months. In addition, information on social competencies and school achievement, such as social integration, autonomy, secondary school track and grades in math and German at primary school age are taken into account.

[2] The study was approved by the ethics committee of the University of Heidelberg and written informed consent was obtained from all participating families. Infants were recruited from two obstetric and six children's hospitals of the Rhine-Neckar Region in Germany. The details of the psychometric assessments of abilities, competences and home resources are presented in Blomeyer et al. (2008).

Figure 1: Basic abilities and risk matrix at 3 months and 11 years (means)



MARS, 364 observations; *IQ* and *MQ* are normalized to mean 100 and SD 15 in the normative group at each age; *P* varies between 1.0, 1.1, … (low persistence) and … 4.9, 5.0 (high persistence). * indicates the significance of differences relative to the highest-risk group at the 5 percent level.

Figure 1 summarizes the means of the three basic abilities *IQ*, *MQ* and *P* in the nine risk groups of MARS at the ages of 3 months and 11 years. Table 1 presents their first-order temporal correlations. In line with the literature on risk research (Kazdin et al., 1997) and previous findings from MARS, our results indicate that unfavorable consequences of initial organic and psychosocial risks persist until adolescence. Organic and psychosocial risks have cumulative effects.

Table 1: First order temporal correlations in abilities and home resources

	2 years/ 3 months	4.5 years/ 2 years	8 years/ 4.5 years	11 years/ 8 years
		Basic abilities		
IQ	0.34	0.72	0.74	0.81
MQ	0.35	0.63	0.53	0.60
P	0.03	0.42	0.59	0.64
		H: HOME score / Y: monthly net equivalence income per member [a]		
H	0.78	0.75	0.88	0.93
Y	0.82	0.86	0.77	0.79

MARS, 364 observations; [a] correlations from a regression model including a constant; all correlation coefficients are significant at the 5 percent level. * indicates the significance of differences relative to the highest-risk group at the 5 percent level.

There is a monotonic decrease in the *IQ* and the *MQ* in both risk dimensions with increasing differences between the ages of 3 months and 11 years. Organic and psychosocial risk factors exhibit equally negative effects, but are specific to the areas they affect. While psychosocial risks primarily influence cognitive and socio-emotional functioning, the impact of early organic risks concentrates on motor and cognitive functioning. Average *persistence* also decreases monotonically along the two risk dimensions. There is a 23 percent difference between the no-risk and the highest-risk group of children at the age of 4.5 years (3.8 vs. 3.1, see Figure 1).

Economic and socio-emotional home resources

There are two types of home resource variables by which the children were assessed in their early life cycle, summarized into socio-emotional categories, *H*, and the economic categories, measured with the monthly net equivalence income per household member, *Y*, in Figure 2 and Table 1. In MARS, the socio-emotional home resources were measured using the Home Observation for Measurement of the Environment, the HOME score (Bradley, 1989). The MARS ratings indicate a high longitudinal stability of both home resources (Table 1).

Figure 2: Home resources at 3 months and 11 years (means)

Psychosocial risk

Organic risk		3 months: no-risk	3 months: moderate	3 months: high	11 years: no-risk	11 years: moderate	11 years: high
no-risk	***H***	106*	102*	93	108*	105*	92
	Y	1,275*	1,122*	775	1,699*	1,632	1,256
moderate	***H***	105*	100	95	107*	99	92
	Y	1,293*	903	984	1,644*	1,325	1,325
high	***H***	106*	100*	94	106*	98	94
	Y	1,180*	927	863	1,806*	1,425	1,355

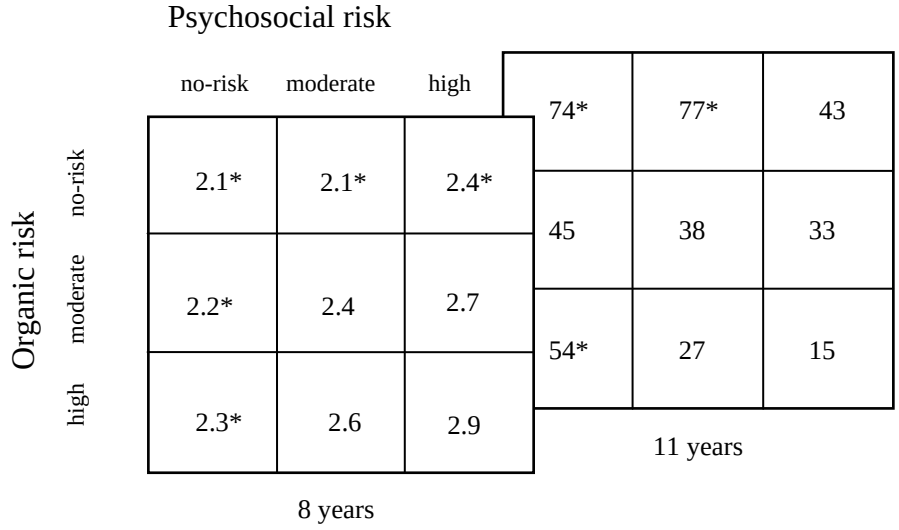
MARS, 364 observations; *H* normalized to mean 100 and SD 15 to facilitate comparison; *Y*: monthly net equivalence income per head in DEM (1 DEM = 0.51129 EUR). * indicates the significance of differences relative to the highest-risk group at the 5 percent level.

The socio-emotional measure of children's home resources declines steadily only along the psychosocial risk dimension (Figure 2). For the group of children with high psychosocial risk, the value of *Y* is on average 60 percent of the value for the no-risk group. The differences in average *H* in the cells of the risk matrix show a similar pattern, albeit not with the same magnitude. For the group of children with high psychosocial risk *H* is 87 percent compared to the no-risk group. The partial elasticity of *H* with respect to *Y* is an average of 0.07. If economic resources were doubled, *H* would be 7 percent higher.

Children's school achievement

On average 45 percent of the children in MARS attend a "Gymnasium", German higher-track school. For attending the *Gymnasium*, the initial risk matrix matters significantly, Figure 3.

Figure 3: Children's school achievement at age 8 and 11 years



MARS, 357 observations; grades in Germany vary from 1.0 (excellent), … to 6.0 (insufficient). * indicates the significance of differences relative to the highest-risk group at the 5 percent level. * indicates the significance of differences relative to the highest-risk group at the 5 percent level.

In the highest risk group, only 15 percent of the children attend the *Gymnasium* compared to 74 percent in the no-risk group. Average school attendance decreases (nearly) monotonically along the two dimensions of our risk design, with two exceptions observed for children born without any psychosocial risk and without any organic risk. In the first case, there seems to be no difference between the moderate and the high organic risk group and, in the second, between the no-risk and the moderate psychosocial

risk group. School choice takes place, as a rule, after the age of ten in Germany and grades are relevant for tracking (in Germany grades vary from 1, excellent, to 6, insufficient). School achievement at the age of eight years, measured as grades in *math*, confirm the importance of the initial risk conditions with the exceptions described above. Grades in the highest risk group are about one grade lower than grades in the no-risk group. A high psychosocial risk has the largest negative average effect.

3 Self-productivity, home resources, and the development of basic abilities

Self-productivity is an essential feature in the process of ability formation (Heckman, 2007). The concept postulates that abilities acquired at one stage in the development process enhance ability formation at later stages. Varied experience in early childhood thus lays the foundation for success or failure in school and for human capital formation in later life. The time-varying model of ability formation by Cunha and Heckman (2007) is summarized in equation (1).

$$\Theta_t = f_t\left(I_t, \Theta_{t-1}, E\right) \tag{1}$$

If the first derivative of the vector of abilities, Θ, in *t*, with respect to the vector of abilities in *t-1* is positive, it is said that this ability exhibits self-productivity. In the case of positive cross derivatives, there are synergies in the formation of these two abilities. For example, higher cognitive abilities may foster persistence and vice versa. Other factors responsible for ability formation and included in equation 1 are the initial conditions, *E*, and the economic and socio-emotional home resources, *I*.

In the following we discuss findings from econometric estimates of central parameters of the technology of ability formation (Figure 4). We focus on the relationship between basic abilities in *t* with *H* in period *t* and the stock of basic abilities available from period *t-1*. *Y* has been excluded because it is never significant in addition to *H*. Estimates were performed for the major stages of development. We assume that equation (1) can be represented in a Cobb-Douglas form. Taking the natural logarithm yields equation (2):

$$\theta_{t,i}^{j} = \alpha_{0,t}^{j,R} + \alpha_{t}^{h,j} \cdot h_{t,i} + \alpha_{t}^{j} \cdot \theta_{t-1,i}^{j} + \alpha_{t}^{k,j} \cdot \theta_{t-1,i}^{k} + \alpha_{t}^{l,j} \cdot \theta_{t-1,i}^{l} + \varepsilon_{t,i}^{j} \tag{2}$$

where *j, k, l* are indices for the three basic abilities *IQ, MQ* and *P*, and $i = 1, \ldots, N$ (=364) is an index for the children. The variable *R* contains all nine cells of the two-

dimensional risk matrix. All parameters can be interpreted as partial elasticity. Our estimation method is OLS (Figure 4). Alternative estimates are discussed in Blomeyer et al. (2008).

Our findings indicate that *H* is significantly related to ability formation at all developmental stages. However, the strength of the relationship differs between our three basic abilities and over time. The importance of home resources and self-productivity for ability formation changes in a way specific to the developmental stage. Basic cognitive and noncognitive abilities are strongly related to the socio-emotional home resources, while the basic motor ability is not. *P* is always significantly associated with *H*, with the estimated partial elasticity varying around 0.4. The *IQ* is positively related to *H* until the age of 4.5 years, with an estimated partial elasticity varying around 0.4. At school age, the elasticity falls to 0.18 and is no longer significant.

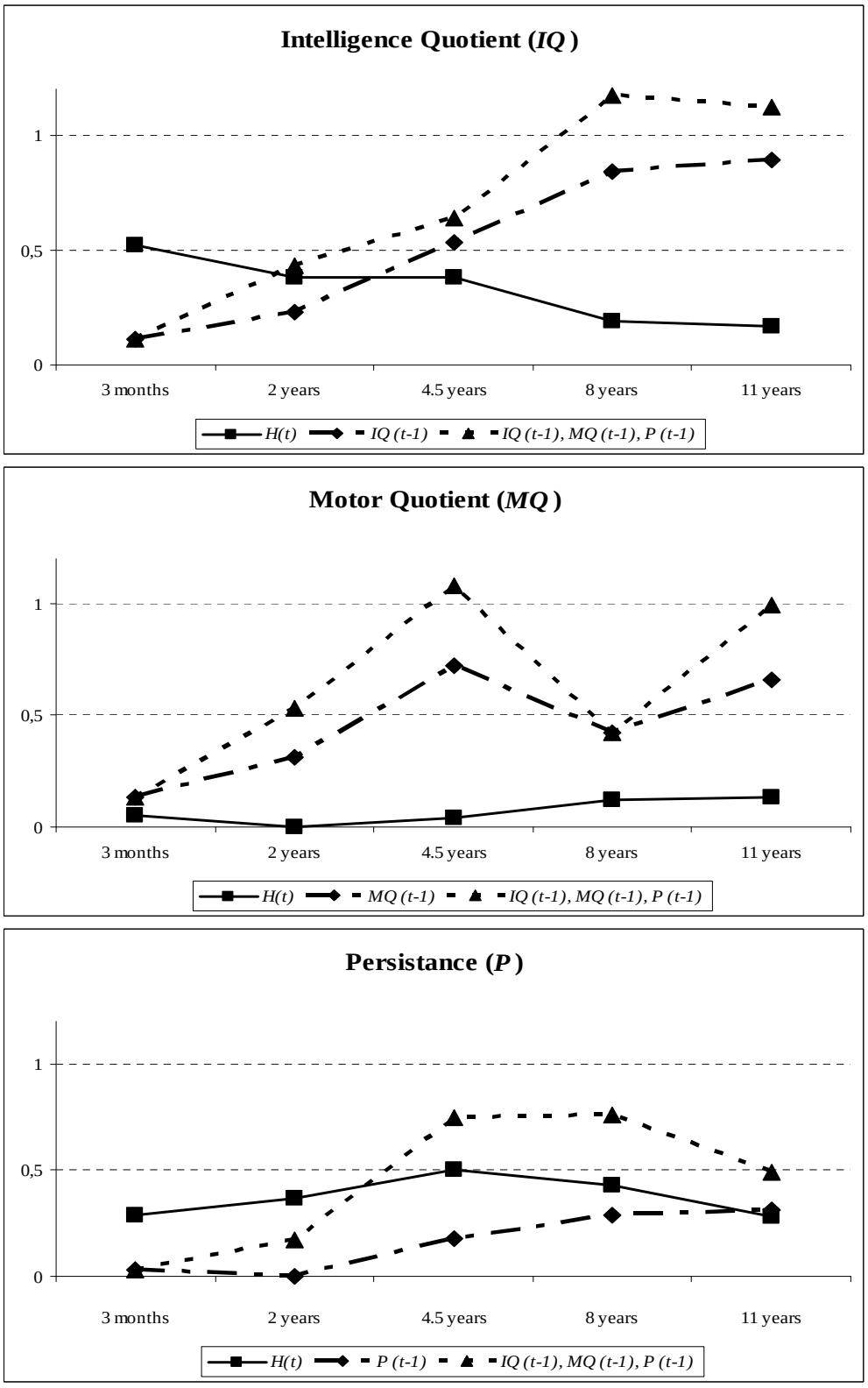
For the *IQ*, self-productivity estimated with the partial elasticity of the past and the current *IQ* increases steadily during development. At the age of eight and eleven years, the partial elasticity approaches 0.9, a value comparable with that of Cunha and Heckman (2008). Self-productivity of the *IQ* in MARS is smaller in early childhood. The importance of self-productivity for human capital formation from adolescence on highlights the role of inadequate home resources in early childhood (emphasized by Heckman, 2007, among others). Since *P* remains malleable during school age, self-productivity remains lower. We found evidence for synergies in ability formation among *P* and *IQ*.

4 Complementarities: Abilities as predictors of children's achievement

We discuss the findings from linear and non-linear regression models predicting social competencies and grades at primary school age and the attendance of higher-track secondary education after the age of 10 years, see Table 2.[3] All probit estimates for attending the *Gymnasium* include the stage-specific home resources *H* as well as *Y* and the cognitive, motor and noncognitive abilities measured at primary school age (8 years), several years before tracking takes place. In a further specification, the total *IQ* is split into verbal and non-verbal cognitive abilities. In addition, all available lags of the three abilities are included in the probit equation to reduce the bias from endogeneity.

[3] The presentations of results in the table focus on school achievement. All estimation results, including those for social competencies, are available in Blomeyer et al. (2008).

Figure 4: The partial elasticity of *H* and past abilities with current abilities



MARS, 364 observations, all variables in natural logarithm; coefficients from OLS regressions performed for each period, including a constant. At the 5-percent level, the coefficient of *H* is significant for all periods in the equation for *P*, for the periods 3 months, 2 and 4.5 years in the *IQ* equation and never significant in the *MQ* equation, for details see Blomeyer et al. (2008).

The *IQ*, the *MQ* and the *P* at primary school age are significantly related to the probability of attending the *Gymnasium*. The magnitude of *P* is lower compared to the *IQ* and higher compared to the *MQ*. Home resources increase the probability of attending the *Gymnasium*. *H* is as important as the *IQ*, and *Y* is also relevant. If the verbal and the non-verbal *IQ* are considered separately, the *NV-IQ* tends to be slightly more important than the *V-IQ*. Using all lags reduces some of the coefficients in the probit equation (Table 2). The reduction is worthy of mention even though it does not change our conclusions.

Table 2: Average marginal effects for the attendance of the *Gymnasium*

	average marginal probability, four specifications			
	IQ	add. lags [a)]	*NV-IQ /V-IQ*	add. lags [a)]
H (t)	0.82*	0.60*	0.90*	0.88*
Y (t)	0.15*	0.18*	0.16*	0.17*
IQ (t – 1)	1.03*	0.84*		
NV-IQ (t-1)			0.74*	0.57*
V-IQ (t-1)			0.51*	0.42*
MQ (t - 1)	0.37*	0.33*	0.36*	0.26
P (t - 1)	0.49*	0.38*	0.46*	0.38*
Pseudo R^2	0.29	0.32	0.29	0.31
Observations	357	357	357	357

MARS, [a)] the specification contains all available additional lags in abilities, albeit not reported here; these lags are jointly significant (LR-tests: 86.18*, 71.35*); * indicates significance at the 5 percent level.

5 Concluding remarks

Deep-seated abilities formed in early childhood have long-term implications for human development and personality. This paper contributes to uncovering the relationship between home resources and self-productivity during the development of basic abilities in childhood. We investigate complementarities between the basic abilities and children's achievement using data taken from MARS, an epidemiological cohort study from birth to adulthood.

Our findings demonstrate that socio-emotional home resources are significantly related to ability and personality formation at all developmental stages. The strength of the relationship differs between our three basic abilities and over time, which is in line with Heckman (2008). The importance of home resources and self-productivity for ability formation changes specific to the developmental stage. Basic cognitive and noncogni-

tive abilities are closely related to the socio-emotional home resources, while the basic motor ability is not. The initial inequality of abilities increases between the ages of 3 months and 11 years. Noncognitive abilities are positively associated with favourable home resources until school age, cognitive abilities until the age of 4.5 years. Basic abilities at primary school age and home resources combine to predict social competencies and school achievement at secondary school age.

Advantages from favourable home resources and disadvantages from poor home resources cumulate across development. Starting at risk and growing up in an unfavourable environment impedes the development of basic cognitive and motor abilities. The disadvantage continues during the early life cycle until school age, a stage that remains important for noncognitive ability formation. Disadvantaged children are impeded again when the transition to higher-track secondary school attendance takes place. At this stage, low economic resources create an additional barrier. Consequences for lifetime inequalities in Germany are discussed in Pfeiffer and Reuß (2008).

We regard our study as a starting point for research on competence formation and the significance of sensitive and critical investment periods. Future research based on economic models will focus on the wide range of parental care and their stage-specific relationship with personality and development.

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