# Three Essays on the Economics of Education and Inequality

PhD Thesis

**Author**: Sergey Alexeev
**Principal Supervisor**: Peter Siminski
**Supervisor**: Kentaro Tomoeda
**Supervisor**: Isa Hafalir
**Supervisor**: Olena Stavrunova

Economics Discipline Group, Business School
University of Technology Sydney

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# Abstract

This thesis consists of three independent essays, unified by the common theme of inequality and education.

Chapter 2 uses harmonized national panels for Australia, the United States and Germany to measure the role of home ownership on income inequality, polarization and intergenerational mobility. Australia stands out as the only country where home ownership drastically changes all three measures. The results of this paper provide strong reinforcement of the Canberra Group's (2001) recommendations to include all in-kind income sources for cross-country comparisons of income distributions.

Chapter 3 continues exploring the topic of intergenerational persistence of income. It uses auction theoretical modelling to demonstrate a flaw in the centralized college admission system. The development of the test-preparation industry makes marks less informative about the underlying skills of the applicants. This is mainly due to the strategic interaction of applicants that inflates the marks. This, in turn, complicates sorting under the centralized college admission system for highly competitive colleges or specializations.

Chapter 4 continues exploring the topic of education. It identifies a demand shock on one specific type of college graduates on the Russian labor market in the early 1990s. The shock changed the structure of employed professionals and technicians, influenced income inequality, and provides a parsimonious explanation for the behavior of the college wage premium in Russia from 1985 to 2015. The nature of the demand shock indicates that firms were deploying organizational technologies in response to a rapid desertion of central planning.

# Certificate of original authorship

I, Sergey Alexeev, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Business School at the University of Technology Sydney. This thesis is wholly my own work unless otherwise indicated in the references or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution. This research was supported by the Australian Government Research Training Program.

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# List of Abbreviations

| | |
|---|---|
| CCA | Centralized college admission |
| CES | Constant elasticity of substitution |
| CNEF | Cross National Equivalent File |
| HE | Higher education |
| HILDA | Household, Income and Labour Dynamics in Australia |
| IGC | Intergenerational correlation |
| IGE | Intergenerational elasticity |
| IR | Imputed rent |
| IRC | Intergenerational rank correlation |
| $\ell b$ | Law and business |
| $\overline{\ell b}$ | Except law and business |
| OECD | Organization for Economic Co-operation and Development |
| OLS | Ordinary least squares |
| PSID | Panel Study of Income Dynamics |
| QR | Quantile regression |
| RLMS | Russia Longitudinal Monitoring Survey |
| SBTC | Skill-Biased Technical Change |
| SOEP | German Socio-Economic Panel |
| STEM | Science, technology, engineering and mathematics |
| TP | Test-preparation |
| TSK | Test-specific knowledge |

# Chapter 1

# Introduction

This thesis comprises three independent essays, unified by the common theme of inequality and education.

Chapter 2 outlines a study in which harmonized national panels for Australia, the United States and Germany are used to measure the role of home ownership on income inequality, polarization and intergenerational mobility. The findings show that Australia is the only country in which home ownership drastically changes all three measures. The intergenerational rank correlation shows that accounting for home ownership drops the Australian measure of income mobility by 22.8%. Transition matrices are also used to show that values are more concentrated on the leading diagonal. Specifically, the lower tertile is 4% more concentrated on the leading diagonal, while the higher tertile is 5% more concentrated on the leading diagonal. Further, among elderly people, home ownership changes inequality by $-10.8\%$ and polarization by $-36.3\%$. Conversely, among working age individuals, home ownership changes inequality by 0.8% and polarization by $-14.4\%$. These results reinforce support for the Canberra Group's recommendations that all in-kind income sources should be included in cross country comparisons of income distributions (Canberra Group 2001, pp. 62–67).

Chapter 3 further explores the topic of the intergenerational persistence of

income. It is widely accepted in economics that an inclusive and universal system of education increases income mobility. However, it appears that the effects of commercial materials on college admission test marks have never been studied by economists. In Chapter 3, previous research on shadow education institutions (a collection of fee-based institutions that exist outside formal schooling institutions and are designed to enhance students' formal school careers) is considered. Research has shown that the college admission test-preparation (TP) industry and aggressive TP practices negatively affect the sorting properties of public systems of education and thus reduce mobility. These adverse effects are particularly conspicuous in relation to centralized college admission (CCA) systems in which a single high stake examination regulates the pool of jobs that individuals will be able to access in the future. In Chapter 3, auction theoretical modeling is used to study applicants' incentives and their college admission test-taking behavior. The results show that, as a result of the commercial TP industry, which is assumed to have accumulated unproductive test-specific knowledge (UTSK), some applicants are able to elevate their examination marks by complementing their skills; however, this makes applicants' examination marks less informative about applicants' underlying skills. The model further demonstrates that applicants who have more opportunities to access UTSK will make the rational decision to invest more heavily into TP schools (regardless of the fact that UTSK is unproductive and can not be used in future studies or labour market occupations) in order to increase their chances against less fortunate applicants who are unable to access UTSK. Such strategic interactions inflate the applicants' examination marks and, as a result, sorting is stable only for educational systems that do not include highly competitive colleges or specializations.

Chapter 4 continues to explore the topic of education. In Chapter 4, a study is undertaken to demonstrate a college wage premium differential between graduates of different specializations in the Russian labor market, produced by a

demand-side shock related to the major economic reforms of the early 1990s. The differential made law and business ($\ell b$) specializations more attractive, inducing a substantial change in the employment of professionals and technicians. It also had a defining effect on the returns of higher education (HE) from 1985 to 2015. Notably, the differential provides a parsimonious explanation for the relatively low college wage premium from 1994 to 1996 (aka the Market Adjustment Puzzle) and the decrease in the college wage premium from 1998 to 2008. The subsiding of the differential also coincided with a decrease in income inequality documented by other researchers. Finally, the differential suggests that firms have been deploying organizational technologies. The deployment was a response to the deliberately rapid desertion by policy makers of deeply entrenched practices of Soviet central planning during the transition period (i.e., "price shock therapy"). It is further hypothesized that an improper mix of skills contributed to the transformational recession. All of the discoveries are considered in relation to the literature on Skill-Biased Technical Change (SBTC) and are captured in a simple mathematical model.

This dissertation concludes with Chapter 5, in which the key findings are summarized and ideas for future areas of research are outlined.

# Chapter 2

# A Cross-Country Comparison of the Effects of Home Ownership on Income Mobility, Inequality and Polarization

The literature on the distribution of economic outcomes and opportunities is principally concerned with the comparison of distributions in quantitative terms across time and space. In its modern form, the literature is a branch of welfare economics; however, it derives much of its intellectual heritage from statistics. The subject is of interest as a discrete area of research, but can also be used to better understand economic growth, aggregate consumption, the occurrence and size of cyclical movements, or the intensity of violent conflicts. As recently discussed in the *Handbook of Income Distribution* (A. Atkinson and Bourguignon 2015), the most renowned measures in this area are income: (1) mobility; (2) inequality; and (3) polarization. All three are distinct, but have close analytical links.

The accepted practice is to use disposable income. The rarely mentioned problem with this practice is that using disposable income risks misinterpreting

the evolution of standards of living, because economic wellbeing is determined not only by the goods one can buy in the market, but also by sources of incomes that are in-kind (such as publicly provided health and education services) and non-monetary (such as imputed rents for owner-occupied accommodation and the consumption of one's own produce). For that reason, income measures that include in-kind and non-monetary sources of incomes are conceptually superior (A. B. Atkinson et al. 1970; Canberra Group 2001; Kravis 1962; Kuznets 1963; Lydall 1979; Sawyer and Wasserman 1976).

One component of non-monetary income that has particular quantitative significance is home ownership. One's home is not only a financial asset, but also a source of services that influences standards of living through various psychological and consumption benefits. Since those who do not own their accommodation have to pay rent to access similar services, and the fraction of homeowners differs across countries and within countries across time, ignoring these differences can produce time-series and cross-sectional comparability problems. One way to solve these problems is to assign a monetary value to home ownership. This hypothetical income stream is known as imputed rent (IR).

This is the first paper to use a dataset of IR values harmonized across countries to study the effects of home ownership on a broad measurements of the distribution of economic outcomes and opportunities. To do this, the paper utilizes the Cross National Equivalent File (CNEF), a dataset for cross-national comparisons that cross-links high-quality national microlevel datasets and which includes similarly calculated IR values for Australia, the United States and Germany. The results support the recommendations of the Canberra Group (2001) that all in-kind income sources should be included in such analyses.

Spearman rank correlation (Dahl and DeLeire 2008) shows that IR value substantially decreases intergenerational relative rank mobility in Australia (by 22.840%), whereas the effect on mobility in both America and Germany is neg-

ligible (2.030% and 3.704%, respectively). Home ownership defines a surprising amount of immobility in Australia. This result is statistically similar for all age groups. The results highlight a disturbing fact related to the Australian housing affordability crisis: it is highly unlikely that many of the young private renters affected by the crisis will ever be able to obtain the economic and social benefits provided by home ownership (Yates 2008, 2016). The decrease in mobility shows that the effects of this rental trap persist across generations.

Australian tertile transition matrices further confirm the decreasing effects of home ownership on intergenerational mobility. Specifically, the results show that children from the poorest households are less likely (4.128%) to move into the higher tertile, children from middle-income households are the least affected (0.654%), and children from the richest household are less likely (5.106%) to move into the lowest tertile. It appears that possessing private property provides a level of insurance for one's children against poverty.

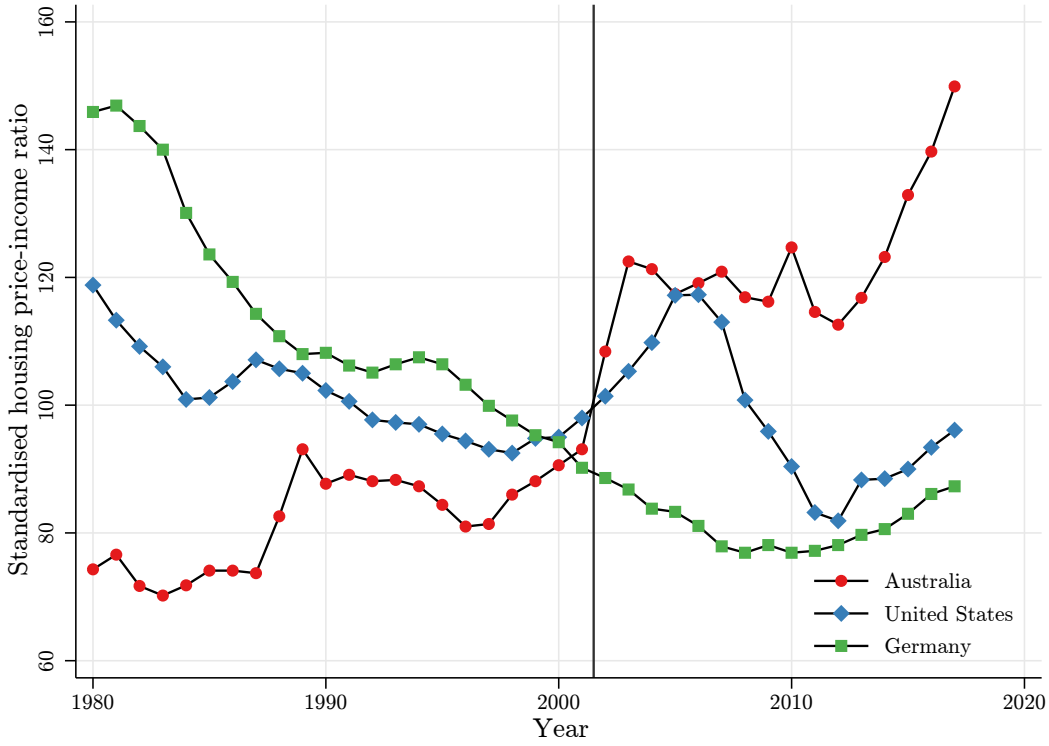
The Gini coefficient shows that IR values have a slightly decreasing effect on income inequality in Australia (–2.348%), a marginally increasing effect in the United States (0.563%), and a borderline effect in Germany (–0.133%). Further, looking at the results for various age groups shows the following: the general direction of the home ownership effect across various age groups is similar across all countries; that is, it decreases among individuals in the elder age group (aged 60+) and increases among individuals in both the pre-working (aged 0–15) and working age groups (aged 15–60). However, in Australia, the effect produces a staggering drop in inequality among individuals in the elder age group (–10.847%), and slightly aggravates inequality among individuals in the pre-working age (3.871%) and working age groups (0.767%). The Australian inequality outcome is driven exclusively by people in the elder age group. Australia is also the only country in which inequality for individuals in the elder age group is much higher than for individuals in the working age groups (29.513%); however, the IR value halves this difference (14.820%). Thus, home ownership

represents a means of providing for the elderly in Australia, but not in Germany, as the inequality among Germans in the elder age group is even lower than the inequality among Germans in the working age group, while IR value has a trivial effect on this difference (–0.735%).

It appears that a rational force drives the unusually high home ownership rates among elderly Australians. In Germany, the public pension system is universal; whereas, in Australia, the Commonwealth-funded age pension is selective and is paid only if a recipient is able to prove an absence of assets or income. In Australia, however, homes are exempted from the asset test and thus have become a device for hiding income or income generating assets. For example, an Australian pensioner whose only asset is their home will receive the Commonwealth-funded pension; however, if that home is traded for cash or other assets, the Commonwealth-funded pension will be canceled. Similarly, to become eligible to receive the Commonwealth-funded pension, a pensioner with cash or assets can purchase a house. It could be that the absence of a universal governmental pension induces inequality among elderly people, who rationally respond by accumulating assets that they are encouraged to buy. This may have contributed to Australia's housing affordability crisis, which began in the early 2000s. In relation to the institutional environment, Figure 2.1 shows the profound increase in housing prices in Australia.

The income polarization index shows that Australia is the most polarized society on average and across all age groups (with the exception of the elder age group in which the United States takes the lead). However, IR value substantially depolarizes income in Australia (–17.742%). Conversely, in America the income depolarization is only marginal (–2.408%), and in Germany it is nonexistent (0.000%). An analysis across age groups shows that the Australian results were driven by the elder age group (–36.281%) and the working age group (–14.370%). Thus, IR value has a negative effect on inequality and polarization among individuals in the elder age group, but increases inequality

Figure 2.1: House prices to income ratios during 1980–2017: Australia, United States, Germany




*Notes:* Nominal house prices divided by nominal disposable income per head. Net household disposable income is used. The long-term average is calculated over the whole period. This value is used as a reference value. The ratio is calculated by dividing the indicator source on this long-term average, and indexed to a reference value equal to 100. The vertical line separates 2001 and 2002 – a drastic increase in housing prices in Australia.
*Source:* OECD (2019).

and decreases polarization among those in the working age group. Home ownership makes income groups substantially less diverse and makes the Australian "middle class" more noticeable.

A drop in intergenerational mobility and a decrease in income clustering among individuals in the working age group suggests that owning property is a unique and distinct feature of the well-established, middle-class Australian household (in the sense that not only is an individual, but also their posterity, noticeably better off).

The reminder of this chapter is structured as follows: Section 2.2 describes the methodology adopted by this study; Section 2.3 sets out the data; Section 2.4 presents the results of the research; and Section 2.5 outlines the con-

clusions that can be drawn from this research.

## 2.1 Literature review

Intergenerational income mobility provides insight into the origins of the distribution of economic outcomes and measures the degree to which children's economic opportunities depend on their parents' economic outcomes. In its modern form, research in this area first began in the mid-1980s with the work of Becker and Tomes (1986). Recently, due to the availability of high-quality datasets, astonishing progress has been made in this area, as exemplified by the work of Chetty et al. (2014), who analyzed 40 million children measured 17 years after their respective parents. Cross-country comparison research shows that mobility is low in countries with high levels of inequality, such as Italy, the United Kingdom and the United States, and is much larger in northern European countries that have more even levels of income distribution (Corak 2013). The Great Gatsby Curve illustrates the connection between the concentration of income in one generation and the ability of those in the next generation to move further up the economic ladder (Krueger 2012). We also know that intergenerational income persistence is greatest in the upper tail of income distributions; however, the United States stands out due to the particularly high likelihood that children of the poorest parents will remain the poorest members of society (Jantti et al. 2006). Further, research has shown that inclusive and universal education (Pekkarinen et al. 2009) and strong social security systems (Bratsberg et al. 2007) increase mobility.

The comparison of income inequality across countries and over time has a rich heritage of being studied in relation to understanding economic outcomes. Indeed, hundreds of researchers have examined income inequality and its effects. Historically, it was of considerable interest to Smith (Book I, Chapter X, 1827), and of even greater interest to Pareto, who in 1897 examined data from the

tax returns of several nations across four centuries and concluded that income inequality is stable over time and locations (Persky 1992). Pareto contends that the distribution of income reflects a natural distribution of abilities among individuals. It was only after considerable debate, as summarized by Bresciani-Turroni (1939), that the notion of "natural" income inequality was disproved. Consequently, modern understandings of income inequality are almost in a diametric opposition to Pareto's law. Kuznets (1955) was the first to offer a novel conceptualization of inequality. He regards inequality as a product of economic growth and thus sees it as being related to economic policy. There is nothing natural about inequality; like growth, it is influenced by public choice. As for empirical evidence, the United States has had the highest level of disposable income inequality since the end of the 1990s, while countries in northern and central parts of European have had the lowest. No universal tendency in income inequality has been seen since the 1970s across OECD countries; however, public governmental benefits affect both levels of, and changes in, inequality. Recently, understandings of inequality have been further enhanced by the research of Piketty (2014), who scrutinized the dynamics of top income earners. He claims that the fundamental dynamics of capitalism create a strong tendency towards the greater inequality of income and dynasties of income, and that both will continue unless this tendency is mitigated by the enactment of appropriate policies (e.g., income tax policies).

Income polarization is a more recent measure of economic outcomes. This measure identifies the degree of within-group similarity and between-group disparity, and characterizes the degree to which the population is segregated into groups. Thus, it captures the phenomena of "a diminishing middle class" or "a divided society" (Chakravarty 2009). Empirical research has shown that income polarization is often a strong predictor of many observed outcomes, including those that have been traditionally linked to inequality. Notably, income polarization has been shown to be a strong predictor of violent conflicts (e.g.,

Montalvo and Reynal-Querol 2005), disparities in individuals' health (e.g., Pérez and Ramos 2010) and economic growth (e.g., Keefer and Knack 2002). Income polarization has often been studied in relation to inequality (e.g., Duclos, Esteban, et al. 2004; Wang and Wan 2015) and has been compared across time and/or countries (e.g., Chakravarty and D'Ambrosio 2010). Research in the last two areas has shown that rapid economic development may increase income polarization without increasing income inequality. In addition, income is unequal but relatively unpolarized in Canada, Australia and the United States; whereas, in the Czech Republic income is equal but highly polarized.

International comparisons of the distribution of economic outcomes and opportunities are highly dependent on the definition of incomes. Researchers have been aware of this issue since Kravis (1962) and Kuznets (1963) and it has been the subject of increasing attention since the mid-1970s (A. B. Atkinson et al. 1970; Lydall 1979; Sawyer and Wasserman 1976). All three of the discussed measures are clearly affected by monetary income and non-monetary or in-kind income components. Countries differ vastly with respect to personal asset ownership (an important factor in cross-country comparisons). One component of non-monetary income that has a particular quantitative significance is imputed rent from owner-occupied housing. IR refers to income received if an owned property is assumed to be rented out and captures the "intensity" of home ownership (therefore, the influence of the inclusion of IR value in the measure of income I would refer to as the effect of home ownership).

In as early as 1968, the United Nations argued in favor of capturing IR from owner-occupied housing in national account statistics for international comparisons and later issued formal guidelines for capturing this data (United Nations 1977). The first report by the Expert Group on Household Income Statistics argued that IR (and other in-kind income sources) should be included as a major income component of disposable income (Canberra Group 2001). More recently, the Stiglitz-Sen-Fitoussi Commission recommended that material

living standards be considered when measuring economic performance (Stiglitz et al. 2009).

The dissimilarities of home ownership (understood as the influence of inclusion of IR value into the measure of income) have already been extensively explored in relation to income inequality. D. Lerman and R. Lerman (1986) note that IR is more equally distributed than monetary income, thus it reduces inequality. The inclusion of IR, therefore, reduces aggregate inequality. Similarly, Smeeding et al. (1993) show a leveling effect on inequality in the Netherlands, Germany, Canada and Sweden. Yates (1994) documents a slight decrease in income inequality in Australia. Buckley and Gurenko (1997) find that IR softens negative consequences of transition in Russia, while Torrey et al. (1999) find similar results for the Czech Republic, Hungary and Poland. Gasparini and Sosa Escudero (2004) show that IR induces a decrease in inequality in Argentina. Additionally, Saunders and Siminski (2005) demonstrate that IR has an unambiguous smoothing effect on income distribution in Australia; and, similarly, Frick, Grabka, et al. (2010) show that IR values decrease poverty and income inequality in Germany, the United States and the United Kingdom. Onrubia et al. (2009) conclude that the inclusion of IR into the measure income measures evaluated at market prices rather than cadastral values (i.e. values calculated for tax purpose) deepens income inequality in Spain. Eurostat (2010) reports on the poverty reducing effects of IR in most European Union countries. T. I. Garner and Short (2009) report that in the United States the impact of IR on inequality is either negligible or marginally increasing; and, more recently, Frick, Goebel, et al. (2014) find poverty and inequality reductions in France, Finland and Denmark after accounting for IR.

The emerging consensus of the literature review above is that the impact of IR on income inequality depends on the population share of owner-occupiers and housing price patterns. The estimation results are sensitive to the methods of calculating IR, and finding a harmonized method for the calculation of IR

represents a major issue for producers and analysts of cross-nationally comparative income data.

## 2.2 Methodology

### 2.2.1 Measuring rent

As recently discussed by Balcázar et al. (2017), the task of assigning a rental value to homeowners and recipients of subsidized housing is hard, and there is no consensus on what methods are preferred and under what circumstances. The authors highlight the following rent-imputation techniques.

The most up-front method to impute rents is to simply ask dwelling residents to estimate how much they would pay if they were renting their home (e.g. Fessler et al. 2016). Subsidized tenants, by the analogy, are asked for an assessment of what the market rent would be if their rent payments were not subsidized, and IR is then understood as the difference between actual rent paid and self-assessed market rent. This self-assessment approach assumes that residents are honest and well-informed about the value of their dwelling and the amount they would have to pay to rent a home of similar quality and location attributes. In reality, the personal affinity of homeowners to their property, known as "owner pride factor", may distort their estimate, especially for long-time homeowners. With interviewer help or in regions where rental markets are active and thick, this approach to IR may work well.

Another common method, especially in situations where the rental market is thick and the share of market tenants is not small, is to employ a hedonic regression (e.g. Hill 2013). Researchers regress rental payment actually paid on a dwelling's observables using a sample of rental dwellings and predict rental value out of sample. Rental payment actually paid can be taken from the household budget survey or real estate agencies. Unfortunately, there is no consensus about the form of this function and about the best way to estimate it. A valid model for one market is often misspecified for another. Semi- or non- parametric forms help to recognize idiosyncratic data features, including non-linearities, but ignore self-selection, and spatial dependency, and suffer the

curse of dimensionality.

Finally, there are rent-to-value and user-cost methods. Here, rather than solely reling on the information regarding rents, the researchers combine the information on the value of the property with outside sources.

In the user-cost method, IR is calculate from net home equity: the current market value of owner occupied housing as estimated by the homeowner, deducting (depending on the availability of the information) the operating costs related to home ownership (e.g. insurance, mortgage interests, mortgage payments, maintenance, repairs, property tax rates and expected appreciation) (e.g. T. Garner et al. 2007). Information on the market value of the home may also be obtained from external statistics. For example, regional and county-level housing prices could be constructed to estimate the current home value. If the resulting value of net home equity is positive, IR is calculated on the basis of this value and an exogenous capitalisation rate (usually an inflation rate plus a safe private market rate of return). Otherwise, IR is assigned a value of zero.

The rent-to-value method is similar to the user-cost method, however, the capitalisation rate is calculated as the value of gross imputed owner occupied rent derived from National Accounts divided by the gross value of the owner occupied housing stock (e.g. Heston and Nakamura 2009).

The advantage of the rent-to-value and user-cost methods is that they allow for negative values of IR in cases where housing prices fall after the collapse of a housing bubble. The limitation is that the same rate is applied to all households despite differences of dwellings' characteristics. Furthermore, both methods again assume that residents are well informed about the value of their dwelling, which is often untrue due to lack of knowledge of ongoing market prices and personal attachments to the dwelling. For example, it is known that IR calculated this way could be higher than that based on a hedonic model and this difference positively correlates with the home ownership tenure (Gonzalez-Navarro and Quintana-Domeque 2009).

The primary components of the analysis are two distributions of economic outcomes. The distribution excludes IR value and is denoted by $Y^{\overline{r}} \in \mathbb{R}^n$, where $n$ is the number of observations. The second distribution includes IR value and is denoted by $Y^r \in \mathbb{R}^n$. Inequality and polarization analyses were undertaken by examining the differences between these two distributions. Intergenerational mobility analyses were undertaken by examining how the two distributions of an individual's economic outcomes are related to the two income distributions of their parents (denoted $X^r$ and $X^{\overline{r}}$).

### 2.2.2 Mobility

In relation to intergenerational mobility, the basic components are two joint distributions, where $X$ is the income of parents and $Y$ is that of children. The first joint distribution excludes an IR value and is denoted by $(X^{\overline{r}}, Y^{\overline{r}}) \in \mathbb{R}^m$, where $m \leq n$ is the number of respondents matched to their parents. The second joint distribution includes an IR value and is denoted by $(X^r, Y^r) \in \mathbb{R}^m$. The most straightforward way to capture the association between $X$ and $Y$ is with the slope coefficient from an ordinary least squares (OLS) linear regression:

$$\ln Y_i^{\mathbb{I}} = \beta_0^{\mathbb{I}} + \beta_1^{\mathbb{I}} \ln X_i^{\mathbb{I}} + \boldsymbol{\Gamma}^{\mathbb{I}} \boldsymbol{V}_i + \varepsilon_i \qquad \mathbb{I} \in \{\overline{r}, r\}. \tag{2.1}$$

The key estimate $\beta_1^{\mathbb{I}}$ is known as intergenerational elasticity (IGE) of income. Controls include the ages of parents and children in a quadratic form and the gender of the children. Age controls are included to account for differences in mean income over age, since incomes are measured over a range of ages for both parents and children. The gender dummy variable accounts for the earnings gap between men and women. Given the key estimate, it is possible to obtain an alternative measure, known as the Pearson (product moment) intergenerational

correlation (IGC):

$$IGC^{\mathbb{I}}(\ln Y_i^{\mathbb{I}}, \ln X_i^{\mathbb{I}}) = IGE^{\mathbb{I}} \frac{\sigma(\ln X_i^{\mathbb{I}})}{\sigma(\ln Y_i^{\mathbb{I}})} \qquad \mathbb{I} \in \{\overline{r}, r\}. \tag{2.2}$$

Here $\sigma(\cdot)$ stands for standard deviation. From this, one can Hart's (1976) index of mobility $H^{\mathbb{I}} = 1 - IGC^{\mathbb{I}}$ [1], the most often used index in the intergenerational mobility context. The index ranges from $-1$ and 1 ($H^{\mathbb{I}} = 0$ in the case of complete immobility).

It should be noted that IGC is IGE after factoring out the cross-sectional dispersion of log earnings in $X$ and $Y$. Conversely, IGE can be higher in one society than in another simply because the variance of log earnings in the child's generation is higher in that society.[2]

Black and Devereux (2011, p. 1490) contend that one measure should not be seen as dominating another; however, unlike IGC, IGE has the practical advantage of not being biased by a classical measurement error in $Y$ and thus is often easier to estimate with real-world data. Jäntti and Jenkins (2015, p. 839) are of the view that the wide employment of IGE is surprising and that its use is related to the inertia of researchers. They argue that the changes in relative position are at the core of the mobility problem; however, IGE and IGC (or $H$) reflect changes in relative position and changes in wage structures. For example, a perfect linear relationship between $Y$ and $X$ ($IGC = 1$, $H = 0$) could, in theory, be driven exclusively by income growth and unchanged ranks. Using the example of Eberharter (2013), they also show that IGC is more suitable than IGE when undertaking cross-national comparisons.

Differences in marginal distributions (of the joint distribution $(X, Y)$ introduced in the beginning of this section) can be fully controlled by employing the Spearman intergenerational rank correlation (IRC). Dahl and DeLeire (2008)

[1] See A. Shorrocks (1992) for a detailed discussion of the properties of this index.

[2] This is related to the fact that the correlation is bounded between 0 and 1 while the elasticity, in principle, could be greater than 1 and would, for example, equal 2 if people from families who were 10% apart in generation 0 were 20% apart in generation 1.

provided an axiomatic characterization of IRC as a measure of mobility, thus extending it beyond a mere "statistical" index that takes a distribution and returns a real number. To measure IRC, let $R_i$ denote the child $i$'s percentile rank in the income distribution of children within their birth cohorts and let $P_i$ denote parent $i$'s percentile rank in the income distribution of parents. The regression of a child's rank $R_i$ on their parents' rank $P_i$, controlling for parents' quadratic age and a child's gender, yields the following regression coefficient:

$$IRC^{\mathbb{I}} = Corr(P_i^{\mathbb{I}}, R_i^{\mathbb{I}}) \qquad \mathbb{I} \in \{\overline{r}, r\}. \tag{2.3}$$

This measure fully controls the change in marginal distributions, as both $P^{\mathbb{I}}$ and $R^{\mathbb{I}}$ have standard uniform distributions.

An apparent advantage of a single-valued mobility index is its capacity for partial rankings that identify general mobility trends in different countries. However, after demonstrating that IR does play an exceptional role in Australia, this paper provides a more detailed characterization of the joint distribution $(X^{\overline{r}}, Y^{\overline{r}})$ and $(X^r, Y^r)$ in $3 \times 3$ transition matrices $A^r$ and $A^{\overline{r}}$:

$$Y^{\mathbb{I}} = X^{\mathbb{I}} \times A^{\mathbb{I}} \qquad \mathbb{I} \in \{\overline{r}, r\}. \tag{2.4}$$

This is another standard tool in the mobility literature (Jäntti and Jenkins 2015, p. 823), which allows the nature of mobility and how it changes after the inclusion of IR into the measure of income to be studied more precisely, but prevents the simple partial ordering of countries.[3]

[3]Strictly speaking, there is a whole class of mobility indices based on transition matrices; e.g., Normalized Trace Measure (A. F. Shorrocks 1978), that captures the sum of the transition proportions on the leading diagonal, or Average Jump Index (Grimm 1974), that captures the number of income class boundaries crossed by an individual (whether upward or downward), averaged over all individuals. All these measures have been calculated and they do reinforce the main conclusions of this paper. They are not reported for expositional efficiency and can be requested from the author.

### 2.2.3 Inequality and polarization

In relation to inequality and polarization, the two primary distributions (introduced at the beginning of this section) form the basic components of the analysis; that is, one distribution of income excluding IR values, denoted by $Y^{\overline{r}} \in \mathbb{R}^n$, where $n \geq m$ is the number of observations, and another distribution of income including IR values, denoted by $Y^r \in \mathbb{R}^n$. Inequality and polarization outcomes are produced for both the distributions by applying a polarization index developed by Esteban and Ray (1994):

$$E_\alpha^{\mathbb{I}}(Y^{\mathbb{I}}) = \frac{1}{2\mu^{\mathbb{I}}} \sum_{i=1}^{n} \sum_{j=1}^{n} |y_i^{\mathbb{I}} - y_j^{\mathbb{I}}|(\pi_i^{\mathbb{I}})^{1+\alpha} \pi_j^{\mathbb{I}} \qquad \mathbb{I} \in \{\overline{r}, r\}. \tag{2.5}$$

In the index, $\alpha$ represents a polarization sensitivity factor, $y^{\mathbb{I}}$ represents the individual value of $Y^{\mathbb{I}}$ normalized by twice its mean value, and $\pi$ represents the proportion of individuals with two or more observations with the same value multiplied by cross-sectional weights (neglected in the formula for expositional purposes). Thus, the number of income groups are equal to the number of distinct values of $Y^{\mathbb{I}}$.

When $\alpha = 0$, the index yields a sample weighted Gini coefficient. When $\alpha > 0$, the index captures the clustering of $Y^{\mathbb{I}}$ around income groups. The index implicitly assumes that members of the same income group identify with each other, while members of different income groups feel alienated from one another. Thus, the greater the level of clustering, or the greater the number of income groups, the greater the level of polarization.

Polarization differs from inequality, as the importance of polarity or (group) homogeneity carries weight, as does the importance of heterogeneity across individuals. Increased distances among individuals of different groups increase both inequality and polarization. Increased bunching among individuals of the same group decreases inequality but raises polarization (Duclos and Taptué 2015, p. 304).

### 2.2.4 Axiomatic foundation of polarization

Index of polarization (2.5) were formulated in Duclos, Esteban, et al. (2004) and Esteban and Ray (1994) by positing a collection of axioms whose consequences should be reflected in a polarization measure. The axioms are founded upon a so-called Identification-Alienation nexus wherein notions of polarization are fostered jointly by an agent's sense of increasing within-group identity and between-group distance or alienation. The four axioms may be loosely summarized as follows:

**Axiom 2.1.** *A mean preserving reduction in the spread of a distribution cannot increase polarization.*

**Axiom 2.2.** *Mean preserving reductions in the spread of sub-distributions at the extremes of a density cannot reduce polarization.*

**Axiom 2.3.** *Separation of two sub-densities towards the extremes of the distributions range must increase polarization.*

**Axiom 2.4.** *Polarization measures should be population-size invariant.*

The expression (2.5) satisfies Identification-Alienation nexus for $\alpha \in [0, 1.6]$

## 2.3 Dataset

To address the research question posed by this paper (i.e., the role of home ownership on income inequality, polarization and intergenerational mobility across countries), two samples need to be constructed; one for intergenerational mobility and another for polarization and inequality. The construction of the polarization and inequality sample is relatively undemanding, as it only has to be representative of the population being studied for one year. The construction of the intergenerational mobility sample is more challenging, as it has to include the sample of parents' income; to this end, the panel data has to be sufficiently lengthy (and large in order to survive inevitable attrition). Finally, the IR values have to be calculated in a similar fashion.

The CNEF versions of the national datasets comprise comparable data for variables across countries, and notably code household structures identically (Frick, Jenkings, et al. 2007). CNEF datasets are available for 10 countries; however, only the following three panels satisfy the aforementioned criteria: the Household, Income and Labour Dynamics in Australia (HILDA) (waves 2001–2017), the United States's Panel Study of Income Dynamics (PSID) (waves 1991–2007), and the German Socio-Economic Panel (SOEP) (waves 1990–2006).[4]

SOEP and PSID first commence in 1984 and 1968, respectively; however, so that the datasets can match the younger Australian panel, SOEP and PSID datasets are narrowed to cover only a 17-year period. Unfortunately, PSID does not report IR values after 2007; thus, I use the waves 1991-2007 of the American panel. SOEP is also shifted back to 1990–2006, even though the 2014 wave is the last wave to contain an IR value. This is done to deal with the SOEP sampling rule: the number of children that can be matched to their parents decreases substantially the further away one moves from the first year data because, in SOEP, only members of the first wave and their offspring are followed. At the

[4]The Swiss dataset includes an IR value, but has to be excluded, as it is too small for an intergenerational mobility analysis.

same time, it is impossible to include data from before 1990, as Eastern German households are excluded prior to that year (Wagner et al. 2007).

### 2.3.1 Imputed rent in three countries

In PSID, the IR is constructed with the user-cost method. The current market value of owner occupied housing is estimated by the homeowners personally, and outstanding credits, such as mortgages, are deducted from the estimated market value. If the resulting value is positive, an IR is calculated on the basis of this value and an interest rate of 6%.

In HILDA, the approach is similar, but the interest rate is 4%. In addition, HILDA calculates rental income for public housing and rent-free tenants by using the census rental values from an external program generated from census tables for 2001, 2006 or 2011, or imputed equal intervals between the same cells in the intervening non-census years. For public housing, IR refers to the difference between the rent paid and the typical rent for housing in that area; typical rent is taken from census rental data and accounts for dwelling type, the number of bedrooms, the state and the section of the state. In relation to rent-free housing, IR is defined as the rent that individuals would need to pay to rent a similar property in the same location; if that rent is not reported by the individual, the census rental data is substituted accounting for dwelling type, the number of bedrooms, the state and the section of the state. Hypothetically, it is possible to assign an IR of zero to Australian public housing and rent-free tenants to match the PSID methodology, but, unfortunately, the CNEF version of HILDA does not report the type of dwelling.

In SOEP, the rent is imputed using a hedonic regression. The gross rent per square meter (not including heating) actually paid by main tenants in privately financed housing (excluding social housing and households with reduced rent) is regressed on indicators describing the condition of the house, year of

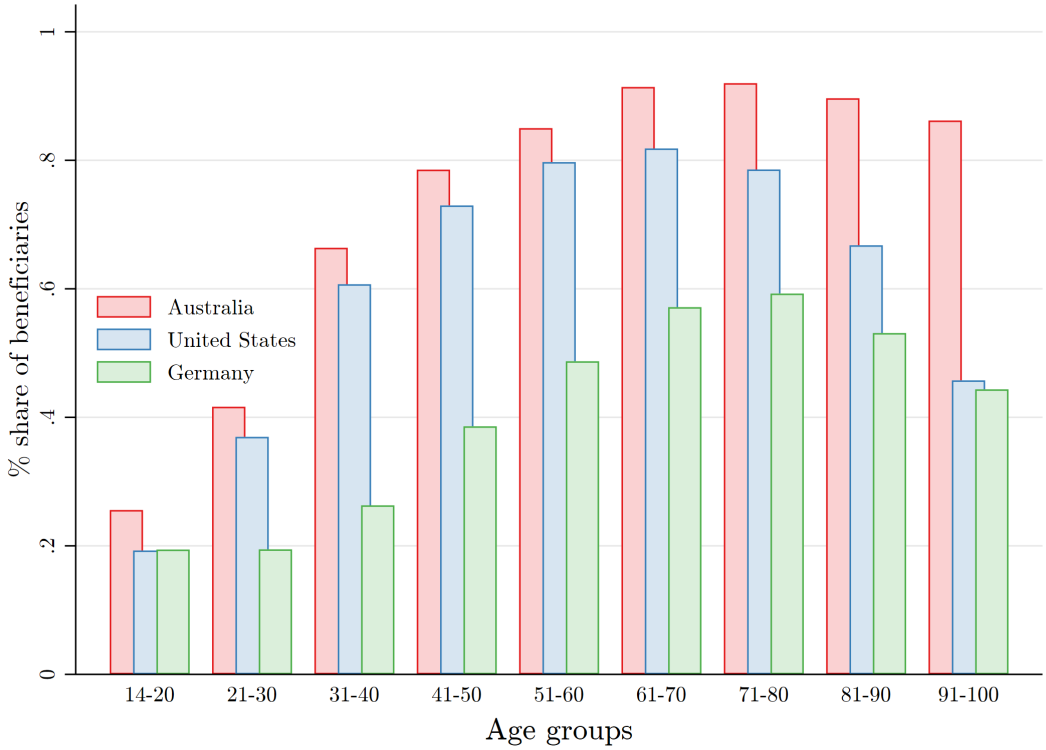
construction, size of dwelling, length of occupancy, community size and disposable income. Then coefficients are applied to owner occupiers and those living in households with reduced rent, such as employer provided flats, social housing or rent-free households. The resulting estimate represents a gross value at market prices (without costs for heating and warm water); therefore, for owner occupiers, owner-specific costs for taxation, maintenance and operating costs, as well as interest on mortgages, are deducted yielding a net value which can be interpreted as IR. For rent-free households and persons living in households with below market rents, no further deductions have to be made.

Figure 2.2 shows the share of the population in each country that enjoys a positive IR by age groups. Noticeable cross-country differences are evident. A larger fraction of Australian households of all age groups enjoy positive IR. Some of this Australian peculiarity unmistakably comes from the fact that HILDA custodians use external data to impute rents for public-housing and rent-free dwellers. But the general manner of unequal allocation of home ownership across countries suggests that inclusion of IR into income measures will have a nontrivial influence on income distribution statistics, which may matter for cross-country comparisons. The existing literature, as discussed in the Introduction, confirms the presence of this influence.

Another noticeable feature is that the fraction of people with positive IR does not decrease for elder age groups in Australia. In fact, the difference between the number of home owners in Australia vs. the number of home owners in the United States and Germany increases along the "Age groups" axis (i.e. the height of the red bar relative to the blue and green bars is increasing).

Figure 2.3 shows the share of the population in Australia that enjoys a positive IR by age and birth cohorts. It shows, for example, that 83% of 45 year old Australians born in 1951-1960 are the beneficiaries of IR, however, only 72% of those born in 1971-1980 are. Evidently, the beneficiaries of IR might not only differ by location and age group, but also by birth cohort.

Figure 2.2: Home ownership: Australia, United States, Germany




*Notes:* Share of respondents with positive household IR value by age group.
*Source:* HILDA 2001–2017, PSID 1991–2007, SOEP 1990–2006.

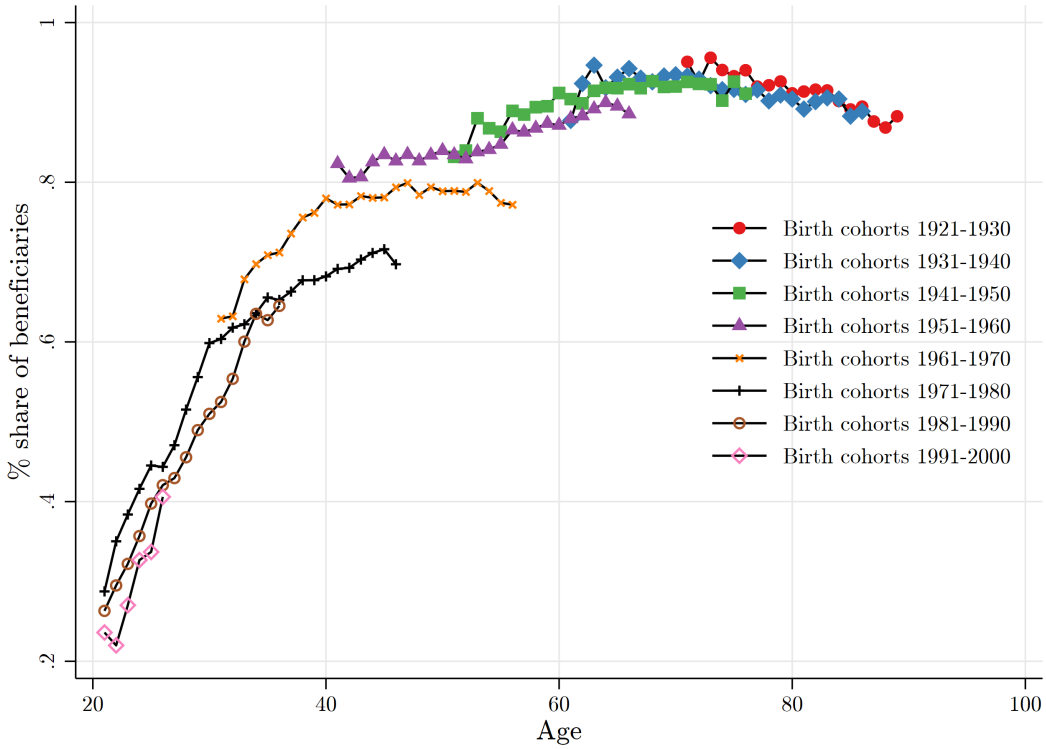
Beneficiaries of non-monetary income from housing differ between countries and within countries across both age groups and birth cohorts. Therefore, IR's inclusion into the measure of income can change the results of intergenerational income mobility for a particular country and for cross-sectional comparisons of countries.

The variable $X^{\overline{r}}$ represents household post-government income (henceforth referred to as income), which refers to the sum of all recorded sources of family income from labor earnings, asset flows, private transfers, private pensions, public transfers and social security pensions, minus total household taxes. The original PSID does not include income derived from non-refundable tax credits (the Earned Income Tax Credit, or EITC) or near-cash benefit income in the form of food stamps (now called the Supplemental Nutrition Assistance Program, or SNAP). CNEF uses the National Bureau of Economic Research TAXSIM

model (Feenberg and Coutts 1993) to simulate taxes to derive a harmonized income. Similarly, due to incomplete reporting, Schwarze (1995) methods are used to simulate the tax burden of SOEP.

$X^r$ represents a household post-government income plus household IR value (henceforth referred to as the +IR value). Household IR values for HILDA and PSID are calculated based on the market value approach and correspond to a percentage of the difference between the house market value and the remaining mortgage principal. In relation to public-housing tenants, IR refers to the difference between the rent paid and the typical rent for housing in that area (census rental data is used that considers dwelling type, the number of bedrooms, the state and the section of the state). In relation to rent-free housing, IR is defined as the rent that individuals would need to pay to rent the property. If IR is unknown, the census rental data is substituted. The census rental values are taken

Figure 2.3: Home ownership by cohorts: Australia

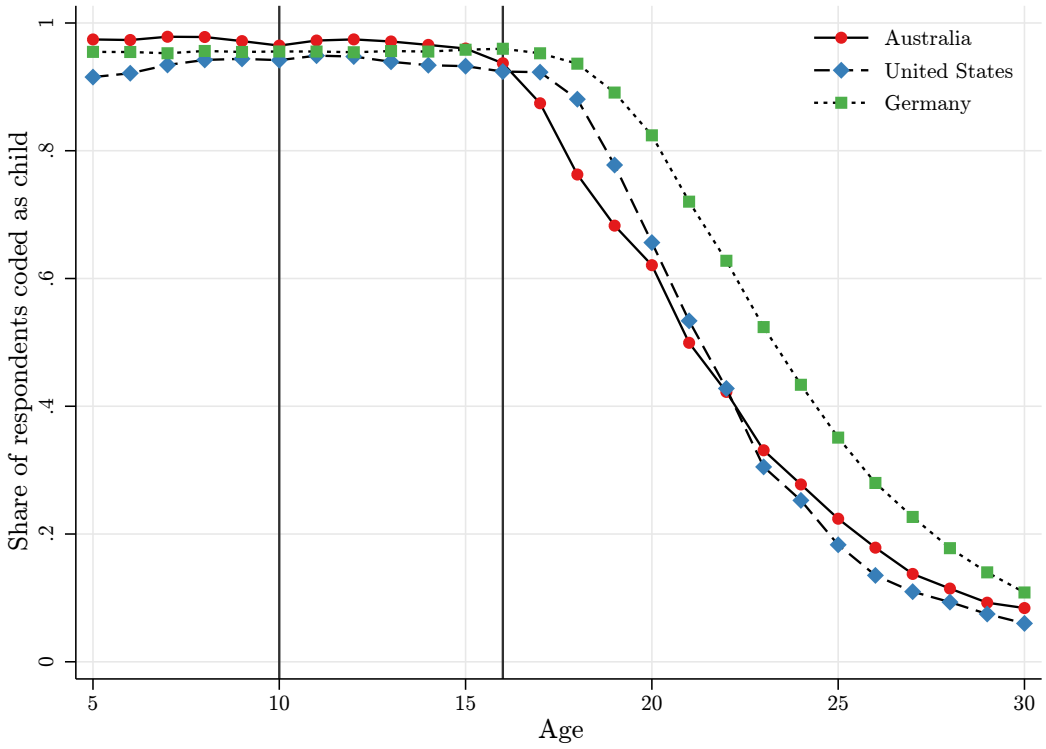



*Notes:* Share of respondents with positive household IR value by birth cohort group and by age. Sample restricted to household head and partner.
*Source:* HILDA 2001–2017.

from an external program that uses census tables to generate these values and imputes equal intervals between the same cells for the intervening non-census years. Medians by state, survey year and time of tenure are substituted for missing data in the public-housing and rent-free groups. Household IR values for SOEP data are based on an opportunity cost approach. At the microlevel, this approach yields information equivalent to that given by the market value approach (Lillard et al. 2015).

To ensure continuity with other studies, the construction of the intergenerational mobility sample adopts the recommendations of Jäntti and Jenkins (2015, p. 892). The sample comprises respondents who were first coded as a "household child" when they were aged 10–16 in the first wave and were then followed until the last wave. The cohorts are as follows: Australia, 1985–1991; the United States, 1975–1981; and Germany 1974–1980. As Figure 2.4 shows,

Figure 2.4: Share of respondents living with parents




*Notes:* Mobility sample consists of children living with their parents at age 10 to 16.
*Source:* HILDA 2001–2005, PSID 1991–1995, SOEP 1990–1994.

including children aged over 16 in the first wave compromises the representativeness of the sample, as a noticeable portion of children began to leave their households at this age.

Children and their parents are matched using the CNEF household member identifier (i.e., head, partner, child, relative, nonrelative). The parents are identified as the head and the partner of a household to which the children are matched.

Table 2.1 shows the attrition rates for the three datasets. The accumulated attrition rate is the highest for the German panel, but lower for the American panel, and lower still for the Australian panel. The sample is also limited to respondents who have become a household head or a partner (i.e., respondents who do not live with their parents). One of the challenges of the intergenerational mobility literature is that permanent, lifetime income is not observed. The income that is observed has a transitory component that behaves differently depending on age (i.e. life-cycle bias). The accepted practice is to use the income data when the child and the parent achieve their highest income potential (late 30s or early 40s in developed economies), as this is when the transitory component is most similar to classical measurement errors (Grawe 2006). In this case, the concern is the attenuation bias, which can be alleviated by averaging income over several years. To reduce the life-cycle bias, the children's income is observed at the latest age available and averaged over the last two available years. To reduce the attenuation bias, the parents' income is averaged over the first five available years. To control for inflation, the parents income is adjusted for inflation.

The final comment is on families with step-parents. A recent study by Murray et al. (2018) on intergenerational income persistence in Australia matches children to their biological parents. Conversely, the present study considers households led by a child's parent per the CNEF identifier. Thus, this study works with the actual resources available to the child. Also, note that house-

Table 2.1: Attrition rates

| | Australia | | | | United States | | | | Germany | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HILDA wave | Full sample | Born 1985-91 | Attrition rate | PSID wave | Full sample | Born 1975-81 | Attrition rate | SOEP wave | Full sample | Born 1974-80 | Attrition rate |
| 2001 | 19,914 | 2,146 | | 1991 | 19,962 | 2,307 | | 1990 | 17,653 | 1,645 | |
| 2002 | 18,295 | 1,866 | -13.05% | 1992 | 20,334 | 2,192 | -4.98% | 1991 | 17,280 | 1,566 | -4.80% |
| 2003 | 17,690 | 1,733 | -19.25% | 1993 | 21,450 | 2,073 | -10.14% | 1992 | 16,976 | 1,515 | -7.90% |
| 2004 | 17,209 | 1,629 | -24.09% | 1994 | 23,622 | 2,008 | -12.96% | 1993 | 16,690 | 1,452 | -11.73% |
| 2005 | 17,467 | 1,636 | -23.77% | 1995 | 23,184 | 1,914 | -17.04% | 1994 | 16,992 | 1,363 | -17.14% |
| 2006 | 17,453 | 1,578 | -26.47% | 1996 | 23,060 | 1,779 | -22.89% | 1995 | 17,423 | 1,281 | -22.13% |
| 2007 | 17,280 | 1,521 | -29.12% | 1997 | 19,132 | 1,290 | -44.08% | 1996 | 17,022 | 1,219 | -25.90% |
| 2008 | 17,144 | 1,455 | -32.20% | | | N/A | | 1997 | 16,676 | 1,136 | -30.94% |
| 2009 | 17,632 | 1,458 | -32.06% | 1999 | 19,669 | 1,182 | -48.76% | 1998 | 18,318 | 1,069 | -35.02% |
| 2010 | 17,855 | 1,434 | -33.18% | | | N/A | | 1999 | 17,605 | 983 | -40.24% |
| 2011 | 23,415 | 1,383 | -35.55% | 2001 | 20,538 | 1,151 | -50.11% | 2000 | 30,779 | 905 | -44.98% |
| 2012 | 23,182 | 1,334 | -37.84% | | | N/A | | 2001 | 27,799 | 834 | -49.30% |
| 2013 | 23,299 | 1,282 | -40.26% | 2003 | 21,277 | 1,163 | -49.59% | 2002 | 29,650 | 745 | -54.71% |
| 2014 | 23,113 | 1,246 | -41.94% | | | N/A | | 2003 | 27,886 | 692 | -57.93% |
| 2015 | 23,303 | 1,225 | -42.92% | 2005 | 21,686 | 1,096 | -52.49% | 2004 | 27,034 | 645 | -60.79% |
| 2016 | 23,504 | 1,195 | -44.32% | | | N/A | | 2005 | 25,875 | 602 | -63.40% |
| 2017 | 23,415 | 1,153 | -46.27% | 2007 | 20,873 | 1,088 | -52.84% | 2006 | 27,677 | 559 | -66.02% |

*Source:* HILDA 2001–2017, PSID 1991–2007, SOEP 1990–2006.

Table 2.2: Descriptive statistics: intergenerational mobility sample

| | N | Mean | S.D | Min | 0.25 | Med | 0.75 | Max |
|---|---|---|---|---|---|---|---|---|
| | | | | Australia | | | | |
| Parent's IR value | 924 | 14191 | 16740 | 0 | 4505 | 10568 | 18066 | 172136 |
| Parent's income | 924 | 97867 | 53468 | -220362 | 64739 | 91447 | 120202 | 456222 |
| + Parent's IR value | 924 | 112077 | 58252 | -48226 | 73122 | 102871 | 137254 | 503922 |
| Parent's age | 924 | 42 | 5.6 | 24 | 39 | 42 | 46 | 66 |
| Child's IR value | 924 | 5044 | 8838 | 0 | 0 | 1009 | 7215 | 76000 |
| Child's income | 924 | 87864 | 42756 | 0 | 58490 | 82663 | 109981 | 351741 |
| + Child's IR value | 924 | 92908 | 46302 | 0 | 61361 | 86426 | 116537 | 372641 |
| Child's age | 924 | 29 | 2 | 26 | 27 | 29 | 31 | 32 |
| Female | 924 | 0.53 | 0.5 | 0 | 0 | 1 | 1 | 1 |
| | | | | United States | | | | |
| Parent's IR value | 947 | 3500 | 5372 | 0 | 185 | 1888 | 4482 | 62771 |
| Parent's income | 947 | 58391 | 42574 | 7310 | 34417 | 52777 | 74343 | 630339 |
| + Parent's IR value | 947 | 61891 | 45981 | 7310 | 35447 | 55296 | 79659 | 693110 |
| Parent's age | 947 | 44 | 5.6 | 30 | 40 | 43 | 47 | 61 |
| Child's IR value | 947 | 1339 | 2931 | 0 | 0 | 0 | 1395 | 30000 |
| Child's income | 947 | 42604 | 36302 | 210 | 23203 | 36385 | 55809 | 752863 |
| + Child's IR value | 947 | 43943 | 37709 | 210 | 23702 | 36978 | 57434 | 764563 |
| Child's age | 947 | 28 | 1.8 | 26 | 27 | 28 | 30 | 32 |
| Female | 947 | 0.55 | 0.5 | 0 | 0 | 1 | 1 | 1 |
| | | | | Germany | | | | |
| Parent's IR Value | 410 | 521 | 929 | -1.1 | -0.5 | 0 | 820 | 7035 |
| Parent's income | 410 | 35468 | 19767 | 7450 | 21821 | 32133 | 43088 | 184183 |
| + Parent's IR Value | 410 | 36200 | 20243 | 7449 | 21842 | 32349 | 44127 | 190588 |
| Parent's age | 410 | 47 | 5.9 | 31 | 43 | 47 | 51 | 65 |
| Child's IR Value | 410 | 590 | 1423 | 0 | 0 | 0 | 0 | 9822 |
| Child's income | 410 | 26485 | 13080 | 4170 | 17953 | 25467 | 32764 | 92614 |
| + Child's IR Value | 410 | 27075 | 13501 | 4359 | 18133 | 25598 | 34099 | 102436 |
| Child's age | 410 | 29 | 2 | 26 | 27 | 29 | 31 | 32 |
| Female | 410 | 0.56 | 0.5 | 0 | 0 | 1 | 1 | 1 |

*Notes:* Income is disposable. Parent and Child's income are averaged for 5 years (e.g. 2001-2005 for HILDA) and 2 years (e.g. 2016-2017 for HILDA), respectively.
*Source:* HILDA 2001–2017, PSID 1991–2007, SOEP 1990–2006.

hold post-government income includes potential child support from a biological parent who does not live with the child in the same household. This matching approach takes advantage of the CNEF's unified coding of household structure. However, as discussed by Jäntti and Jenkins (2015, p. 892), and as the register data works of Björklund and Chadwick (2003), Holmlund et al. (2011) and Björklund et al. (2007) show, the results are relatively insensitive to the definition of a "family".

Table 2.2 sets out the descriptive statistics for the mobility sample. Notably, the share of parents' IR values in relation to parents' income is 14.5% in Australia. Conversely, it is 6% and 1.5% in the United States and Germany, respectively. In relation to children, the share is 5.7% in Australia, 3.1% in the United States and 2.2% in Germany.

The last waves (i.e. HILDA 2017, PSID 2007, SOEP 2006) are used as inequality and polarization measurements. Table 2.3 sets out the descriptive statistics for these measurements. To ensure continuity with previous studies, this sample uses income that is equivalized by the square root of the household size. The income equivalisation is also done because "income receivers" is the household, as we work with a household income and household IR. A similar unique data feature can also be detected in this sample. The share of the IR value in equivalized income is 16.4% in Australia, and 9.4% and 4.6% in the United States and Germany, respectively.

Table 2.3: Descriptive statistics: inequality and polarization sample

| | N | Mean | S.D | Min | 0.25 | Med | 0.75 | Max |
|---|---|---|---|---|---|---|---|---|
| | | | | Australia | | | | |
| IR value | 23415 | 9546 | 13471 | 0 | 0 | 5460 | 13859 | 221230 |
| Income | 23415 | 58345 | 41762 | -39700 | 34523 | 49959 | 71813 | 957626 |
| +IR value | 23415 | 67892 | 47204 | -39700 | 40023 | 57969 | 82437 | 1200000 |
| HH members | 23415 | 3.2 | 1.5 | 1 | 2 | 3 | 4 | 10 |
| | | | | United States | | | | |
| IR value | 20873 | 2987 | 6570 | 0 | 0 | 540 | 3464 | 246073 |
| Income | 20873 | 31738 | 38293 | -33625 | 14057 | 24179 | 38712 | 1000000 |
| +IR value | 20873 | 34725 | 41683 | -29965 | 14863 | 25861 | 42524 | 1100000 |
| HH members | 20873 | 3.5 | 1.6 | 1 | 2 | 3 | 4 | 10 |
| | | | | Germany | | | | |
| IR value | 27677 | 1087 | 1772 | 0 | 0 | 0 | 1826 | 26391 |
| Income | 27677 | 23425 | 25323 | 0 | 14228 | 19596 | 27674 | 2000000 |
| +IR value | 27677 | 24512 | 25801 | 0 | 14919 | 20608 | 28988 | 2000000 |
| HH members | 27677 | 3 | 1.4 | 1 | 2 | 3 | 4 | 13 |

*Notes:* Income is disposable and equivalized.
*Source:* HILDA 2017, PSID 2007, SOEP 2006.

## 2.4 Results

### 2.4.1 Mobility

Table 2.4 reports on IGE (Equation (2.1)), IGC (Equation (2.2)) and IRC (Equation (2.3)). In addition to the main sample (which comprises individuals aged 26–32), Table 2.4 also reports the estimates for the cohorts recently analyzed by Murray et al. (2018) in Australia. In their paper, Murray et al. (2018) use HILDA for the period 2001–2015 to follow individuals from 1984–1986 cohorts until they were aged 30–32. Their approach mimics that of Chetty et al. (2014), who use American tax returns for the period 1996–2012 to follow individuals aged 14–16 in the first year of the dataset. To reduce the discussed in the methodology section left-side life-cycle bias (Haider and Solon 2006) on a rather short dataset, Murray et al. (2018) focus on respondents aged 15–17 in the first wave and 30–32 in the last wave. For CNEF disposable household income averaged over three years, they report an IGE of 0.240 and IRC of 0.219.

When the same cohorts are examined, the results of this study are similar to those found by Murray et al. (2018); albeit, IRC estimates are slightly smaller when the next cohort is observed at a similar age. The differences in the results may be due to different estimates being used for different cohorts or to the life-cycle bias, which arises because the observations used by the present study are for children considerably younger than those in Murray et al.'s (2018) study. Notably, the main results do not appear to be sensitive to which cohort is used.

The decreasing effect related to the inclusion of younger children in the Australian estimates is also observed in another recent work on Australian intergenerational income persistence by Deutscher and Mazumder (2019, Figure 3), who uses Australian tax income data from 1991 to 2015 and focuses on cohorts from 1978 to 1982. Again, adopting the approach of Chetty et al. (2014), the authors report an IGE of 0.175, an IGC of 0.148, and an IRC of 0.211 for household disposable income.

Table 2.4: Intergenerational persistence of income

| | IGE | | | IGC | | | IRC | | |
|---|---|---|---|---|---|---|---|---|---|
| Age | 31-33 | 30-32 | 26-32 | 31-33 | 30-32 | 26-32 | 31-33 | 30-32 | 26-32 |
| | | | | | Australia | | | | |
| Cohorts | 1984-86 | 1985-87 | 1985-91 | 1984-86 | 1985-87 | 1985-91 | 1984-86 | 1985-87 | 1985-91 |
| Income | 0.260 | 0.268 | 0.194 | 0.250 | 0.236 | 0.170 | 0.221 | 0.196 | 0.162 |
| +IR value | 0.226 | 0.210 | 0.200 | 0.239 | 0.208 | 0.186 | 0.279 | 0.229 | 0.199 |
| Change | -0.034 | -0.058 | 0.006 | -0.011 | -0.028 | 0.016 | 0.058 | 0.033 | 0.037 |
| % Change | -13.1% | -21.6% | 3.1% | -4.4% | -11.9% | 9.5% | 26.2% | 16.8% | 22.8% |
| N | 379 | 400 | 924 | 379 | 400 | 924 | 379 | 400 | 924 |
| | | | | | United States | | | | |
| Cohorts | 1974-76 | 1975-77 | 1975-81 | 1974-76 | 1975-77 | 1975-81 | 1974-76 | 1975-77 | 1975-81 |
| Income | 0.472 | 0.483 | 0.460 | 0.420 | 0.407 | 0.394 | 0.419 | 0.391 | 0.394 |
| +IR value | 0.482 | 0.485 | 0.459 | 0.434 | 0.418 | 0.399 | 0.437 | 0.410 | 0.402 |
| Change | 0.010 | 0.002 | -0.001 | 0.014 | 0.011 | 0.005 | 0.018 | 0.019 | 0.008 |
| % Change | 2.1% | 0.4% | -0.2% | 3.3% | 2.6% | 1.3% | 4.3% | 4.9% | 2.0% |
| N | 295 | 305 | 947 | 295 | 305 | 947 | 295 | 305 | 947 |
| | | | | | Germany | | | | |
| Cohorts | 1973-75 | 1974-76 | 1974-80 | 1973-75 | 1974-76 | 1974-80 | 1973-75 | 1974-76 | 1974-80 |
| Income | 0.140 | 0.085 | 0.112 | 0.136 | 0.079 | 0.101 | 0.160 | 0.126 | 0.135 |
| +IR value | 0.149 | 0.083 | 0.113 | 0.144 | 0.077 | 0.102 | 0.165 | 0.138 | 0.140 |
| Change | 0.009 | -0.002 | 0.001 | 0.009 | -0.001 | 0.001 | 0.005 | 0.012 | 0.005 |
| % Change | 6.4% | -2.5% | 0.9% | 6.3% | -1.7% | 0.7% | 3.1% | 9.5% | 3.7% |
| N | 202 | 174 | 410 | 202 | 174 | 410 | 202 | 174 | 410 |

*Notes:* Income is disposable. Parent and Child's income are averaged for 5 years (e.g. 2001-2005 for HILDA) and 2 years (e.g. 2016-2017 for HILDA), respectively. Standard errors are robust and clustered at the parent household level.

*Source:* HILDA 2001–2017, PSID 1991–2007, SOEP 1990–2006.

According to all of the measures in Table 2.4, after Germany, Australia is the second most income mobile country, followed by the United States. This is in line with the existing literature. In Germany and the United States, the inclusion of IR values into the measure of income barely changes the estimates. Conversely, in Australia, the inclusion of an IR value has quite a strong effect, where, according to (as discussed in the methodology section) the most reliable measure, IRC, the inclusion of an IR value decreases mobility by approximately 22.8%.

The effect of the IR value on IGE appears to be age dependent. IR value decreases IGE for children aged 31–33 and 30–32 and increases IGE for children aged 26–32. A similar pattern is found in relation to IGC. Thus, changes in wage dispersions across generations do not appear to be the reason for age dependency. Given the small sample size, it is most likely a result of the fragility of OLS in the intergenerational context. Alternately, it could also be that home ownership has different effects on mobility depending on what stage of life a child is at when her income is measured. This is further explored in Section 2.6.

Table 2.5 shows how home ownership affects transitions from one income group into another. The mass appears more concentrated on the main diagonal, showing that Australian society becomes more rigid. Children in the lowest tertile are 4% more likely to stay in the same income group. Children in the second tertile are not practically affected. Children in the highest tertile are 5% more likely to remain the richest. Thus, home ownership in Australia has an unmistakable effect on the tails of income distribution.

Table 2.5: Australian transition matrices

| Parent | Child: low income | Child: middle income | Child: high income | |
|---|---|---|---|---|
| low income | 44% | 33% | 22% | Income + IR value |
| | 40% | 34% | 26% | Income |
| | 4% | 0% | -4% | Difference |
| middle income | 31% | 37% | 31% | Income + IR value |
| | 31% | 37% | 33% | Income |
| | 1% | 1% | -2% | Difference |
| high income | 24% | 29% | 46% | Income + IR value |
| | 29% | 30% | 41% | Income |
| | -5% | 0% | 5% | Difference |

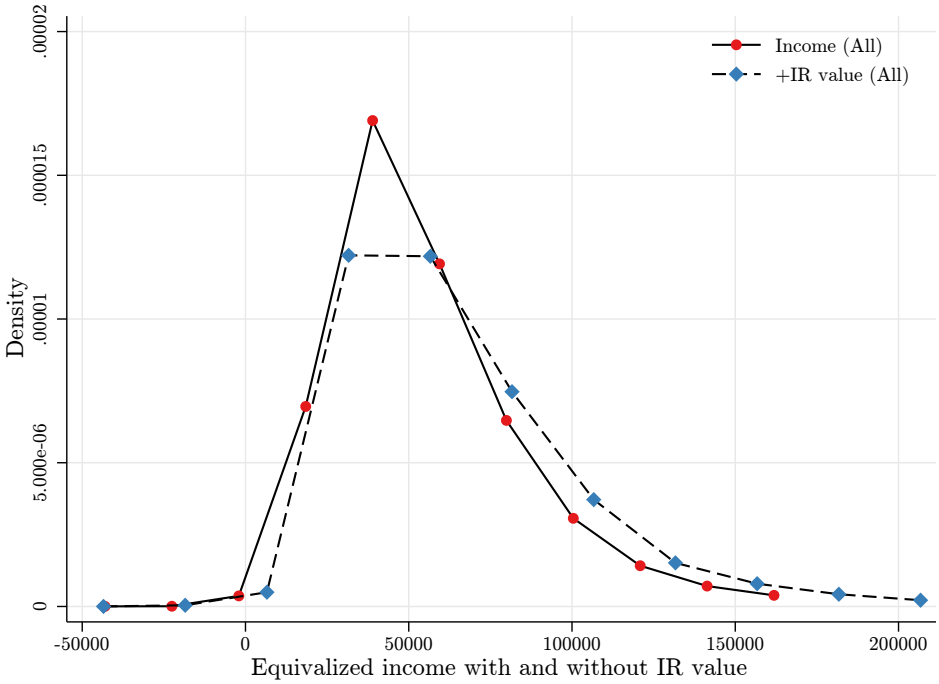
*Notes:* Household disposable income. Parent and child's income are averaged for 5 years (e.g. 2001-2005 for HILDA) and 2 years (e.g. 2016-2017 for HILDA), respectively. Each cell has 103 observations on average. Main sample is used (i.e. age 26-32). Calculations are performed with a code by Savegnago (2016).
*Source:* HILDA 2001–2017.

### 2.4.2 Inequality and polarization

Figure 2.5 shows both $X^r$ and $X^{\overline{r}}$ for the whole Australian sample. The inclusion of IR into the measure of income unambiguously flattens the density (i.e., decreases polarization), but its effect on spread (i.e., inequality) is less clear. The left tail of $X^r$ is less spread out, but the opposite tail appears to be slightly longer. The Gini coefficient would allow us to see whether the right tail eventually dominates the left one. Figure 2.6 shows the densities in relation to the 60+ age group. Without an IR value, the density has an obvious peak; however, the inclusion of an IR value noticeably depolarizes the peak. The effects of an IR value on inequality are more difficult to determine from the shape.

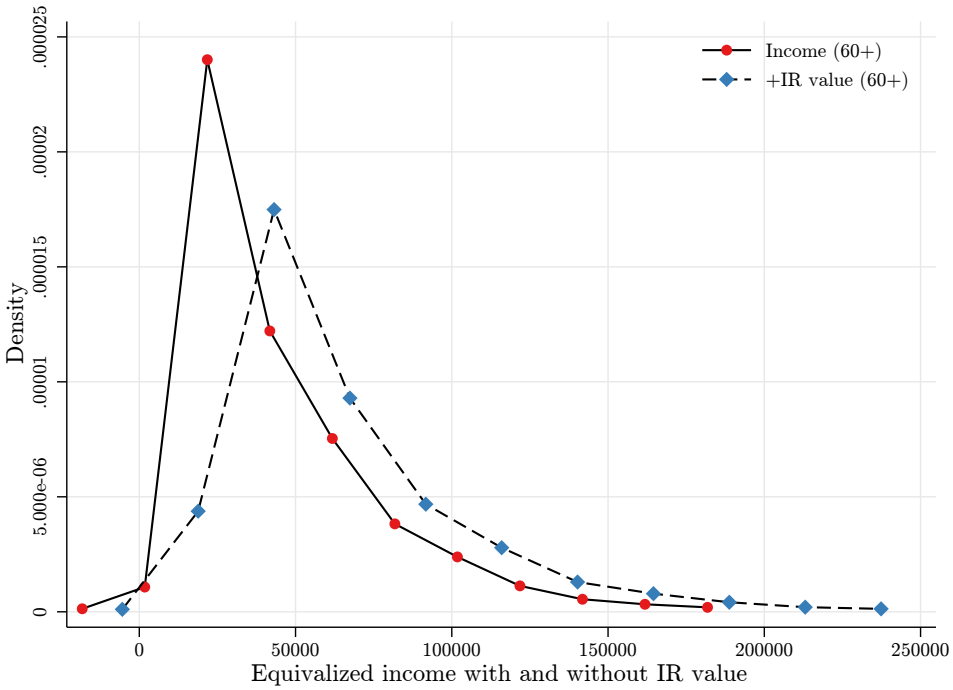
Table 2.6 sets out measurements of inequality according to the Gini coefficient. Similar to the results of Saunders and Siminski (2005) and Yates (1994), the inclusion of an IR value decreases inequality in Australia. Conversely, similar to the results of T. I. Garner and Short (2009), it marginally increases inequality in the United States, while in Germany inequality remains the same.

Figure 2.5: Income distribution for Australia




*Notes:* Densities of equivalized income with and without IR value estimated with adaptive kernel (Van Kerm 2012).
*Source:* HILDA 2017.

Figure 2.6: Income distribution for Australia




*Notes:* Densities of equivalized income with and without IR value estimated with adaptive kernel (Van Kerm 2012).
*Source:* HILDA 2017.

Table 2.6: Income inequility: Gini coefficient

| Age | All | 0-15 | 15-60 | 60+ |
|---|---|---|---|---|
| | | Australia | | |
| Income | 0.307 | 0.268 | 0.288 | 0.373 |
| +IR Value | 0.300 | 0.279 | 0.290 | 0.333 |
| Change | -0.007 | 0.010 | 0.002 | -0.040 |
| % Change | -2.3% | 3.9% | 0.8% | -10.8% |
| N | 23415 | 5084 | 14098 | 4750 |
| N, share | 100% | 22% | 60% | 20% |
| | | United States | | |
| Income | 0.438 | 0.420 | 0.430 | 0.476 |
| +IR Value | 0.441 | 0.432 | 0.435 | 0.457 |
| Change | 0.002 | 0.012 | 0.006 | -0.019 |
| % Change | 0.6% | 2.8% | 1.3% | -4.0% |
| N | 20873 | 5821 | 13441 | 2133 |
| N, share | 100% | 28% | 64% | 10% |
| | | Germany | | |
| Income | 0.297 | 0.266 | 0.302 | 0.299 |
| +IR Value | 0.296 | 0.268 | 0.303 | 0.296 |
| Change | 0.000 | 0.002 | 0.001 | -0.002 |
| % Change | -0.1% | 0.8% | 0.3% | -0.7% |
| N | 27677 | 4471 | 17286 | 6362 |
| N, share | 100% | 16% | 62% | 23% |

*Notes:* Income is disposable and equivalized. Calculations are performed with a code by Gradin (2014).
*Source:* HILDA 2017, PSID 2007, SOEP 2006.

These results reflect the fact that Germany has the lowest home ownership rate in Europe (Eurostat 2010), but slightly contradict the findings of Frick, Goebel, et al. (2014), who found a 1.3% decrease in the 2003 wave of SOEP; however, it should be noted that Frick, Goebel, et al. (2014) did not rely on CNEF harmonized data. In general, Germany is the most equal society, followed by Australia, and then the United States, and IR values have no effect on these countries' equality rankings.

The age restricted samples unmask a noticeable heterogeneity. The direction of the IR effect across restricted age groups is similar across all three countries. The IR value exacerbates inequality in the 0–15 age group, has a slight effect on

the 15–60 age group, and noticeably decreases inequality in the 60+ age group. Australia, again, has the largest home ownership effect across all age groups, excepting the 15–60 age group (in relation to this age group, the effect is the strongest in the United States). The effect is not sufficiently strong to affect the country's ranking; however, values for the 0–15 age groups in Australia and Germany are very close to one another and may be reversed in a repeated sample. In a comparison of age groups within the countries, Australia again differs. If the IR value is not included, the inequality for the 60+ age group jumps by a staggering 23.1% in comparison with the 15–60 age group; however, if the IR value is included, this figure decreases to 14.8%. Although IR has an equalizing effect, the Australian 60+ age group is still the most unequal in comparison with fellow citizens of a younger age.

The absence of a universal governmental pension in Australia may induce inequality among elderly people, who rationally respond by accumulating property, as it is exempt from the asset test. This result speaks to previous works that analyze the Australian asset test (Cho and Sane 2013; Kudrna and A. Woodland 2011).

Table 2.7 sets out the measures in relation to polarization. Germany is the least polarized country, followed by the United States and Australia. In relation to the United States, the results reflect those of Duclos, Esteban, et al. (2004), who show that density in the United States is quite unique for its flatness in the middle, but contradict their findings in relation to Australia, whose level of polarization is equal to that of the United States. It should be noted that their study uses the Luxembourg Income Study: the 1991 wave for the United States and the 1994 wave for Australia (therefore, the usage of a different data sets may explain the deviations in the results). Going back to Table 2.7, the inclusion of home ownership has no effect on German polarization, marginally decreases American polarization, but drastically decreases Australian estimates. An inspection of the effect by the age groups demonstrates that a sizable con-

Table 2.7: Income polarization

| Age | All | 0-15 | 15-60 | 60+ |
|---|---|---|---|---|
| | | Australia | | |
| Income | 0.124 | 0.327 | 0.254 | 0.441 |
| +IR Value | 0.102 | 0.330 | 0.218 | 0.281 |
| Change | -0.022 | 0.003 | -0.037 | -0.160 |
| % Change | -17.7% | 0.9% | -14.4% | -36.3% |
| N | 23415 | 5084 | 14098 | 4750 |
| N, share | 100% | 22% | 60% | 20% |
| | | United States | | |
| Income | 0.031 | 0.250 | 0.043 | 0.640 |
| +IR Value | 0.030 | 0.259 | 0.042 | 0.580 |
| Change | -0.001 | 0.009 | -0.001 | -0.060 |
| % Change | -2.4% | 3.6% | -2.6% | -9.4% |
| N | 20873 | 5821 | 13441 | 2133 |
| N, share | 100% | 28% | 64% | 10% |
| | | Germany | | |
| Income | 0.018 | 0.301 | 0.037 | 0.073 |
| +IR Value | 0.018 | 0.301 | 0.037 | 0.071 |
| Change | 0.000 | 0.000 | 0.001 | -0.002 |
| % Change | 0.0% | 0.2% | 1.4% | -2.1% |
| N | 27677 | 4471 | 17286 | 6362 |
| N, share | 100% | 16% | 62% | 23% |

*Notes:* Income is disposable and equivalized. For readability, measurements are multiplied by 1,000,000. Calculations are performed with a code by Gradin (2014).
*Source:* HILDA 2017, PSID 2007, SOEP 2006.

tribution is made not by respondents from the 60+ age group, but by the 15–60 age group (note that the 15–60 age group is three times larger than the 60+ age group).

Thus, IR value has a similar effect on inequality and polarization in the 60+ age group, but an opposite effect in the 15–60 age group. In relation to the 60+ age group, a decrease in polarization suggests less clustering; however, a decrease in both polarization and inequality suggests that the distance across both individuals and income groups becomes smaller. In relation to the 15–60 age group, a decrease in polarization again suggests that there is less clustering;

however, an increase in inequality suggests that the distance across individuals becomes larger.

## 2.5 Conclusion

This paper has used three harmonized national panels from Australia, the United States and Germany to measure the effect of home ownership on income inequality, polarization and intergenerational mobility. Australia is the only country in which home ownership drastically changes all three measures. On average, members of Australian society become 22.8% less mobile, as measured by IRC, after accounting for home ownership. The transition matrices further show that values become more concentrated on the leading diagonal. The lower tertile is 4% more concentrated on the leading diagonal, while the higher tertile is 5% more concentrated on the leading diagonal. Further, among elderly people, home ownership changes inequality by –10.8% and polarization by –36.3%, while among working age people, it changes inequality by 0.8% and polarization by –14.4%.

As the first Canberra Group report (2001) notes, the under coverage of property and self-employment income, own account production, IR of owner-occupied dwellings, in-kind social transfers, capital gains, and other unrealized income from wealth are major issues that need to be addressed to expand internationally comparable income measures. The results of this paper reinforce the Canberra Group's recommendations that all in-kind income sources may[5] need to be included for an accurate assessment of the economic well.

Notably, the results change understandings of mobility in Australia and challenge the best available calculations performed by Deutscher and Mazumder (2019) on tax data. Generally, calculations based on tax data are impressive in precision; however, they may be biased, since the data is not representative of income, as the Australian example shows. Many capital income sources (e.g., IR, returns on pension funds, interest income) may not be included in an income

[5]The IR value is a good example of the influence of non-monetary sources of income on measure of income, polarisation and inequality, but it is also possible that the result of including all sources of non-monetary sources of income would be the same if we work only with earnings.

tax base, as these types of income are fully exempt from taxation or may be taxed separately. Thus, Deutscher and Mazumder's (2019) comparison of their calculations to American and Swedish calculations may be misleading, as the economic well-being across countries also depend on non-monetary sources of income, such as IR.

## 2.6 Appendix

This section examines why IR value has a different effect on intergenerational mobility across different age groups when measured by IGE or IGC, but not when measured by IRC (see Table 2.4).

Table 2.8 and Table 2.9 consider IGE and IRC, respectively, in relation to age across all three countries by allowing the slope to vary by the different cohorts. IRC estimates fall within each other's confidence intervals and the enormous effects related to IR values persist across all of the age groups in Australia. This is not true of the IGE results. The German estimates are not informative, as only the coefficient for the 1975 cohort differs statistically from

Table 2.8: Intergenerational persistence of income by age: IRC

| | $P \times \mathbb{1}\{Age\}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| Age | 32 | 31 | 30 | 29 | 28 | 27 | 26 |
| | Australia | | | | | | |
| Cohorts | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
| Income | 0.197 | 0.114 | 0.184 | 0.134 | 0.175 | 0.140 | 0.201 |
| +IR value | 0.247 | 0.154 | 0.216 | 0.167 | 0.202 | 0.178 | 0.242 |
| Change | 0.050 | 0.040 | 0.032 | 0.033 | 0.027 | 0.038 | 0.041 |
| % Change | 25.6% | 35.4% | 17.5% | 24.4% | 15.5% | 27.3% | 20.5% |
| | United States | | | | | | |
| Cohorts | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
| Income | 0.435 | 0.394 | 0.376 | 0.392 | 0.402 | 0.357 | 0.448 |
| +IR value | 0.448 | 0.402 | 0.387 | 0.400 | 0.410 | 0.363 | 0.454 |
| Change | 0.013 | 0.008 | 0.011 | 0.007 | 0.008 | 0.006 | 0.006 |
| % Change | 2.9% | 2.1% | 2.8% | 1.8% | 1.9% | 1.8% | 1.4% |
| | Germany | | | | | | |
| Cohorts | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| Income | 0.134 | 0.146 | 0.129 | 0.151 | 0.133 | 0.112 | 0.139 |
| +IR value | 0.137 | 0.155 | 0.136 | 0.153 | 0.138 | 0.115 | 0.144 |
| Change | 0.002 | 0.009 | 0.007 | 0.002 | 0.005 | 0.003 | 0.005 |
| % Change | 1.8% | 6.3% | 5.8% | 1.2% | 3.5% | 2.4% | 3.4% |

*Notes:* Income is disposable. Parent and Child's income are averaged for 5 years (e.g. 2001-2005 for HILDA) and 2 years (e.g. 2016-2017 for HILDA), respectively.
*Source:* HILDA 2001–2017, PSID 1991–2007, SOEP 1990–2006.

Table 2.9: Intergenerational persistence of income by age: IGE

| | $\ln X \times \mathbb{1}\{Age\}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| Age | 32 | 31 | 30 | 29 | 28 | 27 | 26 |
| | Australia | | | | | | |
| Cohorts | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
| Income | 0.313 | 0.232 | 0.168 | 0.150 | 0.133 | 0.135 | 0.175 |
| +IR value | 0.290 | 0.200 | 0.140 | 0.136 | 0.142 | 0.184 | 0.273 |
| Change | -0.023 | -0.032 | -0.028 | -0.014 | 0.009 | 0.049 | 0.098 |
| % Change | -7.3% | -13.8% | -16.7% | -9.3% | 6.8% | 36.3% | 56.0% |
| | United States | | | | | | |
| Cohorts | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
| Income | 0.485 | 0.481 | 0.481 | 0.459 | 0.452 | 0.443 | 0.436 |
| +IR value | 0.490 | 0.484 | 0.483 | 0.459 | 0.451 | 0.441 | 0.433 |
| Change | 0.005 | 0.003 | 0.002 | 0.000 | -0.001 | -0.002 | -0.003 |
| % Change | 1.0% | 0.6% | 0.4% | 0.0% | -0.2% | -0.5% | -0.7% |
| | Germany | | | | | | |
| Cohorts | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| Income | 0.144 | 0.160 | 0.144 | 0.125 | 0.110 | 0.052 | 0.008 |
| +IR value | 0.138 | 0.162 | 0.149 | 0.131 | 0.115 | 0.050 | -0.002 |
| Change | -0.006 | 0.002 | 0.005 | 0.006 | 0.005 | -0.002 | -0.010 |
| % Change | -4.2% | 1.3% | 3.5% | 4.8% | 4.5% | -3.8% | -125.0% |

*Notes:* Income is disposable. Parent and Child's income are averaged for 5 years (e.g. 2001-2005 for HILDA) and 2 years (e.g. 2016-2017 for HILDA), respectively.
*Source:* HILDA 2001–2017, PSID 1991–2007, SOEP 1990–2006.

zero. American estimates are positive, but again are barely affected by IR value. Among Australians aged 29–32, the IR value decreases IGE, but for the other age groups increases it substantially.

These differences are next explored using quantile regression (QR), another tool for measuring intergenerational income persistence. In the United States, Grawe (2004) uses this tool on a sample of 354 observations and finds that IGE is higher at the median than at the tails (i.e., an inverse U-shaped pattern). Similarly, Eide and Showalter (1999) examine a sample of 612 observations in the United States and find a continuous (almost linear) decrease in IGE as income distribution increased. More recently, Palomino et al. (2018) consider 25,084 observations and find a pronounced U-shape pattern in relation to quintile es-

timates. Estimates for Brazil by Tejada et al. (2015) show a similar pattern to the estimates found for the United States by Palomino et al. (2018) (i.e., IGE has higher values at both ends of the income distribution). Bratberg et al. (2007) apply QR in relation to earnings data from Norway and find that the relationship between IGE and earnings distribution positions decreases (i.e., IGE is higher at the bottom tail, but lower at the top of the earnings distribution).

Figure 2.7 and Figure 2.8 show IGE results estimated from a QR for the full sample and for a sample restricted to the 29–32 age group (an age group that demonstrates the irregularity of the IR value effect). Table 2.10 further summarizes the effects of IR value on both these figures.

The full sample shows that IR value usually increases IGE (as the main text of Table 2.4 shows). However, children who fall into the middle part of the distribution show the highest degree of intergenerational income persistence, while top incomes and, more specially, low incomes are more independent of childhood economic circumstances. These differences may reflect Bratsberg et al.'s (2007) famous study, which showed that in countries with strong social security the relationship between the log earnings of sons and fathers is flat in the left section of fathers' earnings distributions and is increasingly positive. Thus, sons who grow up in the poorest households have the same earnings prospects as adults as sons who grow up in moderately poor households.

Further, IR value unequivocally increases intergenerational income persistence across all quantiles, except at the left most end of the tail. The shape of the curve remains about the same, excepting the pronounced spikes at the 8th and 8.5th quantiles. For example, a hypothetical shift in one dollar of parental income without an IR value would shift children's average income in the 8.5th quantiles by 0.18, but with an IR value would shift it by 0.25 (a 39% increase). In Australia, home ownership represents a remarkable portion of capital income and is attained by only the richest of individuals. It may be that as higher earners do not need mortgages, the correlation between parental and

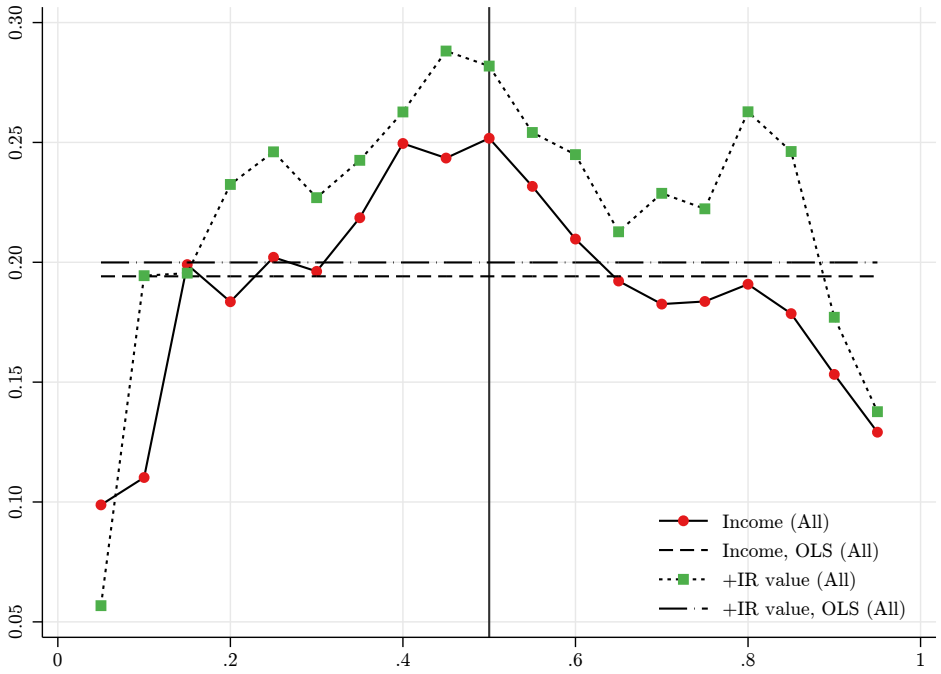
children incomes at the upper part of the distribution is higher.

Notably, when the sample is restricted to those aged 29–32, the results differ. IGE increases up until the second percentile, but then decreases. In the higher quantiles, the IR value decreases the intergenerational income persistence; however, in the lower quantiles, the IR value increases the persistence. Thus, later in life, home ownership appears to have a greater effect on relatively poor households, while its effects on mid- and high-income households are fairly negligible. This may be because education and social networks matter more for high income earners.

The most striking effect occurs on the edges of the distribution. If IR values are not included, the estimates on the edges are fairly close to one another; however, if IR values are included, the persistence of intergenerational income mobility on the lower edge of the distribution is clearly higher. At the 0.5th percentile, IGE increases from 0.18 to 0.27 (a 50% increase). At the 9.5th percentile, IR value decreases the persistence from 0.18 to 0.08 (a –56% decrease). Australian public policies that aim to equalize opportunities are more valuable for those in the lower quantiles; however, it appears that home ownership is having a strong opposite effect.

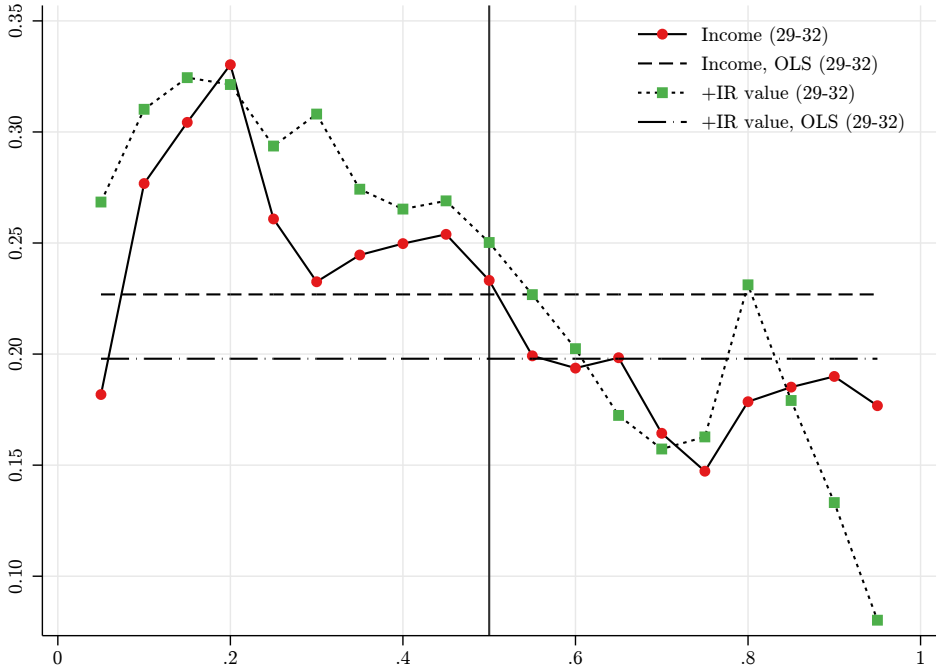
It should be noted that this analysis is seriously limited by the available data; however, the results do suggest that IR values may have a different effect on different portions of children's life cycles. This could represent an interesting area for future analysis as the HILDA dataset grows.

Figure 2.7: IGE by quantiles for Australia: full sample




*Notes:* Intergenerational earning elasticity by quintiles with and without IR value ($n = 924$) estimated with quantile regression (Koenker and Bassett 1978).
*Source:* HILDA 2001–2017.

Figure 2.8: IGE by quantiles for Australia: limited sample




*Notes:* Intergenerational earning elasticity by quintiles with and without IR value ($n = 522$) estimated with quantile regression (Koenker and Bassett 1978).
*Source:* HILDA 2001–2017.

Table 2.10: IGE by quantiles for full and limited samples

| Quantiles | 0.05 | 0.1 | 0.15 | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | | | | | | | | | | 26-32 | | | | | | | | | |
| Income | 0.1 | 0.11 | 0.2 | 0.18 | 0.2 | 0.2 | 0.22 | 0.25 | 0.24 | 0.25 | 0.23 | 0.21 | 0.19 | 0.18 | 0.18 | 0.19 | 0.18 | 0.15 | 0.13 |
| +IR value | 0.06 | 0.19 | 0.2 | 0.23 | 0.25 | 0.23 | 0.24 | 0.26 | 0.29 | 0.28 | 0.25 | 0.24 | 0.21 | 0.23 | 0.22 | 0.26 | 0.25 | 0.18 | 0.14 |
| Change | -0.04 | 0.08 | 0 | 0.05 | 0.05 | 0.03 | 0.02 | 0.01 | 0.05 | 0.03 | 0.02 | 0.03 | 0.02 | 0.05 | 0.04 | 0.07 | 0.07 | 0.03 | 0.01 |
| % Change | -40% | 73% | 0% | 28% | 25% | 15% | 9% | 4% | 21% | 12% | 9% | 14% | 11% | 28% | 22% | 37% | 39% | 20% | 8% |
| Age | | | | | | | | | | 29-32 | | | | | | | | | |
| Income | 0.18 | 0.28 | 0.3 | 0.33 | 0.26 | 0.23 | 0.24 | 0.25 | 0.25 | 0.23 | 0.2 | 0.19 | 0.2 | 0.16 | 0.15 | 0.18 | 0.19 | 0.19 | 0.18 |
| +IR value | 0.27 | 0.31 | 0.32 | 0.32 | 0.29 | 0.31 | 0.27 | 0.27 | 0.27 | 0.25 | 0.23 | 0.2 | 0.17 | 0.16 | 0.16 | 0.23 | 0.18 | 0.13 | 0.08 |
| Change | 0.09 | 0.03 | 0.02 | -0 | 0.03 | 0.08 | 0.03 | 0.02 | 0.02 | 0.02 | 0.03 | 0.01 | -0 | 0 | 0.01 | 0.05 | -0 | -0.1 | -0.1 |
| % Change | 50% | 11% | 7% | -3% | 12% | 35% | 13% | 8% | 8% | 9% | 15% | 5% | -15% | 0% | 7% | 28% | -5% | -32% | -56% |

*Notes:* Income is disposable. Parent and Child's income are averaged for 5 years (e.g. 2001-2005 for HILDA) and 2 years (e.g. 2016-2017 for HILDA), respectively.
*Source:* HILDA 2001–2017.

# Chapter 3

# The Effect of the Test-Preparation Industry on Centralized College Admission

Following the seminal work of Roth and Xing (1997), which delineates and solves the problem of congestion (a failure by participants to make sufficient offers and acceptances to clear the market (Che and Koh 2016)), centralized matching has assumed a prominent place in economic theory and practice. Centralized matching has been successfully applied to medical residencies and public school choices, as an example. College admission represents a similar market and is known to suffer from a lack of coordination. It is widely believed that improved coordination by centralized matching would result in welfare benefits; however, the admission process in many countries still operates in a similar manner to those in decentralized labor markets. A better understanding of the reluctance to adopt a CCA system is a critical aspect of market design. This chapter explores one possible explanation for this reluctance.

Unlike in the medical residency context (in which centralized matching begins after applicants and hospitals interview one another in a decentralized fashion), CCA uses standardized examination marks as a proxy for applicants'

skills and colleges are typically assumed to prefer applicants with high marks to applicants with low marks. CCA has been studied extensively in economic literature; however, to date, no papers appear to have acknowledged that standardized examination marks are subject to what Haladyna et al. (1991) and Mehrens and Kaminski (1989) have dubbed "test marks pollution". Test mark may not reflect true ability due to the availability of commercial cramming schools. Economists see exam test marks as a variable that is defined by students abilities, ignoring a well-established by the educational scientist observations that marks marks are subject to skills-irrelevant variance that is induced by commercial materials that have been specifically designed to improve test performance.

To better understand this idea, this paper studies the most recent wave of the introduction of CCA in ex-Soviet republics.[1] Unlike the applicants of many countries that embraced large-scale test standardization decades ago, the applicants in the ex-Soviet republics, due to their specific shared past, were admitted based on college and often department specific admission examinations. Thus, this wave of CCA introductions in ex-Soviet republics where, previously, nothing that remotely resembled such a system existed, can be used to undertake a rare and useful quasi-experiment. In all of the cases studied (Gorgodze 2007; Prakhov and Yudkevich 2017), over time, the introduction of CCA in ex-Soviet republics created a private TP industry that gradually redistributed the educational opportunities from poorer to wealthier households. Consequently, many colleges began to demonstrate a reluctance to admit students based on their centralized examination marks alone.

This research uses an auction-theoretical framework to explain three empirical regularities observed in ex-Soviet republics: (1) the concentration of TP schools in higher income geographical areas; (2) the elevation of examination

[1] Years of implementation: Azerbaijan 1992, Kazakhstan 1999–2004, Russia 2001–2009, Kyrgyzstan 2002, Ukraine 2004–2005, Georgia 2005.

marks; and (3) the growing number of institutions looking for an alternative to CCA.

The model assumes that CCA examinations, which vary very little in their general designs year to year, enable the TP industry to accumulate UTSK, which is only used to allow private clients to achieve higher examination marks by complementing their skills.[2] Thus, while some activities in the TP industry are productive and increase applicants' skills, other activities (i.e. UTSK) systematically increase the examination marks of applicants who have more access to TP schools, not by increasing their skills (thus, unproductive) but by providing them with UTSK that complements their skills.

The model shows that if access to UTSK is explicitly considered, applicants may be admitted to colleges who do not necessarily possess high levels of skills. Thus, examination marks have become less informative about applicants' underlying skills. If college wage premiums are high, then the gaming of CCA by those with more TP opportunities may decrease the quality of sorting under the CCA system. Applicants with more opportunities to access UTSK may decide it is rational to invest more funds into TP schools (regardless of the fact that UTSK is unproductive and can not be used in future studies or labour market occupations) to increase their chances against less fortunate applicants who are unable to access UTSK.

[2]Examples of UTSK are clearly evident from a typical advertisement of test preparation schools and include, for example, practice questions from previous exams or those that closely resemble them; learning non-obvious but efficient approaches to certain questions; and paying more attention to topics and vocabulary that are typical for the exam. UTSK also exists under the names of "test sophistication" (Anastasi 1981) and "test familiarity" (Reeve et al. 2009). The notion is also believed to be a plausible explanation of the Flynn effect: the substantial and long-sustained increase in IQ test scores (Flynn 1984).

## 3.1 Motivation

### 3.1.1 College admission test-preparation

In recent years, the enormous growth of the college admission TP industry and aggressive TP practices globally have perpetuated social inequalities, negatively affected the sorting properties of the public system of education, and led to resources being consumed that could be better used in other places. This has occurred in Asia, the Middle East, Europe, North America and Australia (Aurini et al. 2013; Bray 2011; Bray and Lykins 2012). In some countries, the TP industry has come to occupy a grotesquely large role in households. For example, in Turkey, Korea, Azerbaijan and Mauritius, students have stopped attending their public high schools en masse (or are using them as places in which to sleep) so that they can attend TP schools later in the day (Bhorkar and Bray 2018; Bray 2017). In other countries, household expenditure on TP schools represents a noticeable fraction of gross domestic product. Notably, the exorbitant financial burden that tutoring places on parents led to the TP industry being banned in Korea in 1980 (Bray 2009; Kim 2007). In general, the reasons for the development of the TP industry and the propensity of households to spend money on TP differ somewhat from country to country; however, "high-stake" college admission examinations are systematically implicated. This was particularly clear during recent introductions of CCA systems to ex-Soviet republics.

In the Soviet Union, and in other independent states that emerged after the Soviet Union's collapse in 1991, college specific examinations remained at the core of the college admission system. The system had its inefficiencies,[3] but demonstrated, after the collapse of the Soviet Union, a particular propensity

[3]Often, each department within each college has administered examinations independently. Many examinations have been delivered orally and can only be taken at the college where they are administered, essentially physically limiting access to education for some applicants (Drummond and Gabrscek 2012). Applicants also have to make college specific investments and take a new examination for each college to which they apply, and since they cannot do this at a single sitting, they must wait for a new test-taking occasion, which delays their entry by a year or more (Heyneman 2004).

towards corruption.[4] Those with higher incomes, connections and closer physical proximities to colleges found themselves in privileged positions that allowed them to almost exclusively use the publicly-financed HE system.[5] CCA was introduced to increase the efficiency of the admission system and equalize the educational opportunities available to various demographic groups. Under the CCA system, any applicant knows the general examination structure, can sit the examination for free, and is able to broadcast their examination marks to a range of colleges.

The Ministry of Education and Science of Georgia provides unique insights into the practical implementation of the CCA system in Georgia (Gorgodze 2007).[6] The educational institutions of the Georgian capital Tbilisi allocates college degrees across the whole country. The introduction of CCA initially equalized admission opportunities for households located outside the capital; however, after only a few admission cycles, residents who lived in the capital discovered that, rather than paying semi-institutional bribes, they could invest money into TP schools. Due to the systematic increase in these students' marks, the eventual allocation of degrees is now much closer to what it was before the policy change.

Russia has had a remarkably similar experience. In Russia, the sequential introduction of CCA (from 2001 to 2009) can be used to show how the absence and presence of the TP industry has led to applicants being sorted differently. A report for the government by Efendiyev and Reshetnikov (2010)

[4]In Georgia and Kyrgyzstan, admission bribes became universal; both, however, had the same problem during the Soviet period. In Russia and Ukraine, TP took an unusual fragmented form where each college has become a sole supplier of TP for its own admission test (Denisova-Schmidt and Leontyeva 2017; Silova and Bray 2006). This arrangement was, in fact, a semi-institutional bribe. Starodubtsev (2011) notes that in Russia by 2004 only 38% of applicants considered it corrupt to be admitted into college due to participation in TP courses, regardless of the quality of their preparation and their exam mark.

[5]Kuzminov (2012) notes that in the late 1980s about 75% of students in Moscow colleges were from out of town; in early 2000 this number was about 25%.

[6]I thank Mark Bray (the Director of Comparative Education Research Centre and UNESCO Chair Professor in Comparative Education at the University of Hong Kong) for sharing this article.

on the experimental introduction of CCA in several regions in 2001 (at a time at which TP schools were not yet common) showed an initial increase in the admission of students from less fortunate backgrounds. However, more than a decade later, Prakhov and Yudkevich (2017) showed that the engagement of TP schools by applicants with higher incomes has substantially and reliably increased their centralized examination marks, which naturally crowds out applicants with lower incomes.

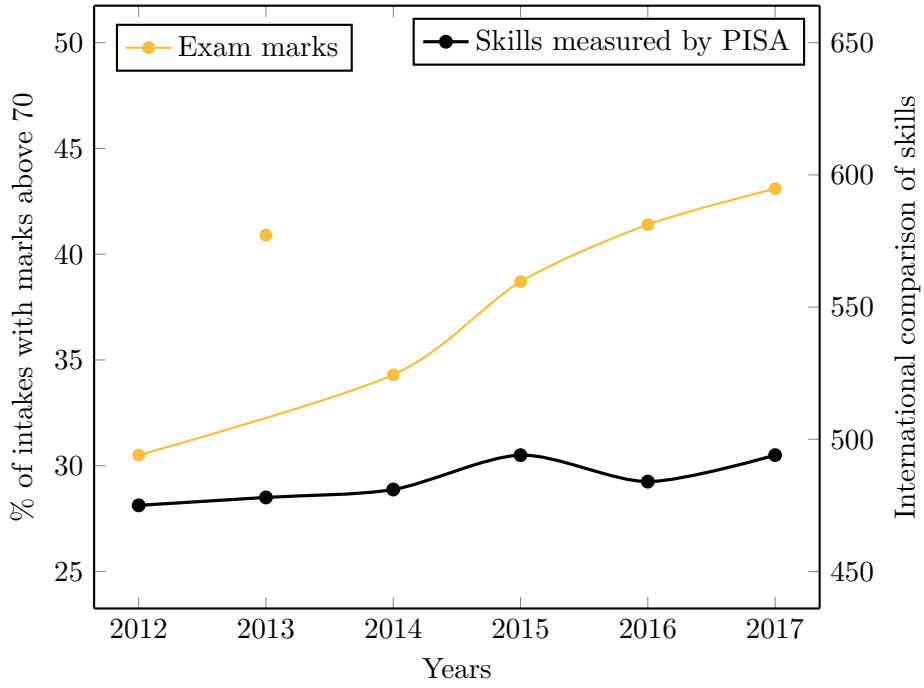
CCA leads to the introduction of examinations, the designs of which are generally publicly known. Consequently, preparation for examination becomes a homogeneous service and leads to the creation of an organized TP industry. Over time, learning by doing allows the TP industry to accumulate knowledge as to how centralized examinations can be passed. However, a substantial portion of that knowledge is unproductive, as it does not increase applicants' skills and they cannot use it in their future studies. Thus, UTSK creates a certain group of applicants that have systematically higher marks, but only because they know the examinations better. As marks become systematically less dependent on skills, a problem is created when colleges sort students based on their marks.

The above described regularity, as seen in the Georgian and Russian examples, likely applies to all standardized tests;[7] however, for this research, the introduction of CCA in Russia is considered as a case study. The following two facts summarize the key observations that accompanied the introduction of CCA in Russia.

**Fact 3.1.** *After CCA is introduced, the right tail of centralized examination marks distribution constantly increases. Concurrently, an alternative measure of skills indicates that the level of high school students' skills remains approximately the same (see Figure 3.1).*

[7] A clean example is the Law School Admission Test, an admission test widely used in the United States that has created a large TP industry, which has been extensively criticized for its inability to predict applicants' performance as lawyers (Haddon and Post 2006).

Figure 3.1: Exam marks elevation



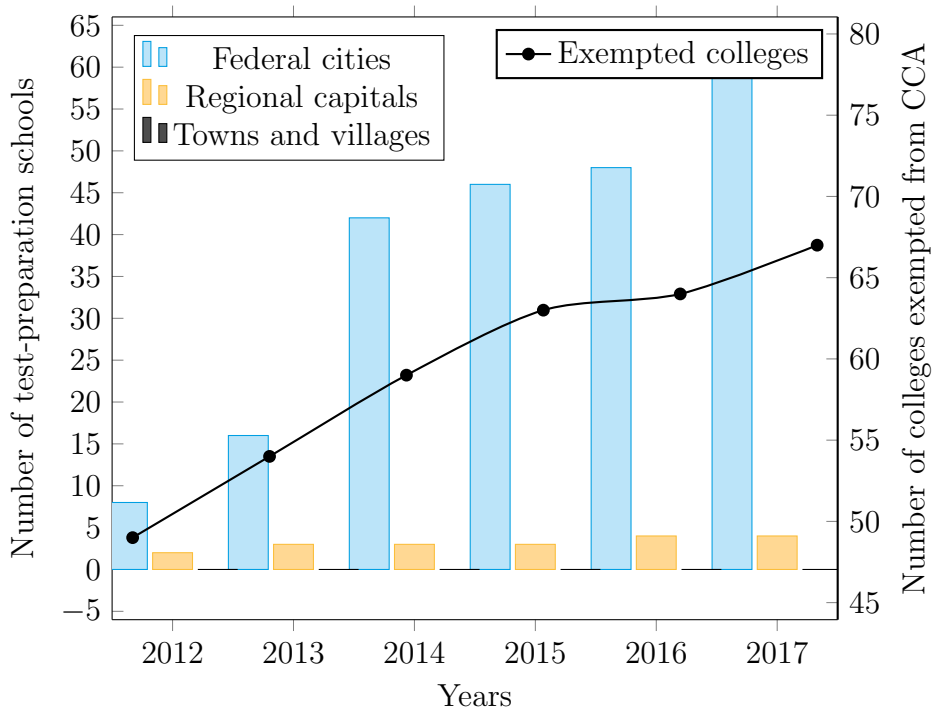

*Notes:* Orange line show an increase in the fraction of students with exceptionally high centralized exam marks (scoring more than 70 out of 100). The black line shows average skills in reading, mathematics and science of 15-year-old students measured by the Programme for International Student Assessment. Marks for 2013 are ignored because questions for centralised exam were leaked to the public right before the test day (Gushchin 2013).
*Sources:* M. S. Dobryakova (2017), OECD (2017)

The fraction of applicants receiving exceptionally high marks in the centralized examination constantly increases, indicating that the aggregate capacity of applicants to do well in the centralized examination increases. However, as the increase is not driven by skills, it must be driven by another factor.

**Fact 3.2.** *The number of TP schools continues to increase and such schools tend to be more concentrated in higher income areas. Concurrently, the number of colleges that requested the federal governemnt if they can use other tests (in addition to the centralized examination) has continued to strictly increase (see Figure 3.2).*

This suggests that the TP industry drives the elevation of the examination marks by systematically accumulating UTSK and dispensing it to those applicants who can afford it. Consequently, it is more difficult for colleges to use

Figure 3.2: Growth of TP industry and CCA exemptions




*Notes:* Bars demonstrate that the growth of private preparation schools is concentrated in high income areas. The black line demonstrates the total number of colleges allowed to have complementary exams to sort applicants.
*Sources:* 4EGE (2017), YP (2017), Spark-interfax (2017)

centralized examination marks to sort applicants. [8]

### 3.1.2 Related game theoretical literature

Research on both CCA by economists and the sorting repercussions of aggressive TP practices by educational scientists is extensive. Thus, it is somewhat surprising that this paper appears to be the first to attempt to merge these two areas together.

An intuitive starting point for this study is Spence's (1973) famous model, under which the level of investment into TP is interpreted as a decision in a

[8] A comparable phenomenon, known as "Grade Inflation", has been documented for the United States (Rojstaczer and Healy 2012) (also see GradeInflation.com) and in many other nations (Baker 2018). It also coincides with a rise of TP industry in 1980s (Shepherd 2011). CCA exemptions can be compared with the United States' ongoing "The Opt-Out Movement": an organized efforts to stop using high-stakes state standardized tests for college admission (Supovitz et al. 2016).

signaling game. College admission regulates the allocation of a scarce signal that gives college graduates access to better jobs and higher salaries. Thus, if a standardized test is used as a screening device, households have a strong incentive to invest in preparing for this test, regardless of the productivity of the knowledge to be gained.

Recently, Bodoh-Creed and Hickman (2018) employed an auction-theoretical treatment of college admission, where a continuum of students sought to enroll into a continuum of colleges, to undertake a policy analysis of the United States' college admission systems. Hafalir et al. (2018) also employed an auction-theoretical treatment of college admission to compare applicants' efforts in relation to CCA and decentralized college admission. Economically, the model suggested in this dissertation's research is similar to these models; technically, it is a mixture of Moldovanu and Sela's (2001) contest model and Che and Gale's (1996) budget constraints auction model.

The contest model is a variation of an all-pay auction that was analyzed in a series of works by Moldovanu and Sela (2006) and Moldovanu, Sela, and Shi (2012), who demonstrated an optimal combination of the prize and punishment that maximizes participants' efforts. Konrad (2009) conducted a rich survey of various applicants on all-pay auctions and contests. The best symmetric responses in auctions with budget constraints were originally analyzed by Che and Gale (1998, 2000), who ranked auction formats by revenue and showed the failure of revenue equivalence. Later, Kotowski and Li (2014) generalized Che and Gale's approach in an all-pay auction with budget constraints and affiliated values. The model in this paper adopts the same assumption as that adopted in the literature on auctions with budget constraints.

## 3.2 The Model

### 3.2.1 Modelling choice

I look at the college admission from the queueing theory point of view. As discussed in "Related game theoretical literature" this auction-theoretical treatment of college admission has been recently used extensively. In addition, Paul Klemperer in "Why Every Economist Should Learn Some Auction Theory" (2000) shows that auctions are remarkably useful in reaching the aspects of the economics interaction that are not accessible in traditional economics models. He also argues that the connections between auction theory and "standard" economic theory run deeper than many people realize; that auction-theoretic tools provide useful arguments in a broad range of contexts; and that a good understanding of auction theory is valuable in developing intuitions and insights that can inform the analysis of many mainstream economic settings. In short, auction theory is central to economics. He also mentions that the Ortega-Reichert (1967)'s path-breaking models of auctions, including a model of signalling significantly predated Spence (1973). In Paul Klemperer's opinion the auction-theoretical treatment of signalling games is not often used by the economists because they have been developed in operation research literature and are not known to economist.

### 3.2.2 Agents and centralized exam marks

CCA exists to help colleges sort high school graduates according to their skills in a given college admission cycle. As skills are not observed and college applicants lack incentives to truthfully reveal their skills, a centralized examination, which is at the core of the CCA system, overcomes this problem by asking all applicants to sit the same examination so that the sorting can be based on observed examination marks. If the test-taking conditions were identical and

nothing other than an applicant's skills were to inform examination marks, then an applicant with higher skills should achieve a higher mark, which would make the sorting outcome identical to one in which an applicant's skills were publicly observed. The assumption of the existence of a perfect proxy allows assortative outcomes to occur under CCA, as shown by Che and Koh (2016).

Test-taking conditions are not identical. To capture this idea, take two college applicants denoted by $\{s_i^\theta\}_{i=1}^2$ and defined as two *i.i.d* privately known draws $\{(V_i, W_i)\}_{i=1}^2$ from a joint probability density function $f_{V,W}(v, w)$ defined over the applicants' potential characteristics: $\text{supp}(V) = [0, 1]$, $\text{supp}(W) = [\underline{w}, \overline{w}]$, and $0 \leq \underline{w} < 1 \leq \overline{w}$. The realized $v$ represents the applicant's skill level (that defines the cost of study effort) and the realized $w$ represents access to UTSK (which is assumed to be accumulated by the TP industry).

The empirical evidence shows that using TP always increases the exam marks of applicants involved (Dang and Rogers 2008). I know introduce Assumption 3.1 that attempts to match this empirical evidence but not at the face value (that applicants' skills are increased), instead, the assumption separates the role of UTSK in the elevation of the exam marks. The assumption accentuates that an instantaneous increase in exam marks can plausibility come from learning certain exam specific short cuts.

**Assumption 3.1.** *An examination mark of an applicant contains information on both skills, and UTSK. Further, the higher the desired mark, the higher the necessity of UTSK:*

$$b(v, w) \stackrel{def}{=} \min\{b(v), w\}. \tag{3.1}$$

Economically, the assumption views the observed mark of an applicant as a complementary mixture of UTSK, $w$, and $b(v)$. The latter is an examination mark that would have perfectly signaled the applicant's skill level (if UTSK were assumed away). An excess of UTSK will not necessarily increase an applicant's marks; similarly, being exceptionally skillful will not necessarily translate

into higher marks in the absence of UTSK. Thus, applicants could be highly skilled, but if they have no training on, for example, the questions typical to the examination, their marks may not reflect their skills. Further, a higher value of $w$ is required to signal a higher $v$. For example, a highly-skilled applicant still has to do full-fledged practice tests in order to achieve a result that signals his/her skill level. Conversely, to achieve a moderate result, a moderately skilled applicant may only need to complete practice questions from free textbooks or online materials. Under this interpretation, marks are explicitly formulated as an isolated contribution of skills when UTSK is controlled for, and as an isolated contribution of UTSK when skills are controlled for, while the assumed perfect complementarity accentuates the importance of UTSK. Finally, it should be noted that the TP industry can still positively effect $v$, as the assumption only accounts for the unproductive component of TP activity. Intuitively, it could be imagined that a typical TP school offers two services. The first service only helps students to read school textbooks (productive knowledge). The second service, which is of importance to this study, only trains students to pass the examination (unproductive knowledge).

It might seem that those deprived of UTSK are doomed to have lower marks, regardless of their skills. This may not be an overstatement in light of the evidence demonstrated in section "Motivation"; however, it generally depends on equilibrium test-taking behaviors, which depend on other parameters.

Finally, two colleges are denoted as $\overline{c}$ and $\underline{c}$. It is public knowledge that graduating from college $\overline{c}$ gives a wage premium $\overline{\beta} \in \mathbb{R}_{>0}$, whereas $\underline{c}$ gives $\underline{\beta} \overset{\text{set}}{<} \overline{\beta}$. Thus, an applicant that is accepted into $\overline{c}$ will get benefit from an extra wage premium $\beta \overset{\text{def}}{=} \overline{\beta} - \underline{\beta}$. The premium of $\underline{c}$ is normalized $\underline{\beta} \overset{\text{set}}{=} 0$. In effect, analytically, colleges are reduced to a single real-valued parameter $\beta$, and below several interpretations to $\beta$ are made.

If $\overline{c}$ and $\underline{c}$ are understood to be different colleges or even two groups of colleges (e.g., regional vs. federal), then the size of $\beta$ captures the presence of a highly

competitive college that provides graduates with access to highly paid jobs. This interpretation provides insight into why most competitive colleges (e.g., the top colleges in Russia or Japan) tend to prefer a decentralized admission processes.

Working with a two-by-two case enriches the model with two additional interpretations, which are less directly inspired by the above mentioned Georgian and Russian examples. If $\overline{c}$ and $\underline{c}$ are levels of education (e.g., a graduate school and college degree, or a high school diploma and a college degree), then $\beta$ is an extra wage premium between levels of education and the model interprets applicants $\{s_i^\theta\}_{i=1}^2$ as two aggregated groups, one of which could be "unprivileged". This interpretation sheds light on cross-country differences in the application of CCA (e.g., in the United States). Finally, if $\overline{c}$ and $\underline{c}$ are different majors, then the size of $\beta$ captures the presence of unusually well-paid specializations. This interpretation helps to explain why some specializations prefer decentralized allocation while others prefer centralized allocation (e.g., the medical profession in Ireland or Australia).

In summary, the game is denoted by $\left(\left\{s_i^\theta, b_i(v_i, w_i)\right\}_{i=1}^2, \beta, f_{V,W}(v,w)\right)$ where:

$$
\begin{aligned}
s_i^\theta &- \text{an applicant } i \text{ with type } \theta \stackrel{\text{def}}{=} (v,w),\\
b_i(v_i,w_i) &- \text{applicant } i\text{'s centralized exam mark},\\
v_i &- \text{applicant } i\text{'s unobserved skills},\\
w_i &- \text{applicant } i\text{'s unobserved access to UTSK},\\
\beta &- \text{the institution's extra wage premium},\\
V,W &- \text{random variable for skills and UTSK, respectively.}
\end{aligned}
$$

### 3.2.3 Sequence of actions and the utilities functions

The basic rules of CCA are fairly well known. In a stylistic version of this system, both applicants simultaneously sit a centralized examination from which

they receive their results in the form of examination marks $\{b_i\}_{i=1}^{2}$. The applicant with the highest mark is assigned to $\overline{c}$; the other applicant goes to $\underline{c}$. The following utility function captures this for an arbitrary applicant, $i$:

$$\mathbb{U}_{s_i^\theta} = \begin{cases} \beta - {}^{b_i}/_{v_i} & \text{if admitted to } \overline{c} \\ -{}^{b_1}/_{v_i} & \text{if admitted to } \underline{c} \end{cases}. \tag{3.2}$$

Putting in an effort in order to achieve the exam mark $b_i$ results in a disutility of ${}^{b_i}/_{v_i}$. Hence, the total utility of a student with ability $v_I$ from achieving exam mark $b_i$ is $\beta - {}^{b_i}/_{v_i}$ if he or she is assigned to college $\overline{c}$ and $-{}^{b_i}/_{v_i}$ otherwise. This utility function has been extensively exploited in college admission context and it originates from the work of Moldovanu and Sela (2001).

Assumption 3.1, while having the already discussed appealing economic content, offers a significant analytical convenience. It reduce the dimensionality of the private space. Instead of finding a solution for $b(v, w)$, which has two arguments, we firstly find a solution for $b(v)$. This approach was first proposed by Che and Gale (1996) and gained wide acceptance (Krishna 2009, p. 42). One could think of $b(v)$ as the examination mark of an applicant who is not limited by UTSK, but who understands that the competing applicant could be constrained, and so on (i.e., common knowledge assumption). This solution approach is consistent with previous studies by Che and Gale (1998), Fang and Parreiras (2002, 2003) and Kotowski (2010) and Kotowski and Li (2014).

Finally, to use auction-theoretical tools, the following is further assumed about $b(v)$.

**Assumption 3.2.** *Applicants with the same skills will achieve the same examination marks:*

$$b_1(\cdot) = b_2(\cdot) = b(\cdot). \tag{3.3}$$

Table 3.1: Sample space of college's utility function

| | $b(v_2) \leq w_2$ | $b(v_2) \geq w_2$ |
|---|---|---|
| $b(v_1) \leq w_1$ | A: $v_1$ if $v_1 \geq v_2$, $v_2$ if $v_1 \leq v_2$ | B: $v_1$ if $b(v_1) \geq w_2$, $v_2$ if $b(v_1) \leq w_2$ |
| $b(v_1) \geq w_1$ | C: $v_1$ if $w_1 \geq b(v_2)$, $v_2$ if $w_1 \leq b(v_2)$ | D: $v_1$ if $w_1 \geq w_2$, $v_2$ if $w_1 \leq w_2$ |

*Additionally, marks strictly increase with skills:*

$$b(v_i) > b(v_j) \Leftrightarrow v_i > v_j \quad i, j \in \{1, 2\} \quad i \neq j. \tag{3.4}$$

Taken together, these two assumptions imply that Applicant 1 distinguishes three states:

$$\mathbb{U}_{s_1}\Big(b, b(\theta_2)\Big) = \begin{cases} \beta - {}^{b_1}/_{v_1} & \text{if } v_1 > v_2 \text{ and } w_2 > b(v_2) \text{ or } w_2 < b(v_2), \\ \beta - {}^{b_1}/_{v_1} & \text{if } v_1 < v_2 \text{ and } w_2 < b(v_2), \\ -{}^{b_1}/_{v_1} & \text{if } v_1 < v_2 \text{ and } w_2 > b(v_2) \end{cases}. \tag{3.5}$$

In the first state, Applicant 1 wins, as he/she is the most skillful regardless of Applicant 2's access to UTSK. In the second state, Applicant 1 wins despite Applicant 2 being more skillful, but fails to complement his/her skills with UTSK. In the third state, Applicant 1 loses because Applicant 2 is more skillful and has better access to UTSK.

College $\bar{c}$ distinguishes two states:

$$\mathbb{U}_{\bar{c}} = \begin{cases} v_1 & \text{if } \min\{b(v_1), w_1\} > \min\{b(v_2), w_2\} \\ v_2 & \text{if } \min\{b(v_1), w_1\} < \min\{b(v_2), w_2\} \end{cases}. \tag{3.6}$$

These two outcomes can be achieved in four different ways (see Table 3.1). Taking the expectation over all possible states produces:

$$\mathbb{U}_{\overline{c}}^{e}(b(v,w)) = A + B + C + D \tag{3.7}$$

where

$$\begin{aligned} A = \int_0^1 \int_{b(v_2)}^{\overline{w}} \int_0^1 \int_{b(v_1)}^{\overline{w}} & v_1 \mathbb{1}\{v_1 \geq v_2\} \\ & + v_2 \mathbb{1}\{v_1 \leq v_2\} f(v_1, w_1) f(v_2, w_2) dw_1 dv_1 dw_2 dv_2 \end{aligned} \tag{3.8}$$

$$\begin{aligned} B = \int_0^1 \int_{\overline{w}}^{b(v_2)} \int_0^1 \int_{b(v_1)}^{\overline{w}} & v_1 \mathbb{1}\{b(v_1) \geq w_2\} \\ & + v_2 \mathbb{1}\{b(v_1) \leq w_2\} f(v_1, w_1) f(v_2, w_2) dw_1 dv_1 dw_2 dv_2 \end{aligned} \tag{3.9}$$

$$\begin{aligned} C = \int_0^1 \int_{b(v_2)}^{\overline{w}} \int_0^1 \int_{\overline{w}}^{b(v_1)} & v_1 \mathbb{1}\{w_1 \geq b(v_2)\} \\ & + v_2 \mathbb{1}\{w_1 \leq b(v_2)\} f(v_1, w_1) f(v_2, w_2) dw_1 dv_1 dw_2 dv_2 \end{aligned} \tag{3.10}$$

$$\begin{aligned} D = \int_0^1 \int_{\overline{w}}^{w_1} \int_0^1 \int_{w_2}^{\overline{w}} & v_1 \mathbb{1}\{w_1 \geq w_2\} \\ & + v_2 \mathbb{1}\{w_1 \leq w_2\} f(v_1, w_1) f(v_2, w_2) dw_1 dv_1 dw_2 dv_2. \end{aligned} \tag{3.11}$$

### 3.2.4 Equilibrium test-taking behavior

For heuristic derivation, the game is treated as a revelation mechanism. Both applicants report their types to a mediator who sits exams for them. Assume truth-telling by Applicant 2. Then, in a symmetric equilibrium, the expected utility for Applicant 1 of type $(v_1, \overline{w})$ with the mediator choosing $b(x)$ for

him/her is:

$$\begin{aligned}\mathbb{U}^e_{s_1}(b(x)) &= \mathbb{E}_{\theta_2}\Big[\mathbb{U}_{s_1}\Big(b(x), b(\theta_2)\Big)\Big] \\ &= \beta\mathbb{P}[v_2 < x] + \beta\mathbb{P}[v_2 > x]\mathbb{P}[w_2 < b(x)] - \frac{b(x)}{v} \\ &= \beta F_V(x) + \beta(1 - F_V(x))F_W(b(x)) - \frac{b(x)}{v}.\end{aligned} \tag{3.12}$$

The first line states that Applicant 1's utility, as prescribed by the Bayes Nash equilibrium, is an expected value over pay-off relevant states with respect to the competing types of applicants. The second line captures an admission when he/she is the most skillful and an admission when he/she is not skillful, but the competing applicant lacks UTSK. The last line holds by the definition of the cumulative distribution function. The first order condition for truth-telling to be an equilibrium is that the derivative of $\mathbb{U}^e_{s_1^{(v_1,\overline{w})}}(\cdot)$ with respect to $x$ evaluated at $v$ is equal to zero. Namely, the condition

$$\frac{\partial \mathbb{U}^e_{s_1}(b(x))}{\partial x}\bigg|_{x=v} \overset{\text{set}}{=} 0 \tag{3.13}$$

takes the form of

$$-\beta F_W(b(v))f_V(v) + \beta f_V(v) - \frac{b'(v)}{v} + \beta(1 - F_V(v))f_W(b(v))b'(v) \overset{\text{set}}{=} 0, \tag{3.14}$$

which can be simplified to identify a differential equation that characterizes $b(v;\beta)$, with a real valued parameter $\beta$ denoted explicitly for expositional convenience. The following proposition summarizes the results.

**Proposition 3.1.** *Suppose the environment satisfies Assumptions 3.1 and 3.2, then there exists a symmetric equilibrium of the form* $b(v,w) = \min\{b(v), w\}$ *in*

*increasing piecewise differentiable strategies*

$$b^{EQ}(v,w)=\begin{cases}\hat{b}(v) & \text{if } v\le\tilde{v}\\ \min\{b(v),w\} & \text{if } v>\tilde{v}\end{cases}, \tag{3.15}$$

*where*

*(a)* $\tilde{v}\overset{def}{=}\inf\{v\in[0,1]:b(v)\ge\underline{w}\}$;

*(b)* $b(\cdot)$ *is implied in*

$$b'(v)=\frac{\beta v f_V(v)\Big(1-F_W\Big(b(v)\Big)\Big)}{1-\beta v f_W\Big(b(v)\Big)\Big(1-F_V(v)\Big)}, \tag{3.16}$$

*which has a boundary condition* $b(\tilde{v})=\underline{w}$;

*(c) Case* $v\le\tilde{v}$ *yields a differential equation* $\beta v f_V(v)=b'(v)$ *that gives an explicit*

$$\hat{b}(v)=\beta\int_0^v y f_V(y)dy. \tag{3.17}$$

*Proof.* We can write the expected utility as

$$\mathbb{U}^e_{s_1}(b(x))=\mathbb{U}^e_{s_1}(b(\tilde{v}))+\int_{\tilde{v}}^{x}\frac{d}{dt}\mathbb{U}^e_{s_1}(b(t))\Big|_{t=y}dy \tag{3.18}$$

I now verify that no applicant wishes to deviate. Consider an applicant with skills $v<\tilde{v}$. When following the strategy $b(v,w)$, this applicant puts an effort that yields him or her an exam mark $b(v)=\hat{b}(v)$. From Moldovanu and Sela (2001), we know that this applicant will not have a profitable deviation to any effort level $b(x)$, $x\in[0,\tilde{v}]$. Suppose instead that this applicant contemplates about $b(x)$ for some $x>\tilde{v}$. The expected payoff from this effort level is given

by Equation (3.18). It is sufficient to verify that when $v < x$, $\frac{d}{dt}\mathbb{U}^e_{s_1}(b(t)) \leq 0$

$$\begin{aligned}\frac{d}{dt}\mathbb{U}^e_{s_1}(b(t)) &= \frac{d}{dt}\Big(\beta F_V(t) + \beta(1-F_V(t))F_W(b(t)) - \frac{b(t)}{v}\Big)\\ &= b'(t)\Big(\beta(1-F_V(t))f_W(b(t)) - \frac{1}{v}\Big) + \beta f_V(t)(1-F_W(b(t)))\\ &= (v-t)\frac{\beta(1-F_W(b(t)))f_V(t)}{v(1+t\beta(F_V(t)-1)f_W(b(t)))}\\ &\leq (t-t)\frac{\beta(1-F_W(b(t)))f_V(t)}{t(1+t\beta(F_V(t)-1)f_W(b(t)))} = 0\end{aligned} \tag{3.19}$$

Consider instead an applicant with a skill level $v \geq \tilde{v}$. An argument parallel to the preceding case confirms that an effort that results in $b(x)$, $x > v$, will not be a profitable deviation.

Finally, consider a deviation to $b(x)$, $x < \tilde{v}$. It is sufficient to show that $\frac{d}{dt}\mathbb{U}^e_{s_1}(b(t)) \geq 0$ for all $t < \tilde{v}$.

$$\begin{aligned}\frac{d}{dt}\mathbb{U}^e_{s_1}(b(t)) &= \beta\int_0^v tf_V(t)dt - \beta\int_0^t tf_V(t)dt\\ &\geq \beta\int_0^t tf_V(t)dt - \beta\int_0^t tf_V(t)dt = 0\end{aligned} \tag{3.20}$$

The above analysis is exhaustive of all the cases; thus, the considered strategy profile is a symmetric equilibrium. □

The differential equation (3.16) is defined over a set $\{v \in [0,1] : b(v) \geq \underline{w}\}$ and it accounts for the change in marginal incentives faced by Applicant 1. A slight increase in investment in marks not only allows an applicant to outperform other applicants with slightly higher skill levels, $v$, but also to outperform applicants with sufficiently low access to UTSK, $w$, regardless of their skill level, $v$.

A property of the differential equation is that it permits an explicit solution when $b(v) < \underline{w}$. The technical reason for this is that the value of $b(v)$ of this size

is outside of the support of $W$, which makes $f_W(\cdot) = F_W(\cdot) = 0$. The solution to the differential equation under these conditions coincides with a one prize, two players tournament absent the budget constraint defined in Proposition 1 in Moldovanu and Sela (2001), and denoted here by $\hat{b}(v)$. The economic meaning is that an applicant with low skills will not strategize against applicants who might have less fortunate TP opportunities.

**Example 3.1.** *Assume* $V \overset{i.i.d.}{\sim} \mathcal{U}[0,1]$, $W \overset{i.i.d.}{\sim} \mathcal{U}[0.5, 2.08]$ *and* $\beta = 3$ *then*

$$b^{EQ}(v,w) = \begin{cases} \hat{b}(v) & \text{if } v \leq 0.57 \\ \min\{b(v), w\} & \text{if } v > 0.57 \end{cases}, \tag{3.21}$$

*where*

$$\hat{b}(v) = (3/2)v^2 \tag{3.22}$$

*and* $b(v)$ *is implied in*

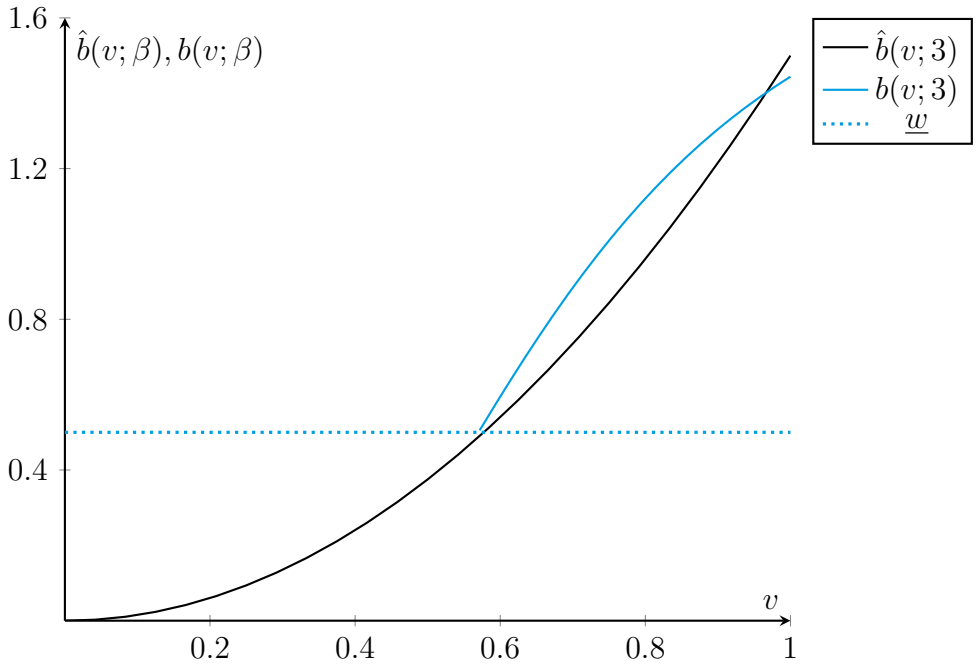
$$b'(v) = \frac{3v\left(1 - \left(\frac{b(v)-0.3}{2.08-0.5}\right)\right)}{1 - 3v\left(\frac{1-v}{2.08-0.5}\right)}, \tag{3.23}$$

*which has a boundary condition* $b(0.57) = 0.5$.

$\hat{b}(v)$ in Figure 3.3 represents the mark that an applicant with skill level, $v$, would have had if UTSK were assumed away. In an explicit formulation of UTSK, applicants with skill levels of $v < 0.57$ will still receive the same mark; however, applicants with skill levels of $v > 0.57$ will choose to invest more in preparation and will be awarded marks in the size of $b(v)$. The parameter $\underline{w}$ plays a defining role here; in the case when $\underline{w} \geq b(1)$, function $b(v)$ never emerges and applicants of all types behave in accordance with $\hat{b}(v)$. Therefore, this model is a generalization of Moldovanu and Sela's (2001) model.

The model clearly indicates that under CCA certain types of applicants with better access to UTSK will rationalize their overinvestment in TP not because

Figure 3.3: Functions $\hat{b}(v)$ and $b(v)$ from Example 3.1.




they are concerned about their knowledge productivity, but merely to gain an advantage over those who may have less access to UTSK.

## 3.3 Implications for Centralized College Admission

This section explores a change in the equilibrium behaviors and sorting outcomes in response to a change in the college wage premium, $\beta$, and a change in distribution, $F_W$.

A technical prelude is required. It is known from analyses of the war of attrition (Kotowski and Li 2014) and first (Che and Gale 1998) and second (Fang and Parreiras 2002) price auctions that the presence of a budget constraint may encourage more aggressive bidding. Due to the competing effects of budget constraints, behavior in all-pay auctions can go either way (Kotowski and Li 2014). A bidder is more optimistic regarding an item's value because, in equilibrium, that bidder may defeat an opponent with a high private value who has a low budget. However, budgets also stratify competition, as when fewer bidders are capable of competing at higher levels, the marginal incentive to bid higher declines. This serves to depress bidding.

A unique feature of my model is that $\beta$ can regulate which effect will eventually dominate. For lower values of $\beta$, a budget constraint might depress bidding for some types (see Figure 3.3); however, for higher values of $\beta$, all types of bidders bid more aggressively.

Some of this intuition carries over to a change in $F_W$: when an applicant is more likely to win admission into college because his/her opponent has a lower budget rather than a lower skill level. In the war of attrition, and first and second price auctions, the change encourages bidding. In an all-pay auction, the effect is ambiguous. These behavior features have economic significance for the college admission problem.

### 3.3.1 Comparative statics in wage premium

A change in $\beta$ captures the change in equilibrium test-taking behaviors in relation to different colleges (groups of colleges, levels of education or specializations). Intuitively, a higher wage premium justifies a higher investment into activities that will lead to higher marks being achieved; however, this requires both high levels of skills and UTSK.

Figure 3.4 uses Example 3.1 to show how applicants respond to a change in $\beta$. Prima facie intuition is indeed confirmed. The most prestigious colleges are overwhelmed by applicants with exceptionally high examination marks but mediocre skill levels. When beta is equal to 2 the presence of TSK changes practically nothing in the applicants' behaviour, as shown by the difference between blue and black solid lines. When beta is equal to 6 the blue and black dashed lines are radically different. It shows that the behaviour of applicants is highly sensitive to the size of the college wage premium, but only if TSK is accounted for. In other workds, accounting for UTSK reveals that high wage premium colleges are more likely to be affected by gaming against applicants with fewer preparation opportunities. These results hold generally.

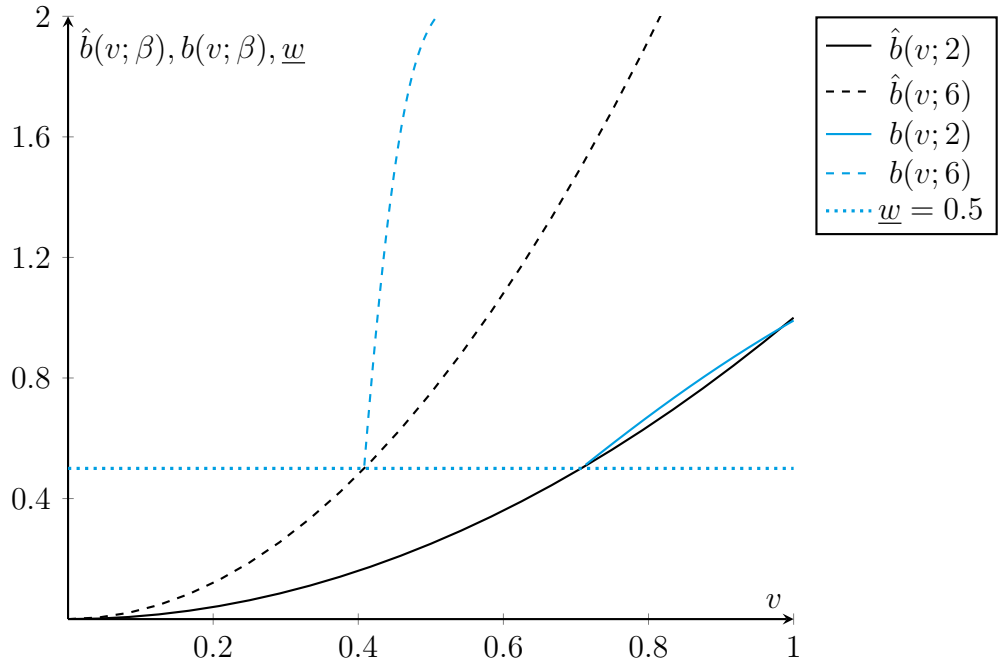
**Proposition 3.2.** *Suppose $\beta' > \beta$, i.e., the college wage premium is higher. Then under the conditions of Proposition 3.1:*

*(a)* $\lim_{v\to\tilde{v}^+} b'(v;\beta) > \lim_{v\to\tilde{v}^-} b'(v;\beta)$;

*(b)* $\lim_{v\to\tilde{v}^+} b'(v;\beta') - \lim_{v\to\tilde{v}^-} b'(v;\beta') > \lim_{v\to\tilde{v}^+} b'(v;\beta) - \lim_{v\to\tilde{v}^-} b'(v;\beta) > 0$;

*(c)* $b(v;\beta') > b(v;\beta) > \hat{b}(v;\beta)$ *for* $\beta > \frac{F_W(b(v;\beta))}{f_W(b(v;\beta))} \frac{1}{1-F_V(v)} \frac{1}{v}$.

Figure 3.4: Comparative statics in $\beta$ using Example 3.1.




*Proof.* A direct calculation gives (a)

$$\begin{aligned}
\lim_{v\to\tilde{v}^+} b'(v;\beta) &= \lim_{v\to\tilde{v}^+} \frac{\beta v f_V(v)(1-F_W(b(v)))}{1-\beta v f_W(b(v))(1-F_V(v))} \\
&= \frac{\beta\tilde{v} f_V(\tilde{v})(1-F_W(b(\tilde{v})))}{1-\beta\tilde{v} f_W(b(\tilde{v}))(1-F_V(\tilde{v}))} \\
&= \frac{\beta\tilde{v} f_V(\tilde{v})(1-F_W(\underline{w}))}{1-\beta\tilde{v} f_W(\underline{w})(1-F_V(\tilde{v}))} \\
&= \frac{\beta\tilde{v} f_V(\tilde{v})}{1-\beta\tilde{v} f_W(\underline{w})(1-F_V(\tilde{v}))} \\
&= \frac{1}{1-\underbrace{\beta\tilde{v} f_W(\underline{w})(1-F_V(\tilde{v}))}_{<1}}\beta\tilde{v} f_V(\tilde{v}) \\
&> \beta\tilde{v} f_V(\tilde{v}) = \lim_{v\to\tilde{v}^-} b'(v;\beta).
\end{aligned} \tag{3.24}$$

The third line uses a boundary condition $b(\tilde{v}) = \underline{w}$, whereas the last line uses a differential equation for case $v \le \tilde{v}$.

To see (b), note that the above showed

$$\lim_{v\to\tilde{v}^+} b'(v;\beta) = \psi(\beta) \lim_{v\to\tilde{v}^-} b'(v;\beta) \tag{3.25}$$

where

$$\psi(\beta) \stackrel{\text{def}}{=} \frac{1}{1-\beta\tilde{v}f_W(\underline{w})(1-F_V(\tilde{v}))} > 1. \tag{3.26}$$

Clearly, $\psi'(\beta) > 0$ as

$$\frac{\partial}{\partial\beta}\left(\frac{1}{1-\beta\tilde{v}f_W(\underline{w})(1-F_V(\tilde{v}))}\right) = \frac{f_W(\underline{w})(1-F_V(\tilde{v}))\tilde{v}}{((F_V(\tilde{v})f_W(\underline{w})-f_W(\underline{w}))\tilde{v}\beta+1)^2} > 0. \tag{3.27}$$

An increase in $\beta$ reinforces the gap between $b(\cdot)$ and $\hat{b}(\cdot)$.

A direct calculation gives (c)

$$\begin{aligned} b'(v;\beta) &> \hat{b}'(v;\beta) \\ \frac{\beta v f_V(v)(1-F_W(b(v)))}{1-\beta v f_W(b(v))(1-F_V(v))} &> \beta v f_V(v) \\ \beta &> \frac{F_W(b(v;\beta))}{f_W(b(v;\beta))}\frac{1}{1-F_V(v)}\frac{1}{v}. \end{aligned} \tag{3.28}$$

□

Thus, Part (a) of Proposition 3.2 shows that UTSK always encourages more aggressive test-taking behaviors among some applicants (due to the realization of their relative advantage). Part (b) shows that an increase in the wage premium always makes test-taking behaviors more aggressive. Part (c) shows that, for a sufficiently high wage premium, applicants of all skill levels will behave more aggressively (to my knowledge, this is a unique novel property of a contest version of an all-pay auction, that only emerges when we incorporate a budget constraint).

### 3.3.2 Change in access to UTSK

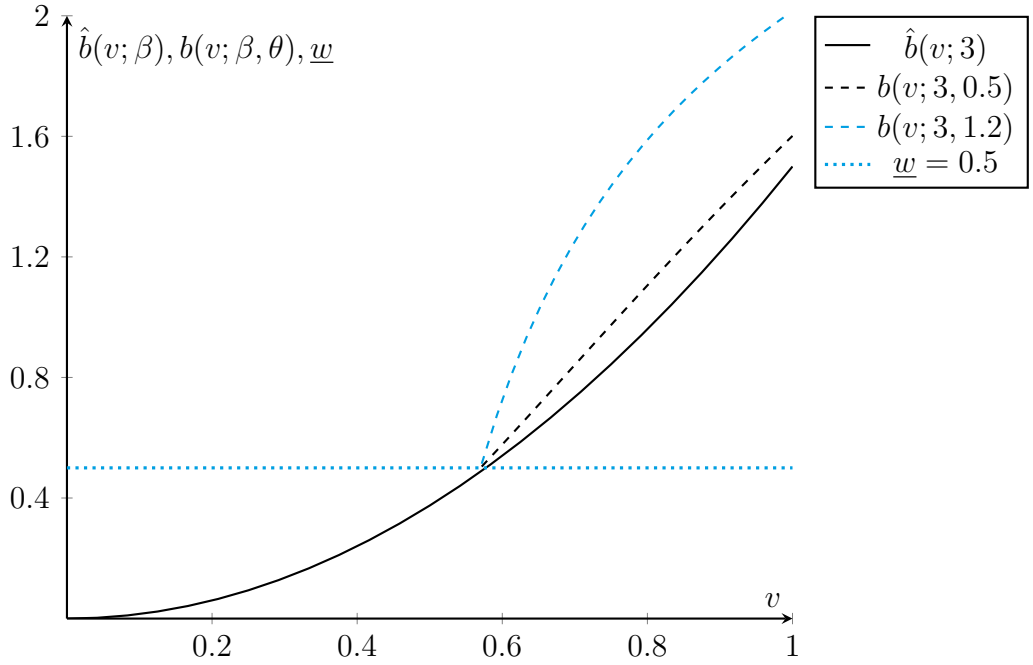
As Figure 3.2 demonstrates, TP schools tend to be located in higher income areas. This tendency produces areas where applicants are more deprived of UTSK in comparison to applicants from higher income areas who are less deprived of UTSK. Such circumstances systematically place applicants from lower

income areas in less advantageous positions. This mechanism can be studied in the current model as an increase in probability that one's opponent will fail to broadcast his/her skill level due to a lack of UTSK.

It is natural to expect more aggressive test-taking behaviors ceteris paribus whenever a competing applicant is more likely to be constrained by UTSK. CCA intensifies competition for admission into colleges, as a remote location stops being a barrier to become an applicant for a college sit. In this context, a sure way to game the system is to exploit non-universal access to UTSK.

Consider Example 3.1, and replace distribution of UTSK with $F_W(w;\theta) = 1 - \exp(-\theta(w - \underline{w}))$ distributed on $[\underline{w}, \infty)$ and fix $\underline{w} = 0.5$. An increase in $\theta$ makes one's opponent more likely to be constrained. This corresponds to rising deprivation of TSK in comparison to applicants from higher income areas who are less deprived of TSK (i.e., growth of TP industry from Figure 3.2). Figure 3.5 shows equilibrium test-taking behavior as the function of $\theta$.

Figure 3.5: Comparative statics in $\theta$ using Example 3.1.




**Proposition 3.3.** *Suppose $F_{W'}(w)$ dominates $F_W(w)$ in terms of the reverse hazard rate, i.e., the likelihood that one's opponent would fail to complement*

*his/her skills with UTSK is higher. Then, under the conditions of Proposition 3.1:*

$$b_{W'}(v) > b_W(v) > \hat{b}(v) \quad for \quad \beta > \frac{F_W(b(v;\beta))}{f_W(b(v;\beta))} \frac{1}{1-F_V(v)} \frac{1}{v}. \tag{3.29}$$

*Proof.* The proof is similar to that in Krishna (2009, p. 47). Let $b > b_{W'}(\tilde{v}) = b_W(\tilde{v})$. Then $F_{W'}(w) < F_W(w)$ and $f_{W'}(w) > f_W(w)$. Thus, for all $b$ where Equation (3.16) is positive:

$$0 < \frac{\beta v f_V(v)(1-F_W(b))}{1-\beta v f_W(b)(1-F_V(v))} < \frac{\beta v f_V(v)(1-F_{W'}(b))}{1-\beta v f_{W'}(b)(1-F_V(v))}. \tag{3.30}$$

If $b_{W'}(v)$ and $b_W(v)$ intersect, the former is steeper than the latter and this implies that they intersect once at most. Additionally, $b_W(v)$ would cross $b_{W'}(v)$ from above.

Thus, if $b_W(v) > b_{W'}(v)$ for any $v > \tilde{v}$, then $b_W(v) > b_{W'}(v)$ for $v \in (\tilde{v}, z)$, where $z$ sufficiently small. Fix $\tilde{v} < v < z$ then

$$f_{W'}(b_{W'}(v)) \geq f_W(b_{W'}(v)) \geq f_W(b_W(v)) \tag{3.31}$$

and

$$F_{W'}(b_{W'}(v)) \leq F_W(b_{W'}(v)) \leq F_W(b_W(v)). \tag{3.32}$$

Therefore, $b'_{W'}(v) \geq b'_W(v)$.

Finally, because $b_W(v)$ and $b_{W'}(v)$ can be expressed as integral equation,

$$b_W(\tilde{v}) = b_W(z) - \int_{\tilde{v}}^{z} b'_W(x)dx > b_{W'}(z) - \int_{\tilde{v}}^{z} b'_{W'}(x)dx = b_{W'}(\tilde{v}) \tag{3.33}$$

which contradicts $b_{W'}(\tilde{v}) = b_W(\tilde{v})$. Therefore, $b_{W'}(v) > b_W(v)$. □

Thus, a better prospect for defeating an applicant with no access to UTSK rationalizes more aggressive test-taking behaviors across applicants of all skill

levels. Proposition 3.3 connects the concentration of TP schools in higher income areas, as shown by Figure 3.2, and the elevation of exams marks, as shown by Figure 3.1.

Importantly, there is another subtle economic counterpart to the comparative statics of Proposition 3.3, which reveals the unearned power that the TP industry possesses due to the presence of a certain information asymmetry. A Bayes Nash equilibrium requires that a characterization of a bivariate random variable $(V, W)$ be commonly known. It is plausible to envision that applicants would be able to make a sound guess on the characterization of $V$, due to the inherent long-term stability of the distribution of skills; however, it is somewhat less appealing to envision that applicants would be able to make a sound guess on the characterization of $W$. For example, an average applicant might know how skilled in math a competing applicant is, but is likely clueless as to how skilled the competing applicant is in sitting standardized exams that have been recently introduced. The support and the distribution of availability of UTSK are unlikely to be stable long enough to become common knowledge. Thus, applicants at a given admission cycle should infer how many applicants do not use the TP industry to access UTSK (e.g., come from areas that do not have a well-developed TP industry.).

In a typical advertisement campaign, a typical TP school will contend that its paying clients will gain access to an exclusive bank of questions that mimics the real test. Such TP schools are effectively declaring that they can help applicants who attend their school to outperform those who will not have access to such questions. The moment that parents accept this declaration, the mechanics of Proposition 3.3 apply.

Therefore, to explain the elevation of exam marks in Figure 3.1, there is no need for a massive TP industry to emerge in higher income areas, as in Figure 3.2. All it takes is a noisy advertisement campaign by a few TP schools, through which parents would attempt to infer the distribution of the availability

of UTSK and rationally respond by over-engaging the TP industry.

What is quite remarkable is that this outcome is entirely in line with an idea of normalization of aggressive TP practices, which has been extensively documented by educational scientists. Once aggressive TP practices enter a society, it is impossible to remove them (Bray 2009). The model exposes the force (i.e., information) that makes aggressive TP practices so persistent.

### 3.3.3 Influence on college's utility

Thus far, the model has shown that an increase in wage premium and the probability that a competing applicant lacks UTSK intensifies test-taking behaviors. The following summarizes the consequences of such behaviors on the quality of sorting.

**Theorem 3.1.** *Suppose* $\beta' > \beta > \frac{F_W(b(v;\beta))}{f_W(b(v;\beta))} \frac{1}{1-F_V(v)} \frac{1}{v}$ *or* $F_{W'}(w) \leq F_W(w)$*, then under the conditions of Proposition 3.1:*

$$\mathbb{U}_{\bar{c}}^{e}(b(v,w);\beta') < \mathbb{U}_{\bar{c}}^{e}(b(v,w);\beta) \tag{3.34}$$

*or*

$$\mathbb{U}_{\bar{c}}^{e}(b_{W'}(v,w)) < \mathbb{U}_{\bar{c}}^{e}(b_{W}(v,w)). \tag{3.35}$$

*Proof.* Note that the results in Proposition 3.2 and Proposition 3.3 show that the conditions of this theorem guarantee that all types of applicants will behave more aggressively; that is, function $b(v)$ will attain a higher value for all $v$.

Now we inspect the definition of college utility $\mathbb{U}_{\bar{c}}^{e}(b(v,w))$ from Equation (3.7) to see what this aggression implies for the sorting quality.

Clearly, the first component of the utility function (event $A$) is strictly decreasing in $b$, since the area of integration is strictly smaller. The last component (event $D$) is independent of $b$ and can be ignored.

Note that event $B$ can be rewritten to remove $b(\cdot)$ from inside the integral:

$$
\begin{aligned}
B = &\int_0^1 \int_{\underline{w}}^{b(v_2)} \int_0^1 \int_{b(v_1)}^{\overline{w}} v_1 \mathbb{1}\{v_1 \geq b^{-1}(w_2)\} \\
&\qquad + v_2 \mathbb{1}\{v_1 \leq b^{-1}(w_2)\} f(v_1, w_1) f(v_2, w_2) dw_1 dv_1 dw_2 dv_2 \\
= &\int_0^1 \int_{\underline{w}}^{b(v_2)} \int_0^1 \int_{b(v_1)}^{\overline{w}} v_1 \mathbb{1}\{v_1 \geq v_2\} \\
&\qquad + v_2 \mathbb{1}\{v_1 \leq v_2\} f(v_1, w_1) f(v_2, w_2) dw_1 dv_1 dw_2 dv_2.
\end{aligned} \tag{3.36}
$$

An increase in the area of integration in $w_2$ is compensated by a decrease in the area of integration in $w_1$, and, since $w$ is *i.i.d.*, event $B$ does not change the utility. Event $C$ is symmetric to event $B$; thus, the same reasoning can be applied to event $C$.

In sum, the utility is lower due to the influence of event $A$, whereas events $B$, $C$ and $D$ do not contribute to the change of utility. □

Proposition 3.2 and Proposition 3.3 show what could drive the skills-irrelevant elevation of exam marks, while Theorem 3.1 shows that the same forces explain the increasing number of colleges trying to exit CCA. Facts 3.1 and 3.2 are explained.

## 3.4 Conclusion

Inspired by wide ranging literature on shadow education, this paper uses auction-theoretical modeling to demonstrate a flaw in the college admission market design literature. For a clean illustration of this flaw, the paper explores a recent wave of introduction of CCA in ex-Soviet republics. It is shown that a disproportional accumulation of UTSK (proxied by the emergence of TP schools in higher income areas; depicted in Figure 3.1) rationalizes more aggressive TP practices (as seen by the skills-independent elevation of marks; depicted in Figure 3.2). This makes the sorting of applicants troublesome for colleges, especially for those that are highly competitive, and incentivizes colleges to exit the CCA system (depicted in Figure 3.2). The key economic message is that the functionality of CCA eventually depends on students' access to a stock of UTSK, which is created and managed by the TP industry and cannot be directly controlled or even credibly measured by a government regulator. The TP industry is an integral element of CCA. It benefits from an increase in the examination marks, but ignores the role of those marks in resolving uncertainty.

The test-preparation industry has reduced the social value and efficiency of centralised college admissions systems, and the mechanisms of these reductions involve students and their parents over-investing in tutoring designed expressly to help students pass centralised tests. The same essential problem would be expected to result whenever an educational selection mechanism (whether to college, to selective schools, or to any other type of educational opportunity) relies heavily on a single test or indicator of performance that can be inflated substantially via investments in third-party-provided training that does not comprehensively prepare students for the educational opportunity being allocated via the selection mechanism. The basic point of the chapter applicable to everything from centralised college-admission exams to Scholastic Aptitude Tests to English-language tests to selective-high-school tests, and the seeming

inevitability of the problem in any situation where third-party providers can enter the market argues against the use of small-dimension measures of performance in any educational selection mechanism. The basic point implies that there is a threshold amount of per-student evaluative effort that needs to be allocated in any mechanism of selection into educational opportunities in order for that mechanism to continue to perform as intended (at least given certain conditions, such as the ability of third-party providers to exploit market niches and sufficient income inequality to lead to more third-party training for better-off students irrespective of their actual ability, conditions which are surely true in most cases of interest).

The long-run implication of the phenomena highlighted in this chapter is that wage premia associated with college degrees may fall, to the extent that colleges are forced to use the polluted selection mechanism and are unable to educate to the prior standard the less-able student cohorts they must therefore take in, given the limited resources society allocates to them. One would then predict that at a certain (low) wage premium level, the incentive to get into college reduces enough that the pollution in the selection mechanism reduces, stabilizing the system. Alternatively, the system abundances the selection mechanism. As in the following example.

Conceptually, this flaw is not unique to the college admission context and possible existed (and became obsolete due to mechanics demonstrated in Theorem 3.1) on the marriage market. In hunter-gatherer societies, a man would signal his devotion to a woman by delivering to her, as a present, a piece of meat from a hunt. In being delivered as a present, the piece of meat contains information about the man's skills as a hunter and how devoted he is to the woman (Allen et al. 2011; Hawkes and Bird 2005). However, today, if a present (such as an item of jewelry) were to be given, a modern woman would be unable to determine if the gift were given as a sign of the man's genuine devotion or simply because the man had passed a gift store on his way to meet her for their

date and had sufficient money to buy the gift. Similarly, colleges cannot tell if applicants' high marks are driven by their skills (devotion to a woman) or by their having greater access to TP opportunities (low costs of buying a present).

# Chapter 4

# The Structure of Wages in Russia: 1985–2015

It is widely accepted that the information technology (IT) revolution drove changes in wage structures and earnings inequality in the United States and other Organization for Economic Co-operation and Development (OECD) countries in the 1970s. The empirical observation that the deployment of a new technology is accompanied by the creation of better paid jobs that require higher qualifications is known as SBTC (Acemoglu and Autor 2011; L. F. Katz and Autor 1999; Violante 2016). To generalize SBTC beyond IT, economists use the term "general purpose technology" to describe technological advances that pervade many sectors, improve rapidly, spawn further innovations and induce wage inequalities (Rousseau 2016). Jovanovic and Rousseau (2005) identify similarities in the ways in which the United States economy reacted to adaptations of electricity and IT from 1894 to 1930 and 1971 to 2005, respectively. Chin et al. (2006) show that the introduction of the steam engine from 1891 to 1912 created a new demand for engineers and deskilled able-bodied seamen. More recently, it has been argued that, in a modern economy, SBTC mechanisms reduce the demand for unskilled workers as a result of organizational changes (i.e., the decentralization of authority, the delayering of managerial functions

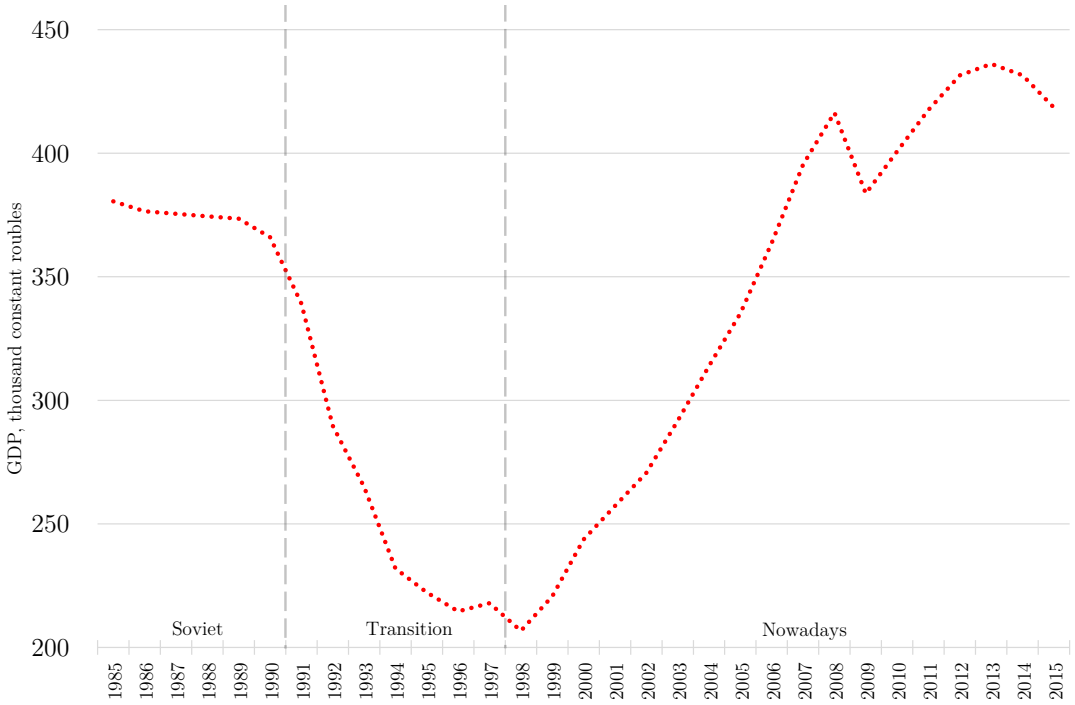
and increased multitasking) (Bresnahan et al. 2002; Caroli and Van Reenen 2001; Dessein and Santos 2006; Garicano and Rossi-Hansberg 2006; Milgrom and Roberts 1990).

Although SBTC processes have become the leading explanation for changes in the wage structures of developed countries, in Russia, little consideration regarding the effects of technological changes on the wage structure has been given to date. This paper shows that the SBTC framework provides a powerful explanation of the Russian wage structure for the period 1985 to 2015 and consolidates the somewhat disorganized literature on wages in Russia.

Academic discussions of wages in Russia generally consider three periods (see Figure 4.1): (1) wages in the Soviet period (i.e., before 1991); (2) wages during the transition period (the transition period is from 1991 to 1998); and (3) wages in Russia nowadays (i.e., from 1998 to date).

During the Soviet period, both college wage premiums (Gregory and Kohlhase

Figure 4.1: Russian economic output




*Notes:* GDP per capita is gross domestic product divided by midyear population. Data are in constant 2010 Russian roubles. Dashed vertical lines separate the periods.
*Source:* World Bank.

1988; K. Katz 1999) and general monetary inequalities (Novokmet et al. 2018) were very low. Inequalities existed in the form of access to better shops, products or vacation facilities, and jobs that required HE often provided that access. Unlike other Eastern European countries that were signatories to the Warsaw Pact,[1] returns to education during the transition period in Russia remained among the lowest in the world and were only slightly above returns during the Soviet period (aka the Market Adjustment Puzzle). This is attributed to the abundance of well-educated workers in an economy in which blue-collar employees were in high demand (Brainerd 1998; Cheidvasser and Benítez-Silva 2007).[2] Returns peaked in 1998, but have been gradually decreasing ever since. This is attributed to the larger involvement of applicants with lower levels of ability during the expansion of the HE system (Belskaya and Sabirianova Peter 2014; Belskaya, Sabirianova Peter, and Posso 2014; Kyui 2016). Similarly, Gorodnichenko, Peter, and Stolyarov (2010) detect a peaking of income inequality in 1998 and a gradual decrease ever since. They attribute this to an absence of significant macroeconomic turmoil.

The explanation of the Russian wage structure in this paper hinges on the

[1] In Poland, returns to education increased while the experience premium fell (Rutkowski 1996). Similar patterns took place in the Czech Republic and Slovakia (Chase 1998). In contrast, returns to both education and experience fell during the transition in Slovenia (Stanovnik and Verbič 2005) and in Romania (Andrén et al. 2005). Other influential comparative studies for the period of transition are as follows. Fleisher et al. (2005) concluded that returns to schooling increased proportionally with the speed of economic reforms and favored the young. Brainerd (2000) found that wage penalty for women increased in Russia and Ukraine, but decreased in the rest of Eastern Europe. Krueger and Pischke (1992) showed that returns to both education and experience fell slightly in eastern Germany after unification. Sabirianova Peter (2003) used linked employer-employee data and showed that in Russia the transition to a market economy was skills-biased because market liberalization adjusted wages to the true marginal productivity. Gorodnichenko and Peter (2005) compared wage premiums for schooling between Russia and its closest institutional analog, Ukraine, for the period 1985–2002 and noted that, once both economies were decentralized, the Russian wage premium went up quicker than that of Ukraine's and attained a significantly higher value.

[2] Other Russian HE wage premium studies for the period of transition are as follows. Newell and Reilly (1996) estimate a wage function at the very beginning of the reforms, and find low (about 4%) returns for schooling. Newell and Reilly (1999) report returns on levels of education up to 1996 and show an initial increase in returns and a subsequent decline. Clark (2003) utilizes the data for 1994-1998 and notes a significant (6-13%) return on a year of schooling comparable in magnitude to those in other transition economies.

most characteristic feature of the transition period – the transformational recession (an unexpected and universal[3] decline in output during the transition from a centralized to a market economy). To date, the transformational recession has largely been ignored in discussions on Russian wage structures.

A common theme of the theories of the recession is reorganisation (within and between firms). Atkeson and Kehoe (1995, 2005) put forward the first theoretical explanation for the recession, developing a model in which the transition is interpreted as an investment in new organizational capital. Their theory accentuate within firm reorganisation. The economic output decline during the first year of the transition may have reflected the adoption of new organizational technologies. If national accounts were to include firms' investments in information capital and reorganization, the decline would not have been so drastic.

Blanchard and Kremer (1997) hypothesize that this drop is the result of a coordination failure. Their theory accentuate between firm reorganisation. During the transition period, the Central Planner was dismissed but contractual institutions (e.g., reputation, vertical integration) were still not developed. Firms that manufactured intermediary products within the same chain of production in the command economy found options for alternative uses of their products (outside of their established uses) after decentralization. Ultimately, a product – generating profit for all firms in the chain – will only be produced within a chain of production if no firm uses an alternative option, and firms continue to not supply their intermediary product outside the established production chain. The more producers in a chain of production, the higher the chance of defection; hence, the observed pattern of output decline. Later, Roland and Verdier (1999) argue that this pattern could also be the result of higher search frictions in more complex industries.

In this research, it is noted that, if indeed economy collectively invested

[3]In ten out of the fifteen ex-Soviet republics, GDP for 1996 was estimated to stand at less than half its 1989 estimate (Boycko et al. 1997).

into reorganization, then the detectable creation of better paid jobs should accompany this effort (due to technology-skill complementarity and SBTC). To this end, this paper reestimates the return on HE from 1985 to 2015 and acknowledges that the skills of $\ell b$ graduates are complementary to organizational technologies.

Using the Russia Longitudinal Monitoring Survey (RLMS), it is shown that, during the transition period, the skills provided by $\ell b$ graduates experienced a substantial increase in returns. Conversely, the return on the skills provided by the remaining ($\overline{\ell b}$) graduates remained stagnant until 1997 (the returns of $\ell b$ were 136% higher than that of $\overline{\ell b}$ in 1995/1996). A scaled-up version of this differential persisted for another 10 years after a return of economic growth in 1998 (the returns were 120% higher in 2000 and 40% higher in 2002/2003); however, it ceased to exist in 2007/2008 due to the increase in the supply of $\ell b$ graduates in the market. This pattern suggests that firms did deploy organizational technologies after the economic reforms that created an unusually large labor market demand-side shock on the skills of $\ell b$ graduates after economic decentralization.

These findings provide a parsimonious explanation for the relatively low returns of HE from 1994 to 1996 and the decrease in returns from 1998 to 2015. Low returns during the transition period are not the result of an oversupply of educated workers; rather, it is the undersupply of $\ell b$ graduates that spikes the returns on specialization (up to 53%), and the oversupply of $\overline{\ell b}$ graduates, whose returns are the same as those of the Soviet Union (no more than 19%). The decrease in returns in present day Russia is not (at least exclusively) the result of a larger enrollment of applicants with lower abilities during the expansion of the HE system; rather, it is the effect of the transitory wage differential, which initially elevates the average returns and then causes them to plunge.

An analysis of occupations shows that the transitory differences in returns of various specializations led to massive changes in the structure of employed

professionals and technicians from 1985 to 2015. The economic transformation made most skills supplied by science, technology, engineering and math (STEM) graduates redundant (41% decrease) and replaced them with skills supplied by $\ell b$ graduates (240% increase).

These empirical findings add to an existing body of evidence that points to the similarity between the processes of economic transitions and SBTC. Economic theories that explicitly formulate an economic mechanism to explain SBTC also emphasize the effect of learning during periods of radical technical change. For example, this explains the productivity decline which occurred in most developed economies in the 1980s (Caselli 1999; Galor and Moav 2000; Greenwood and Yorukoglu 1997). When a new technology is first being deployed, output can decrease temporarily, as workers and firms learn how to use it (Aghion 2002; Hornstein and Krusell 1996).

Interpreting economic transition as a form of SBTC implies that the transformational recession may have been a period of learning/adaptation of the new technology. As such, it can be argued using theoretical modeling that the transformational recession could have been reduced if policy makers had acknowledged the dependency of the implementation of technologies on the supply of workers with complementary skills. Conversely, the HE system, unlike most of the economy, remained the property of the state, which led to a decade of underfunding, as the government struggled to balance its finances. In 1994, the parliament passed a series of laws that formally allowed private firms to invest in HE (Belskaya and Sabirianova Peter 2014); however, a fully functional regulatory framework that allowed HE to be privately financed by firms and applicants was not institutionalized until the 2000s. Thus, while the popularity of $\ell b$ specializations due to the high returns was unprecedented (Public Opinion Foundation 1998, 2006), the HE system was insensitive to labor market price signals for almost a decade after the beginning of the reforms.

Given the well-documented structural similarities between Russian and So-

viet economies (Ananyev and Guriev 2018; Mikhailova 2012), and that the differential leveled out in 2007/2008 (exactly when the Russian economy regained its size to that of late Soviet Russia), it can be conjectured that 6–7% of the labor force should have been supplying their $\ell b$ skills to foster the adoption of new organizational technologies in the market economy, which would have cushioned the transformational recession. However, at the beginning of the transitional reform, only 2–3% of the labor force had such skills, complicating the adoption of technologies and exacerbating the recession.

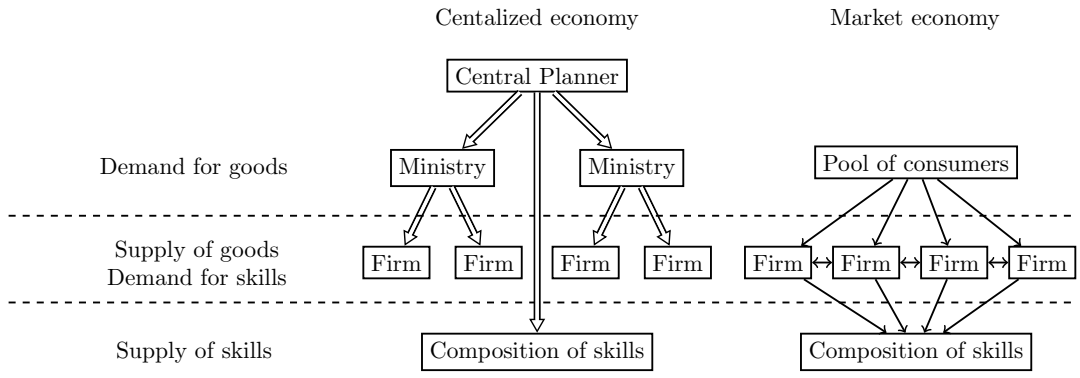
The remainder of this chapter proceeds as follows: Section 4.1 stylistically compares centralized and market economies; Section 4.2 summarizes the institutional environment using a compact theoretical model; Section 4.3 introduces the dataset and the solutions to certain data complications, provides definitions of specializations and outlines the empirical strategy; Section 4.4 provides estimates of the wage premium, the transitory wage differential and occupational shifts; Section 4.5 confirms the robustness of the results; Section 4.6 shows the significance of the discovered differential in relation to output decline; and Section 4.7 provides a reiteration of the main findings.

## 4.1 Institutional Background

Walras's general equilibrium is a widely accepted representation of a market economy (Arrow and Debreu 1954). A pool of consumers defines an aggregate consumption profile and, through the price system, firms follow demand. The environment requires firms to engage with consumers and each other; however, the contractual and informational imperfections that arise from these interactions require a judicial system and a body of contracts. This accounts for the amount of $\ell b$ graduates in the market economy. By analogy, a stylistical centralized economy does not use price signals to broadcast values and an aggregated consumption profile is defined by politicians. Demand and supply are connected by the Central Planner, while the execution of the plan is carried out by several hundreds of ministries that, through directives, harmonize enterprises into industries and industries into an economy. Firms have no need to engage with each other or consumers, which suggests a significantly lesser need for personnel trained in $\ell b$.

Figure 4.2 compares both types of economies in relation to the criteria. The thick arrows on the centralized type of economy signify the coordination of economic activities undertaken through administrative means (e.g., commands, directives, targets and regulations) rather than by a market mechanism, which is signified by the thin arrows.

Figure 4.2: Centralized and market economies



Central planning was applied to the United States economy from 1942 to 1946, the Mormon economic system in mid-19th century Utah, and the Inca production system in the 16th-century Andes; however, the Soviet Union was the first country to implement central planning to its fullest development in the 1920s (Ericson 2017). Initially, central planning proved effective at fostering growth. However, whereas market economies experienced an improvement in efficiency and delivered modern products through inter-branch relationships and flexible cross-industrial coordination from the 1970s, the existing system of branch ministerial organization in the Soviet Union resisted such arrangements. As the Russian economy grew in size and sophistication (e.g., in 1980, approximately 25 million commodities had entered the Central Plan in the Soviet Union; by comparison, no more than 1,200 had entered China's (Qian and Xu 1993)), centralized planning and control became more difficult and errors began to have a greater effect. In the late 1980s, disequilibria and imbalance, which had always existed, reached intolerable levels. The absence of the price system prevented a Walrasian re-equilibration and planning mistakes accumulated over decades, driving demand and supply further and further apart. By the last year of the Soviet Union, non-market considerations for resource allocation resulted in a situation in which the economy was able to send cosmonauts to space, but failed to produce enough food for the people (Levine 1983; Nove 2003).

The major economic and political reforms started in 1991 and were collectively labelled "price shock therapy" due to the inclusion of a sudden release of price and currency controls, the withdrawal of state subsidies, trade liberalization, large-scale privatization, and the dismissal of the Central Planner and ministries. The reforms assumed that the elimination of price and trade distortions that had kept the economy far inside its production frontiers would bring the economy closer to its potential output, while the development of new activities would shift the production frontier further out, leading to further increases in output over time. Most prices and wages were freed on January 2, 1992; in

1994, 70% of industrial workers were working in private firms (Boycko et al. 1997).[4]

[4]A wonderful coverage of the nature the Soviet centralized economy and the Gorbachev era or perestroika and glasnost can be found in Ericson (1983, 1991, 2006) and Grossman (1962, 1963, 1966).

## 4.2 Conceptual Framework and Predictions

The modeling is based on the observation that transformation is similar to SBTC and that price shock therapy did not change the fundamentals of the economy in the short- to mid-term. However, the sudden release of price and currency controls, the withdrawal of state subsidies, trade liberalization, large-scale privatization, and the dismissal of the Central Planner increased the share of work that required personnel to be trained in $\ell b$.

The modeling adopts an approach that became standard in the SBTC literature after it was first used by L. F. Katz and Murphy (1992).

There is a representative good

$$Y = F(A, K, L_s(\cdot), L_u), \tag{4.1}$$

generated by skilled labor $L_s(\cdot)$, unskilled labor $L_u$, capital $K$, and economy-wide technological change $A$, with $F(\cdot)$ increasing in all arguments.

The setup is similar to that used by Card and Lemieux (2001), who analyze the differential between different age groups. However, in this model, the differential relates to the same demographic group (within the same argument $L_s$ of the function $F(\cdot)$). Thus, there is no need to parametrize the relationship between the arguments.

Skilled workers are assumed to be risk-neutral labor income maximizers who are divided into two educational groups (i.e., $\ell b$ and $\overline{\ell b}$) that coexist under two assumptions. First, for a given amount of output, the possibility of substituting $\ell b$ with $\overline{\ell b}$ is fixed. Second, relative wages paid in the equilibrium reflect the relative productivity of workers. The latter assumption is empirically plausible, as we know that after price shock therapy wages were set via informal plant-level bargaining over which unions had little influence (Brainerd 1998).

The first assumption permits the specification of $L_s$ as a Constant Elasticity

of Substitution (CES) aggregate of $\ell b$ and $\overline{\ell b}$ graduates

$$L_s = \left[\alpha N_{\ell b}^{\rho} + (1-\alpha) N_{\overline{\ell b}}^{\rho}\right]^{1/\rho}, \tag{4.2}$$

where $\rho \overset{\text{def}}{=} 1 - (1/\sigma)$, with $\sigma$ being the elasticity of substitution between college graduates of types $\ell b$ and $\overline{\ell b}$. As the groups are substitutes, it implies that $\rho \in (0, 1]$.[5] Parameter $\alpha \in (0, 1)$ governs a share of work that has be to performed by $\ell b$ graduates due to a certain economic environment. It captures an increase in relative demand; thus, a demand side shock for $\ell b$ graduates can be interpreted in this framework as an increase in $\alpha$.

The second assumption (i.e., that wages reflect marginal productivity) implies that the relative wage premium is

$$\frac{\beta_{\ell b}}{\beta_{\overline{\ell b}}} \overset{\text{set}}{=} \frac{\frac{\partial Y}{\partial N_{\ell b}}}{\frac{\partial Y}{\partial N_{\overline{\ell b}}}} = \frac{\cancel{\frac{\partial Y}{\partial L_s}} \times \frac{\partial L_s}{\partial N_{\ell b}}}{\cancel{\frac{\partial Y}{\partial L_s}} \times \frac{\partial L_s}{\partial N_{\overline{\ell b}}}} = \frac{\alpha}{(1-\alpha)} \frac{N_{\ell b}^{\rho-1}}{N_{\overline{\ell b}}^{\rho-1}}. \tag{4.3}$$

Noting the definition of $\rho$ and taking a natural logarithm yields

$$\ln\left(\frac{\beta_{\ell b}}{\beta_{\overline{\ell b}}}\right) = \ln\left(\frac{\alpha}{1-\alpha}\right) - \frac{1}{\sigma} \ln\left(\frac{N_{\ell b}}{N_{\overline{\ell b}}}\right). \tag{4.4}$$

The wage premium of $\ell b$ graduates relative to $\overline{\ell b}$ depends on the share of work allocated to them, their relative supply, and the technological capacity to substitute $\ell b$ with $\overline{\ell b}$.

The following proposition summarizes the straightforward comparative statics.

**Proposition 4.1.** *An increase in the share of work that has to be performed by $\ell b$ increases the relative wage premium. Conversely, an increase in the relative supply pushes the premium down:*

[5] A thorough discussion of the parameters of substitution in a similar context can be found, for example, in Acemoglu (2002, p. 18). A good general discussion of a CES function can be found in Rainer et al. (2011).

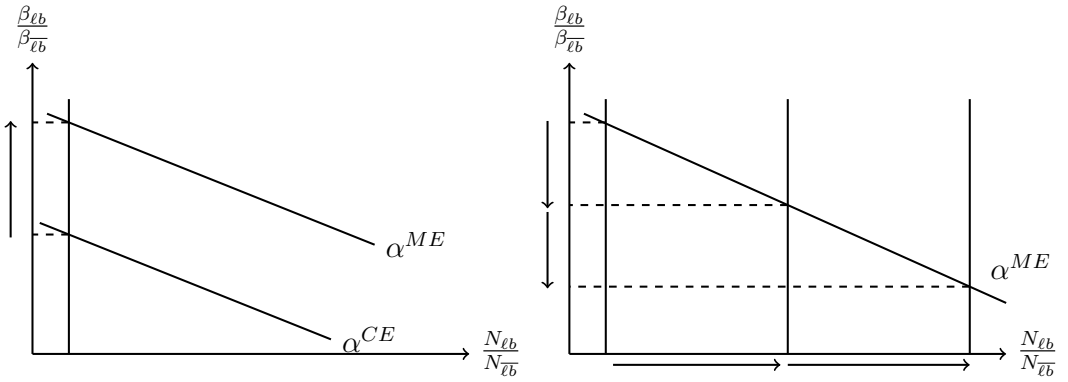
$$\frac{\partial \ln\left(\beta_{\ell b}/\beta_{\overline{\ell b}}\right)}{\partial \alpha} = \frac{1}{(1-\alpha)\alpha} > 0 \tag{4.5}$$

*and*

$$\frac{\partial \ln\left(\beta_{\ell b}/\beta_{\overline{\ell b}}\right)}{\partial \left(N_{\ell b}/N_{\overline{\ell b}}\right)} = -\frac{1}{\sigma} < 0. \tag{4.6}$$

Figure 4.3 visually summarizes this proposition. The key results in Section 4.4 are presented as an empirical counterpart of this visualization.

Figure 4.3: Comparative statics graphically




*Left figure:* A share of work performed by law or business graduates in the market economy, $\alpha^{ME}$, is higher than that in the command economy, $\alpha^{CE}$. A rapid switch from one type of economy to another without a change in the composition of skills increases the relative wage premium.
*Right figure:* An increase in the relative supply decreases the relative wage premium.

## 4.3 Data and Methods

### 4.3.1 Data

For empirical purposes, this paper uses individual dataset RLMS, a series of nationally representative panel surveys designed to monitor the effects of Russian reforms on the health and economic welfare of households and individuals in the Russian Federation. The data has been collected annually since 1994 (with the exception of 1997 and 1999). The data for 1985, 1990 and 1991 are collected retrospectively. The RLMS project is run jointly by the Carolina Population Center at the University of North Carolina, Chapel Hill, and the Demoscope team in Russia. For a history of the survey, an outline of the sample design and the replenishment of sample designs, the loss to follow-up and other key factors, see the data resource profile in Kozyreva et al.'s (2016) paper. This paper uses information for years 1985–2015. In total, the dataset spans 109,607 observations, or an average of 5,768 observations per wave. Biases caused by sample attrition due to the higher mortality rates of older age groups or labor mobility are reduced by restricting age to 15–59 years (this restriction is a widely accepted for RLMS convention) and using sample weights.

Retrospective recall in RLMS is a threat to validity. However, this remains the best data source for my research question. IPrior to RLMS, the only household survey of the Soviet Union was "Soviet Interview Project, 1979-1985". This survey was undertaken to study everyday life in the Soviet Union by conducting highly-structured interviews with a probability sample of eligible Soviet emigrants in the United States. RLMS is a massive improvement. A recall bias does exist, but it's extent comparatively speaking is small.

The following variables are constructed from the dataset. *Experience* is age minus the variable *Schooling* and minus the number 6. *Schooling* is constructed based on respondents' self-declared educational status: 4 years for grades 1–6, 8 years for grades 7–9, 10 years for secondary school grades 10–12, 9 years for a

vocational non-secondary school diploma, 11.5 years for a vocational secondary school diploma, 13 years for a technical school diploma and an incomplete HE, 14 years for a bachelor's degree, 15 years for a specialist diploma, 16 years for a master's degree, and 18 years for a doctorate degree. *Tenure* refers to the number of years a respondent has worked at their current job. *Education level* has five indicators: *Secondary school*, *Vocational diploma*, *Higher education* and *Graduate school*. *Residency* has four indicators: living in *Regional center*, *Town*, *Urban village* or *Rural area*. *Federal city* is an indicator of if a respondent lives in Saint-Petersburg, Moscow or Moscow Oblast. *Ownership* has three indicators: *State company*, *National company* and *Foreign company*. The latter also includes mixed ownership.[6] *Employer size* has seven indicators: *Size 0-10, 10–50, 50–100, 100–500, 500–1000, >1000* and *Size missing*. All definitions closely resemble those adopted by Gorodnichenko and Peter (2005) and Münich et al. (2005).

The dependent variable is a log of monthly contractual wages after tax at the primary workplace corrected for in-kind remuneration. This choice of dependent variable is standard for the dataset and is considered the best choice to proxy wages. This is due to wage delays during the transition period and the low quality of information on hours worked.[7] One limitation related to choosing this dependent variable is that it is agnostic about the hours actually worked. As earnings clearly depend on working hours, this creates a version of an omitted variable bias. On average, those who are the most educated tend to work fewer hours (Card 1999). Thus, omitting the *Hours worked* variable, which is negatively correlated with the level of education, produces a downward bias. However, as this research is focused on the time behavior of the wage

[6] A note on businessmen. Firm fall into three categories. State company, National company or Foreign company. If the person is self-employed the firm that he/she owns (and works in) still fall into one of those three categories. Therefore, businessmen are in National company.

[7] See Gorodnichenko and Peter (2005) and Gregory and Kohlhase (1988) for careful discussion on wage delays during 1990s and on the low quality of information on hours worked.

premium, this issue is somewhat less pressing.

Some earlier researchers (e.g., Gregory and Kohlhase 1988) include *Hours worked* as a covariate, although for a different dataset. More recent studies use monthly wages (e.g., Kyui 2016) or even wages averaged across several months (e.g., Carnoy et al. 2012). Exceptionally, Belskaya and Sabirianova Peter (2014) use hourly wages, ignoring the issue of missing hours or hours that fall outside the normal range.[8]

In cases in which respondents state that, in addition to their wages, their firm makes payments in-kind and those values are known to the respondents, these values are added to their wages.[9] This approach is similar to that of Gregory and Kohlhase (1988), who include indicators to address differences related to non-monetary job privileges. In the Soviet period, a significant portion of compensation was non-pecuniary (e.g., paid vacation at health resorts). It may be that respondents who are employed in newly created positions or who work in a new industry are compensated entirely by wages, while more traditional specializations are partially compensated by other types of non-pecuniary rewards. Not correcting for in-kind payments creates spurious differences in returns, as graduates non-randomly select themselves into different industries. This correction also addresses the issue of the low quality of the variable *Hours worked*, as it varies across specializations. One limitation of this correction is that, similar to wages, such monetary values are self-declared.

Table 4.1 provides the descriptive statistics for the variables considered in this study. One can see that the large Soviet firms were breaking down into smaller firms, which supports the claim that the economy is reorganising. Years

[8]The present study also tested the key results against monthly wage divided by the hours worked; however, no practical difference was found. The calculations are not included in this paper and may be requested from the author.

[9]Respondents are asked "Have you received in the last 30 days at this enterprise in lieu of payment for your labor something from its production or from the production of another enterprise, for example groceries or non-food goods?" and then "Estimate, please, how much the product cost in rubles, regardless of what you did with it.". The estimate is added to the contractual wage.

1985 and 1990 were collected retrospectively in 2000 and 2001, therefore the wage values for the Soviet period are located in the column 1998-2008. The reason for lowest values of wage is in the pre-transition period is hyperinflation of the early period of transition.

### 4.3.2 Fields of specialization and occupation

Educational levels are separated into graduate school, HE, vocational school and secondary school. As a proxy for the type of skills, HE is further categorized into specializations. *STEM, Medical* and *Liberal arts* categories bear the most natural definitions. However, *ℓb* graduates are excluded and treated separately. The *Public sector* includes professions for which the state is the only employer. The specialization definitions adopted for this study are similar to those used by Denisova and Kartseva (2007). A respondent with missing specialization information falls into the *Unspecified* category (Table 4.3 and Table 4.4 in Section 4.8 have further details on definitions). See Section 4.8 for further detail on categorization of specializations.

A slight issue arises, as the respondents are only asked for their specialization from 1998 to 2001 and 2010 to 2015. Adopting the approach of Belskaya and Sabirianova Peter (2014) and Belskaya, Sabirianova Peter, and Posso (2014), the information for the missing years is obtained through a panel component of the data (the same respondents respond each year). The information on specializations is fully available in the data for the last six years. Thus, it is possible to pretend that information for those last six years is missing and to replicate an imputation procedure to assess its accuracy (see Section 4.8.2 for further details). The data for 1985 and 1990 is a recall of that of 2000/2001; thus, there is an assumption that most respondents do not change their university specializations.

The category definitions are applied to the dataset to produce Figure 4.4.

Table 4.1: Descriptive statistics

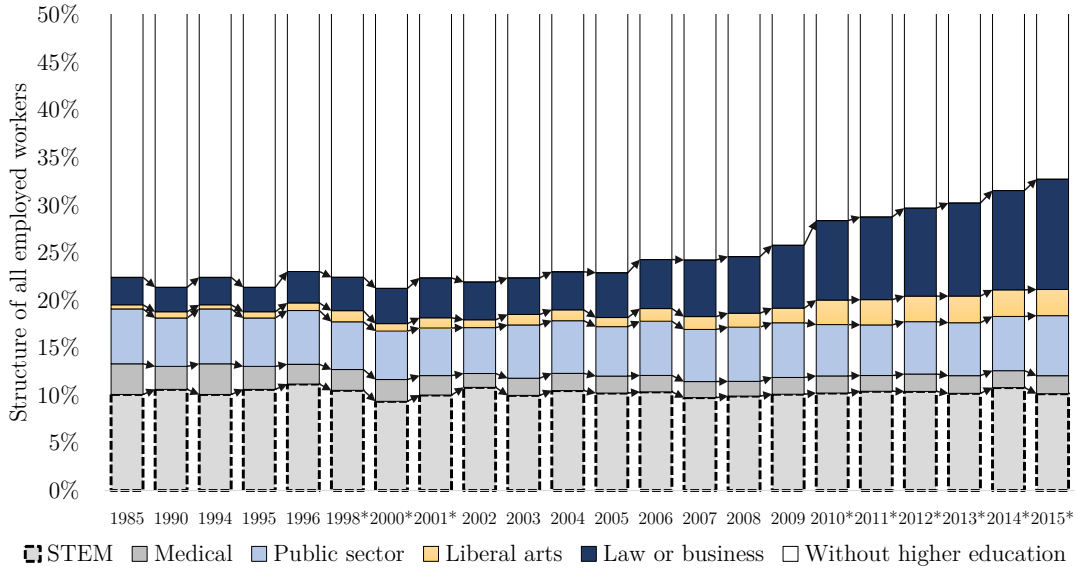
| Period | 1994-1996 | | 1998-2008 | | 2009-2015 | | 1985-2015 | |
|---|---|---|---|---|---|---|---|---|
| | Mean | St. Dev | Mean | St. Dev | Mean | St. Dev | Mean | St. Dev |
| Log of wage | 12.64 | 1.05 | 8.12 | 1.12 | 9.55 | 0.77 | 9.30 | 1.53 |
| in 1985 | · | · | 5.20 | 0.51 | · | · | 5.20 | 0.51 |
| in 1990 | · | · | 5.54 | 0.62 | · | · | 5.54 | 0.62 |
| Higher education | 0.22 | 0.42 | 0.23 | 0.42 | 0.29 | 0.45 | 0.26 | 0.44 |
| Experience | 20.44 | 10.83 | 20.04 | 10.97 | 20.49 | 11.25 | 20.33 | 11.12 |
| Female | 0.53 | 0.50 | 0.53 | 0.50 | 0.53 | 0.50 | 0.53 | 0.50 |
| Federal City | 0.18 | 0.39 | 0.18 | 0.38 | 0.16 | 0.37 | 0.17 | 0.37 |
| Tenure | 7.63 | 8.59 | 6.70 | 8.31 | 6.78 | 8.01 | 6.82 | 8.17 |
| Regional Center | 0.48 | 0.50 | 0.46 | 0.50 | 0.43 | 0.49 | 0.44 | 0.50 |
| Town | 0.30 | 0.46 | 0.29 | 0.45 | 0.29 | 0.45 | 0.29 | 0.45 |
| Urban Village | 0.06 | 0.23 | 0.05 | 0.22 | 0.06 | 0.24 | 0.06 | 0.23 |
| Rural Area | 0.16 | 0.37 | 0.20 | 0.40 | 0.22 | 0.42 | 0.21 | 0.41 |
| Foreign company | 0.04 | 0.19 | 0.04 | 0.20 | 0.03 | 0.17 | 0.03 | 0.18 |
| National company | 0.25 | 0.43 | 0.41 | 0.49 | 0.49 | 0.50 | 0.44 | 0.50 |
| State company | 0.69 | 0.46 | 0.55 | 0.50 | 0.41 | 0.49 | 0.48 | 0.50 |
| Ownership missing | 0.14 | 0.35 | 0.13 | 0.34 | 0.14 | 0.34 | 0.13 | 0.34 |
| Size 0-10 | 0.07 | 0.25 | 0.07 | 0.26 | 0.09 | 0.29 | 0.08 | 0.28 |
| Size 10-50 | 0.20 | 0.40 | 0.19 | 0.40 | 0.22 | 0.41 | 0.21 | 0.41 |
| Size 50-100 | 0.09 | 0.29 | 0.09 | 0.29 | 0.09 | 0.29 | 0.09 | 0.29 |
| Size 100-500 | 0.19 | 0.39 | 0.17 | 0.37 | 0.14 | 0.35 | 0.16 | 0.36 |
| Size 500-1000 | 0.05 | 0.22 | 0.05 | 0.22 | 0.04 | 0.19 | 0.04 | 0.20 |
| Size $\geq$ 1000 | 0.12 | 0.33 | 0.13 | 0.34 | 0.06 | 0.24 | 0.09 | 0.29 |
| Size missing | 0.28 | 0.45 | 0.30 | 0.46 | 0.35 | 0.48 | 0.33 | 0.47 |
| Sample size | 9193 | | 39308 | | 61106 | | 109607 | |

*Source:* RLMS.

The composition of the labor force demonstrates an obvious tendency: in 1994, *ℓb* graduates occupy approximately 3% of the labor force, whereas, in 2015, they occupy 12%.

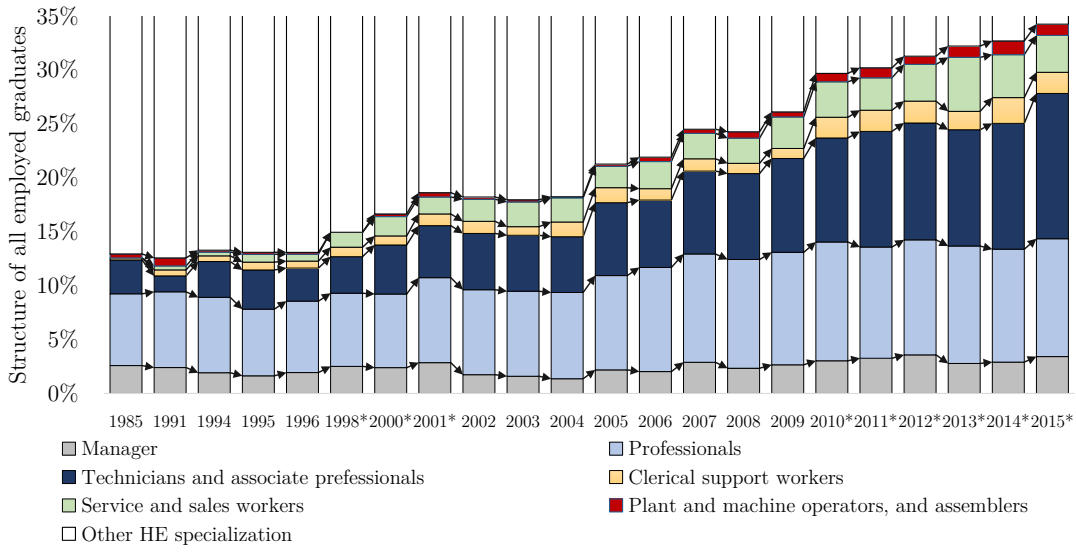
A job is a set of tasks and duties performed, or meant to be performed, by one person, including for an employer or in self employment, and that occupation

Figure 4.4: Share of graduates with higher education in the labor force




*Notes:* Years marked with * do not use specialization imputation. Workers with *Unspecified* specialization are excluded. Percentage of workers with higher education corresponds to the mean of variable *Higher education*.
*Source:* RLMS.

Figure 4.5: Occupation of law and business graduates




*Notes:* See comments for Figure 4.4
*Source:* RLMS.

refers to the kind of work performed in a job. The concept of occupation is defined as a set of jobs whose main tasks and duties are characterized by a high degree of similarity. A person may be associated with an occupation through the main job currently held, a future job or a job previously held. Now, Figure 4.5 shows the occupations of $\ell b$ graduates. In 1985, $\ell b$ graduates account for 13.3% of all employed HE graduates; in 2015, this number increases to 35.6% (a 167% increase). The largest increase, from 3.14% in 1985 to 13.48% in 2015 (a 328.82% increase), occurs among *Technicians and associate professionals.*[10] The second largest increase, from 6.65% in 1985 to 10.93% in 2015 (a 64.25% increase), occurs among *Professionals.* These two occupations require skills that are typically acquired through HE programs. An increase in these two occupations is intuitive and supports the argument that the Russian economy is employing new organizational technologies.

The following two changes in occupation are interesting, as they either never exist or are never performed by HE graduates in the late Soviet Union. The third largest increase from 0.00% in 1985 to 3.42% in 2015 occurs among *Service and sales workers.* Interestingly, the share of this occupation in the general employed labor force (as distinct from the HE labor force) in 1985 is still close to nil. The fourth largest increase, from 0.18% in 1985 to 1.96% in 2015 (a 960.78% increase), occurs among *Clerical support workers.* The increase for this occupation remains continuous for the entire period. This reflects the increasing complication of organizational technologies, as professionals in this occupation are responsible for recording, organizing, storing, computing and retrieving information. The fifth largest increase, from 2.59% in 1985 to 3.42% in 2015 (a 32.2% increase), occurs among *Managers.*

In 2007/2008, there is an increase in *Plant and machine operators, and assemblers.* Previous research on Russian wage structures may take this as

[10] See Internatioanl Labour Organizations (2012) for the definitions of all occupations and their typical tasks.

evidence of a fall in the quality of HE due to a larger enrollment of applicants with poor unobservable variables. However, while this mismatch is detectable, it is minuscule; it changes from 0.37% in 1985 to 1.04% in 2015 (a 182.12% increase). The differential that this paper discovers clarifies the reasons for this mismatch.

### 4.3.3 Empirical strategy

This paper uses a standard human capital equation, adjusted for residency and occupation, to break wages into workers' observables, and then break the premium for HE across various groups of university graduates to uncover $\beta_{\ell b}$ and $\beta_{\overline{\ell b}}$. The estimates capture the interactions of the demand and the supply sides, by revealing the price of a particular observable (e.g., gender, experience) that prevails in the labor market.[11] Specifically, in the current context, the estimates capture the competition among firms to obtain the scarce supply of the skills possessed by $\ell b$ graduates.

The baseline Specification:

$$\begin{aligned}\ln Wage_{it} =& \beta_0^t + \sum_{n=1}^{4} \beta_n^t \mathbb{1}\Big\{Education\ level_{it}^n\Big\} + \beta_5^t Experience_{it} + \beta_6^t Experience_{it}^2 \\ &+ \beta_7^t \mathbb{1}\Big\{Female_{it}\Big\} + \beta_8^t Tenure_{it} + \beta_9^t Tenure_{it}^2 \\ &+ \sum_{k=1}^{3} \gamma_k^t \mathbb{1}\Big\{Residency_{it}^k\Big\} + \gamma_4^t \mathbb{1}\Big\{Federal\ city_{it}\Big\} \\ &+ \sum_{p=1}^{3} \theta_p^t \mathbb{1}\Big\{Ownership_{it}^p\Big\} + \sum_{q=4}^{10} \theta_q^t \mathbb{1}\Big\{Employer\ size_{it}^q\Big\} + \varepsilon_{it} \\ & t \in \{1985, 1990, 1994-1996, 1998, 2000-2015\}.\end{aligned} \tag{4.7}$$

Subscript $i$ indexes individuals and $t$ indexes years. The explanatory vari-

[11] Note this interpretation of the coefficients. The specialisation choice is not a predetermined, exogenous event. This implies that comparing differences in average earnings for treatment (different major) and control groups (secondary school diploma) would not lead to credible causal estimates. This endogeneity problem is even worse in my case as different non-observed factors motivates applicant to choose different majors.

ables are standard for the dataset and are grouped according to human capital measures (the $\beta$ coefficients), job characteristics (the $\theta$ coefficients) and demographic characteristics (the $\gamma$ coefficients).

The expanded Specification:

$$\begin{aligned}\ln Wage_{it} =& \beta_0^t + \sum_{j=1}^{27} \zeta_j^t Controls_{it}^j + \varepsilon_{it} \\ &+ \beta_{\ell b}^t \mathbb{1}\Big\{Higher\ education_{it} \times Law\ or\ business_{it}\Big\} \\ &+ \beta_{\ell b}^t \mathbb{1}\Big\{Higher\ education_{it} \times Except\ law\ or\ business_{it}\Big\} \\ & t \in \{1985, 1990, 1994-1996, 1998, 2000-2015\}.\end{aligned} \tag{4.8}$$

Equation (4.8) is different from (4.7), as it replaces the *Higher education* variable with *Higher education*×*Law or business*, *Higher education*×*Except law or business* and *Higher education*×*Unspecified* (neglected in the formula for expositional purposes).

The *Unspecified* variable includes workers who have obtained a HE, but for whom specialization information is missing. These workers are treated as a separate category. If these categories are not included, an omitted variable upward bias is produced, as the *Unspecified* variable correlates positively with all other levels of education and with the dependent variable. However, the corresponding coefficient does not carry meaningful information, as it includes a non-random collection of graduates. The same reasoning applies to the *Size missing* or *Ownership missing* variables, just as it does to the *Graduate school* variable and other levels of education.

Omitted categories. Secondary school for educational levels. Regional centre for residency. Employer ownership type has national company omitted. Employer size has size 0-10 omitted.

## 4.4 Results

### 4.4.1 Estimates of the wage premium

Using data from 2008, Table 4.2 illustrates the effects of various controls on the returns to education. Column (1) replicates the basic specification used by Gorodnichenko and Peter (2005). The 95% confidence interval for their estimates for *Schooling* for the year 2002 are $[0.084, 0.098]$, whereas this paper's estimates for the year 2008, which are of the same magnitude, but slightly lower, are $[0.082, 0.091]$. Column (2) estimates the returns on the levels of education using the original specifications of Brainerd (1998). Column (3) includes *Tenure* and uncovers its nil market value; an original discovery of Cheidvasser and Benítez-Silva (2007). Column (4) demonstrates the importance of demographic characteristics in estimating returns on levels of education. Column (5), which corresponds to the baseline Specification (4.7), further includes job characteristics (i.e., firm size and ownership type), whose importance to a transitional economy is originally shown by Münich et al. (2005). Note that, although estimates for HE are less affected, estimates for other levels of education and *Female* change considerably, indicating that *Schooling*, which includes all levels of education, would be changed considerably. The last column shows results when indicator for "Russian" is included. This control speaks to racial dummies for the American datasets. There is no change in estimates suggesting that either this observable does not matter for the Russian context or that the selection into jobs and location captures the importance of nationality.

Figure 4.6 depicts the returns on HE by running Specification (4.7) on each wave separately. As the literature review discusses, returns during the Soviet period are low but increase during the transition period. At the end of the 1990s, the market price for HE doubles, and then drops until it reaches about the same level as that in the middle of the transition period.

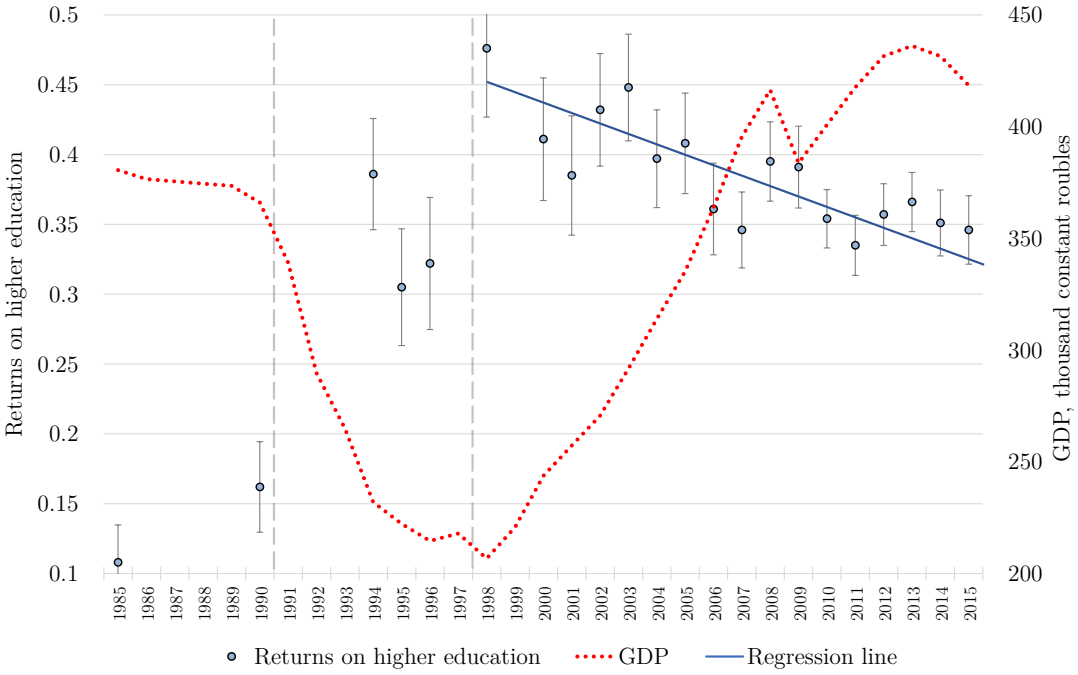
Figure 4.7 shows the estimated returns for the $\ell b$ and $\overline{\ell b}$ specializations

Table 4.2: The baseline Specification results for 2008

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | **log of monthly contractual wages after taxes** | | | | | |
| Schooling (adjusted year) | 0.0864*** | | | | | |
| | (16.75) | | | | | |
| *Education levels (Secondary school is omitted)* | | | | | | |
| Graduate school | | 0.538*** | 0.540*** | 0.466*** | 0.505*** | 0.507*** |
| | | (5.60) | (5.60) | (4.91) | (5.97) | (5.98) |
| Higher education | | 0.406*** | 0.408*** | 0.364*** | 0.396*** | 0.397*** |
| | | (13.26) | (13.27) | (11.99) | (13.32) | (13.35) |
| Vocation diploma | | 0.111*** | 0.113*** | 0.0873** | 0.102*** | 0.103*** |
| | | (3.92) | (3.95) | (3.13) | (3.73) | (3.76) |
| Experience | 0.0376*** | 0.0344*** | 0.0361*** | 0.0386*** | 0.0378*** | 0.0383*** |
| | (9.03) | (8.34) | (8.21) | (8.89) | (8.95) | (8.93) |
| Experience$^2 \div 1000$ | -0.915*** | -0.869*** | -0.918*** | -0.973*** | -0.935*** | -0.946*** |
| | (-8.81) | (-8.41) | (-8.48) | (-9.15) | (-9.02) | (-9.02) |
| Female | -0.501*** | -0.502*** | -0.504*** | -0.503*** | -0.465*** | -0.464*** |
| | (-21.78) | (-21.71) | (-21.79) | (-22.15) | (-20.74) | (-20.73) |
| Federal city | 0.665*** | 0.675*** | 0.676*** | 0.589*** | 0.564*** | 0.565*** |
| | (24.56) | (24.76) | (24.65) | (20.42) | (20.41) | (20.42) |
| Tenure | | | -0.00551 | -0.00332 | 0.00490 | 0.00491 |
| | | | (-1.22) | (-0.74) | (1.09) | (1.09) |
| Tenure$^2 \div 1000$ | | | 0.246 | 0.188 | -0.0101 | -0.0116 |
| | | | (1.62) | (1.26) | (-0.07) | (-0.08) |
| *Residency (Regional centre is omitted)* | | | | | | |
| Town | | | | -0.105*** | -0.0955*** | -0.0960*** |
| | | | | (-3.91) | (-3.65) | (-3.67) |
| Urban village | | | | -0.117* | -0.0674 | -0.0669 |
| | | | | (-2.13) | (-1.23) | (-1.22) |
| Rural area | | | | -0.393*** | -0.283*** | -0.284*** |
| | | | | (-12.35) | (-8.73) | (-8.73) |
| Employer ownership type | NO | NO | NO | NO | YES | YES |
| Employer size | NO | NO | NO | NO | YES | YES |
| Nationality | NO | NO | NO | NO | NO | YES |
| Number of observations | 3655 | 3655 | 3655 | 3655 | 3655 | 3655 |
| Adjusted $R^2$ | 0.270 | 0.269 | 0.269 | 0.301 | 0.342 | 0.342 |

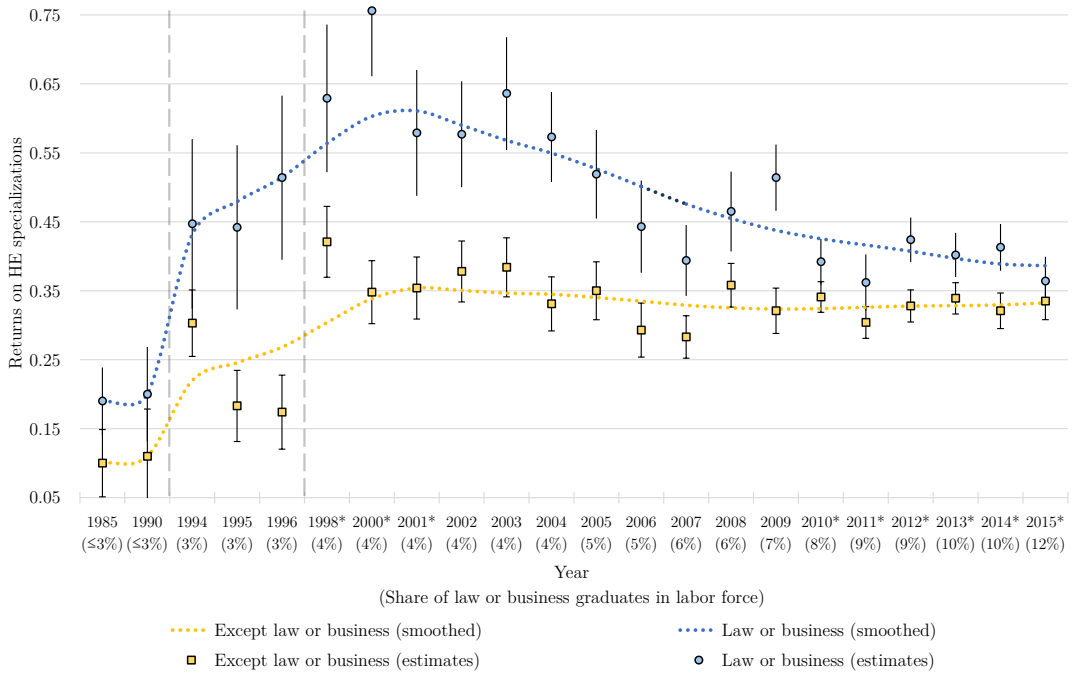
*Notes:* (Where relevant) indicator for Russian nationality, employer ownership type (with national company omitted), employer size (with size 0-10 omitted) and (for all models) constant are estimated but not shown. Sample restricted to respondents aged 15-59. Respondent clustered standard errors and sample weights are used. A model in column 5 (boxed) corresponds to equation (4.7). $t$ statistics in parentheses. *, **, and *** indicate significance at the 5%, 1%, and 0.1% levels.
*Source:* RLMS 2008.

Figure 4.6: Premium for higher education:1985–2015




*Notes:* Returns are from Specification (4.7) for each year separately. Respondent clustered 95% confidence intervals are shown. See Figure 4.1 for comments on GDP. Vertical grey dashed lines separate the periods. A line fitted only to the data from 1998 to 2015
*Source:* RLMS and World Bank.

Figure 4.7: Returns for $\ell b$ and $\overline{\ell b}$: 1985–2015




*Notes:* Returns are from Specification (4.8) for each year separately. Years marked with * do not use specialization imputation. Dotted lines are locally weighted scatterplot smoothers. Respondent clustered 95% confidence intervals are shown. Vertical grey dashed lines separate the periods.
*Source:* RLMS.

from Specification (4.8). The results show that, during the transition period, the returns on $\overline{\ell b}$ specializations are not statistically different from returns in the Soviet period (with the exception of 1994, which has the least amount of reliable information on specializations; see Section 4.8). Conversely, the returns for $\ell b$ are about 4–5 times higher. Further, in 1998, once economic growth has returned, the returns on the skills of $\ell b$ graduates are 6–7 times higher than returns on HE in the Soviet period. In the following years, the returns slow down possibly in response to an increase in supply. Naturally, the overall wage premium for HE, which is a weighted average across all specializations, partially mimics this massive transitory differential. This manifests as a decrease in the HE premium. The point where the returns on skills of $\ell b$ graduates gravitates to in 2015 appears to be one supported by the new post-transitional economic realities. The same level of returns is shown by $\overline{\ell b}$ specializations starting in 1998.

The economic reforms of the early 1990s introduce the market price system. Companies take advantage of the opportunities that this new system brings, and signal that they require a new mix of skills on the labor market.

The end of the differential reflects the growing occupation mismatch that can be observed in Figure 4.5. Thus, there is not simply an excessive expansion of HE; rather, there is a rigidity in supply. Neither universities nor applicants could have foreseen that the differential would cease to exist when they started the educational process in 2002/2003. The HE system had to expand disproportionately to quickly fill the demand for $\ell b$ skills. However, once this gap was filled, the training capacity remained the same. Consequently, $\ell b$ graduates entered the market and began to crowd out unusual occupations. In addition, young people do not make specialization choices by observing current market returns as is generally assumed.

## 4.5 Results Robustness

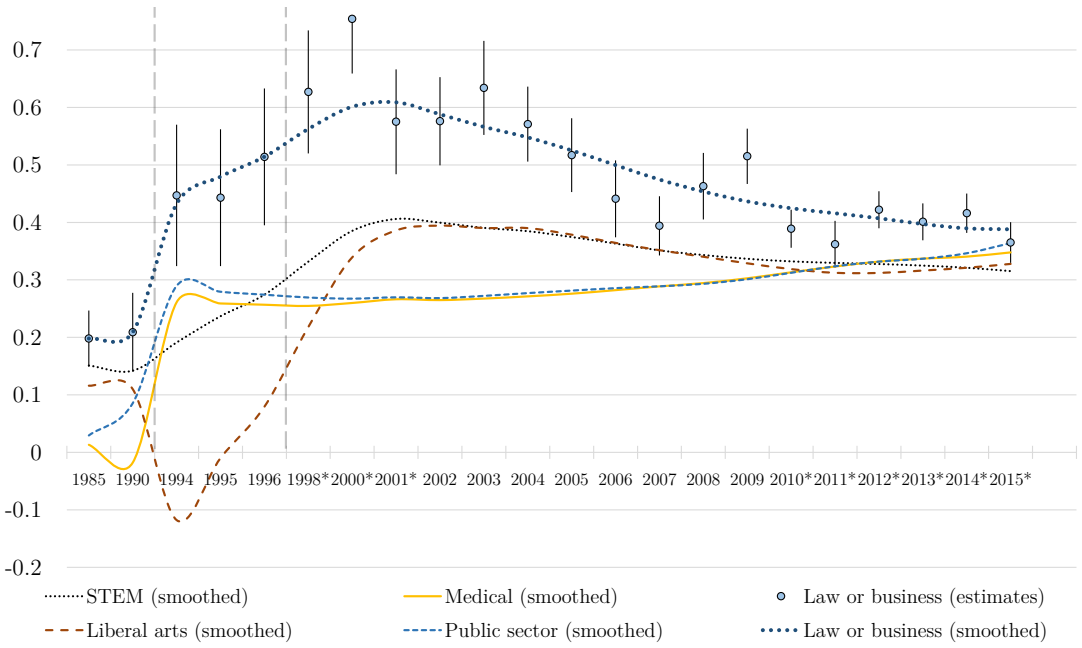
This section confirms the robustness of the results in three different ways. First, estimates of the returns are provided for all groups of specializations to confirm that only returns on $\ell b$ produced a substantial transitory wage differential. Second, a QR is undertaken that combines information for two adjacent years during the transition, at the peak of the differential and at the end of the study period, to confirm that the results are not driven by a potentially erroneous specialization imputation, a narrow income group (e.g., entrepreneurs) or a small sample. The years are selected to confirm the presence of the wage differential. Third, the HE wage premium is reestimated after dropping respondents with an $\ell b$ specialization to confirm that accounting for $\ell b$ explains the decrease in returns from 1998 to 2015.

To confirm the uniqueness of the size of the transitory wage differential for the $\ell b$ specialization, the following estimates for the returns for all groups of specializations are made for each year:

$$\begin{aligned} \ln Wage_{it} =& \beta_0^t + \sum_{j=1}^{27} \zeta_j^t Controls_{it}^j + \varepsilon_{it} \\ &+ \sum_r \beta_r^t \mathbb{1}\Big\{ Higher\ education_{it} \times r_{it} \Big\} \\ & t \in \{1985, 1990, 1994-1998, 1998, 2000-2015\} \\ & r \in \{STEM, Medical, Law\ or\ business, \\ & \qquad Liberal\ arts, Public\ sector\}. \end{aligned} \tag{4.9}$$

Figure 4.8 depicts returns in relation to all specializations. The government is practically the sole employer of the skilled *Medical* and *Public sector* graduates. This explains the stability of the observed returns. During the transition period, *Liberal arts* graduates had the same wage premium as high school students; however, *STEM* graduates performed somewhat better. Later, *Liberal arts* graduates caught up with *STEM* graduates.

Figure 4.8: Returns on various groups of specialization




*Notes:* Returns are from Specification (4.9). Years marked with * do not use specialization imputation. Dotted lines are locally weighted scatterplot smoothers. Respondent clustered 95% confidence intervals are shown. Vertical grey dashed lines separate the periods.
*Source:* RLMS.

The results are intuitive with the exception of *Liberal arts*. The occupation structure shows that *ℓb* and *Liberal arts* graduates replaced *STEM* graduates. Ideally (from the interpretation point of view), the returns for *ℓb* and *Liberal arts* graduates should be higher, and the returns for *STEM* graduates should be lower. It may be that the wage equation shows gross returns.[12] It is clearly easier to graduate with a *Liberal arts* degree than a *STEM* degree. Thus, the net returns for *Liberal arts* are higher than the net returns for *STEM*. However, the data during the recession of the transition period does not fit this narrative

[12]Mincerian regression does not account for the costs of education. Conceptually, the estimates depict gross monetary returns to schooling. But what if low monetary returns on some specialisations are compensated by the higher nonmonetary benefits of schooling or its lower direct costs, thus leading to the higher net value of education? For example, part of the returns to schooling may occur in the form of lower unemployment rate. In one of the previous versions of the chapter I do show that college major do have very different levels of unemployments (Alexeev 2017) . The direct costs of education are another important factor that is often omitted in conventionally measured returns to schooling. Hypothetically, it is possible to have different gross returns but similar net returns if direct costs were significantly lower for one major relative to the other. There are several paper (Fleisher et al. 2005; Gorodnichenko and Peter 2005) that computing net returns to schooling as $\beta/(1+\alpha)$, where $\alpha$ is the ratio of the direct costs of education (e.g. tuition) to the indirect costs (i.e. forgone earnings). Gross and net returns are indeed often different.

well. The estimates for that period can probably be dismissed due to data limitations. There were very few *Liberal arts* graduates and imputation worsened the problem. Alternatively, given that the wage equation ran at an even lower level than HE, there could be a severe endogeneity problem. Companies might know more about *Liberal arts* graduates trained in the late Soviet Union than the data reveals.

A QR that combines information for several years is undertaken to confirm that the results are not driven by a small sample that is not representative of underlying population tendencies, or by only one income group (e.g., entrepreneurs):

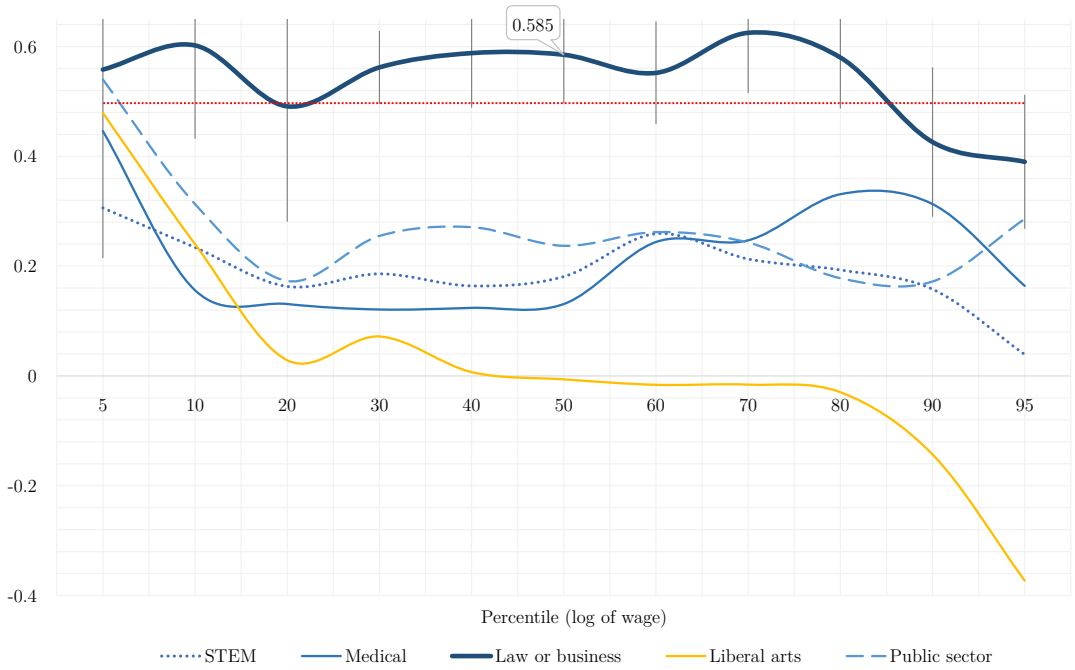
$$\begin{aligned} \mathbb{Q}^k\Big(\ln Wage_{it}|\mathbf{X}_{it}\Big) =& \beta_0^{k,t} + \sum_{n=1}^{27} \zeta_n^{k,t} Controls_{it}^n + \tau_{28}^{k,t} Trend_{it} \\ &+ \sum_r \beta_r^{k,t} \mathbb{1}\Big\{Higher\ education_{it} \times r_{it}\Big\} \\ t \in& \{1995/1996, 1998/2000, 2014/2015\} \\ r \in& \{STEM, Medical, Law\ or\ business, \\ & Liberal\ arts, Public\ sector, Unspecified\}. \end{aligned} \tag{4.10}$$

In relation to the covariates, Equation (4.10) is identical to Equation (4.9) with the exception of the *Trend* variable, which refers to the numbering of years. $\mathbb{Q}^k\left(\ln \text{Wage}_{it}|\mathbf{X}_{it}\right)$ denotes the $k^{th}$ percentile of the log wage conditional on the covariate matrix $\mathbf{X}_{it}$, and $\beta_j^k$ is the $k^{th}$ percentile estimate of the slope of variable $j$.

Figure 4.9 depicts the estimation for 1995 and 1996 during the transformational recession and shows that companies do indeed compete for $\ell b$ graduates, which drives their wages up. The results for *Liberal art* graduates are once again unusual; however, this is likely due to a data limitation.

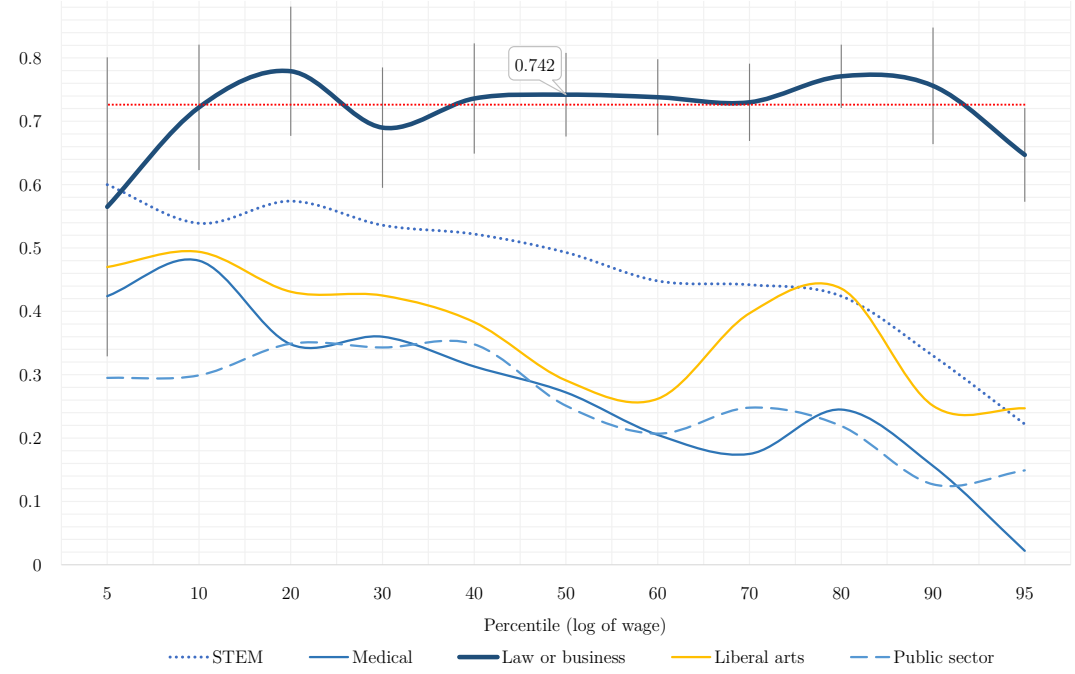
Figure 4.10 depicts the estimations for 1998 and 2000. The shape of the

Figure 4.9: Distribution of returns on higher education: 1995/1996




*Notes:* Black vertical lines indicate a bootstrapped 95% confidence interval. Red dotted line is a corresponding OLS estimator. $\ell b$ graduates occupy $\approx 2\%$ of the labor force.
*Source:* RLMS.

Figure 4.10: Distribution of returns on higher education: 1998/2000




*Notes:* Black vertical lines indicate a bootstrapped 95% confidence interval. Red dotted line is a corresponding OLS estimator. $\ell b$ graduates occupy $\approx 3\%$ of the labor force.
*Source:* RLMS.

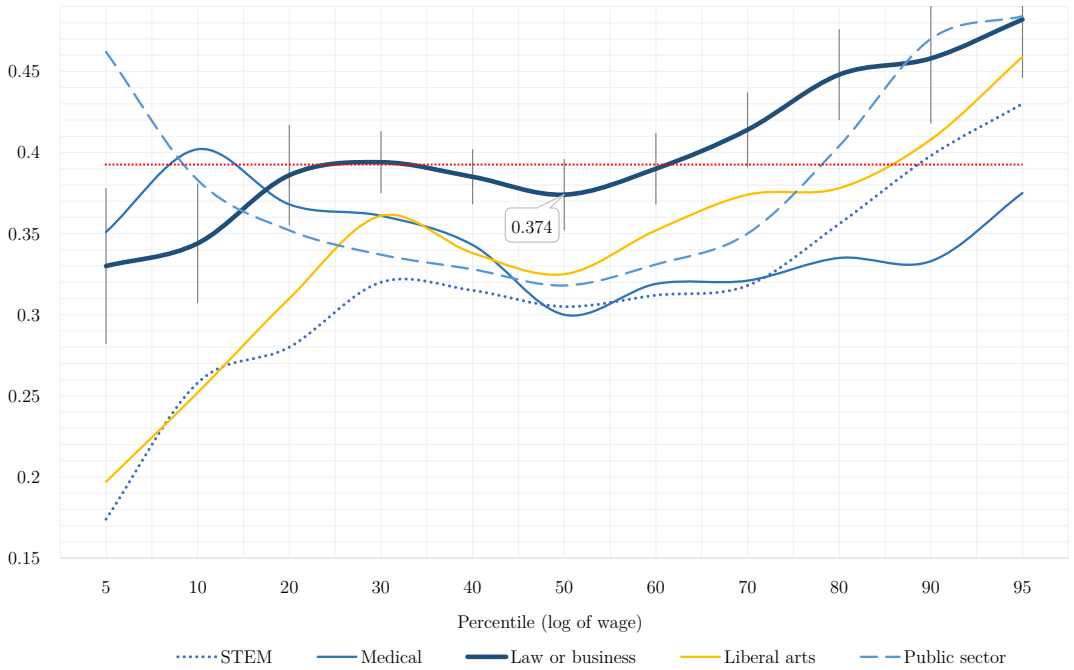
line again confirms that the market treated *ℓb* graduates differently from other graduates. The coefficient for the median income group for *ℓb* graduates is slightly higher than the OLS estimate, suggesting that the outliers actually push the premium down rather than up. *Public sector* and *Medical* graduates have the lowest returns,[13] and the returns for *Liberal arts* graduates are similar to those for the *Public sector* and *Medical* graduates, with the exception of a few workers (in the 60–90th percentile) who were lucky to find higher paid jobs. Notably, the OLS estimates mask the fact that the rewards for the skills of *Liberal arts* graduates are closer to those for *Public sector* and *Medical* graduates than those for *STEM* graduates. Conversely, as Figure 4.11 shows, the labor market for 2014 and 2015 rewards *ℓb* graduates no differently than it does any other specializations.

It seems that wage returns have over time become less progressive (note how the downward slope of returns at the far left-hand side disappears), which is what we would expect if income is related to skill and skill enhances the returns to education. This makes sense given what is happening over time, i.e., a transition from an older system in which wage and skill didn't move together strongly (communism) to one in which they arguably do (capitalism).

To confirm that the unusually high returns for *ℓb* graduates are responsible for a drop in the wage premium in 1998–2008, the baseline Specification (4.7) is used to reestimate college wage premiums after excluding respondents with *ℓb* specializations (including those hidden in the *Unspecified* category), namely:

[13] But have the lowest probability of being unemployed (Alexeev 2017) and have non-monetary job privileges.

Figure 4.11: Distribution of returns on higher education: 2014/2015



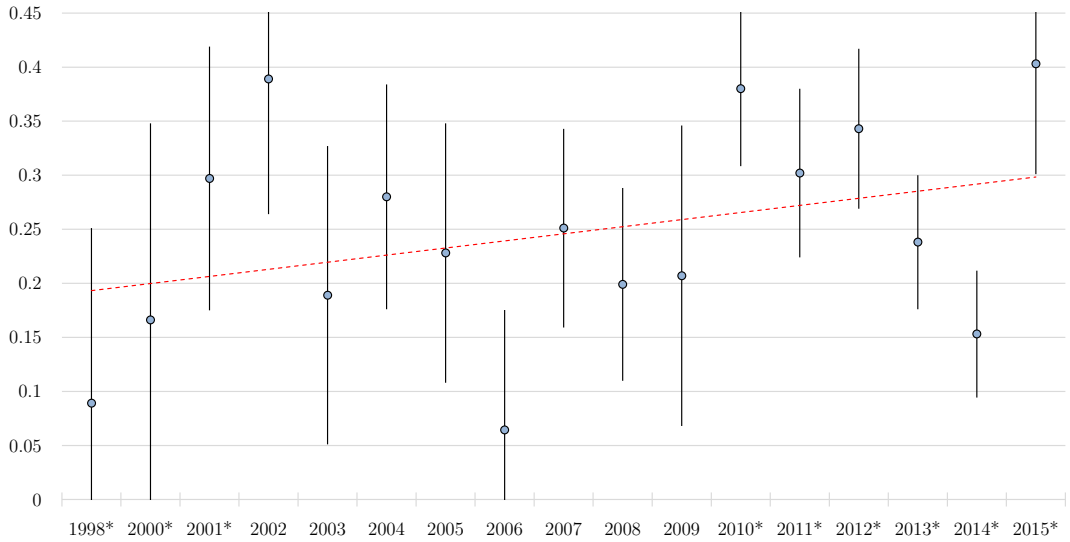

*Notes:* Black vertical lines indicate a bootstrapped 95% confidence interval. Red dotted line is a corresponding OLS estimator. $\ell b$ graduates occupy $\approx 12\%$ of the labor force.
*Source:* RLMS.

$$
\begin{aligned}
\ln Wage_{it} =& \beta_0^t + \sum_{n=1}^{4} \beta_n^t \mathbb{1}\left\{ Education\ level_{it}^n \right\} + \beta_5^t Experience_{it} + \beta_6^t Experience_{it}^2 \\
&+ \beta_7^t \mathbb{1}\left\{ Female_{it} \right\} + \beta_8^t Tenure_{it} + \beta_9^t Tenure_{it}^2 \\
&+ \sum_{k=1}^{3} \gamma_k^t \mathbb{1}\left\{ Residency_{it}^k \right\} + \gamma_4^t \mathbb{1}\left\{ Federal\ city_{it} \right\} \\
&+ \sum_{p=1}^{3} \theta_p^t \mathbb{1}\left\{ Ownership_{it}^p \right\} + \sum_{q=4}^{10} \theta_q^t \mathbb{1}\left\{ Employer\ size_{it}^q \right\} + \varepsilon_{it} \\
& t \in \{1998, 2000 - 2015\} \\
& i \setminus \{Law\ or\ business,\ Unspecified\}.
\end{aligned}
\tag{4.11}
$$

As Figure 4.12 shows, the returns do not decrease; however, an issue arises in relation to this approach, as, for a number of years (i.e., 1998, 2000 and 2006), the returns are statistically indistinguishable from zero. The reason for

the drastic drop in the efficiency is the exclusion of those additional respondents with graduate degrees who also have a HE.

Figure 4.12: Premium for higher education without $\ell b$ respondents



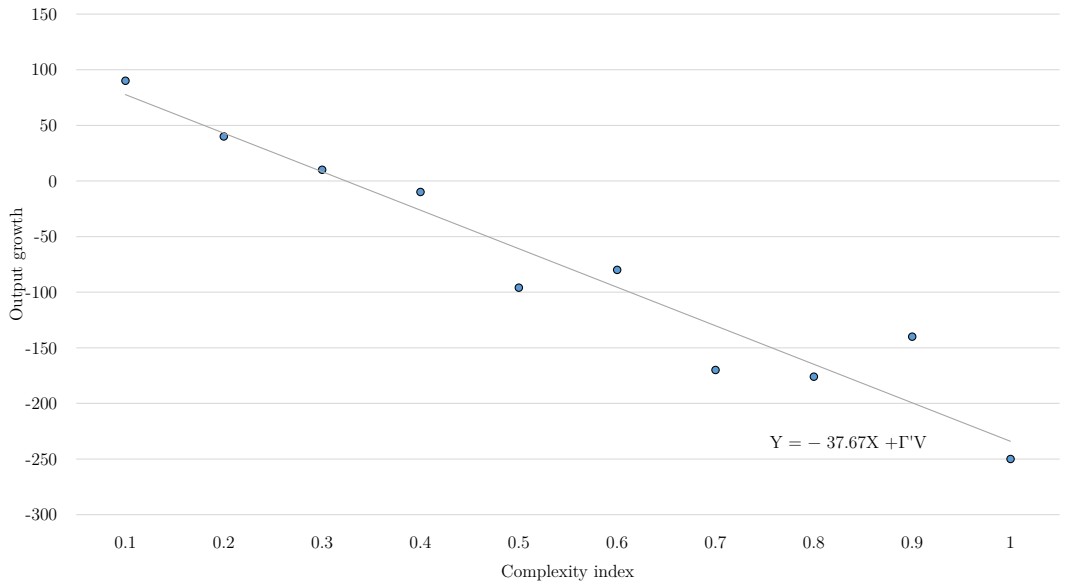

*Notes:* Returns are from Specification (4.11). Years marked with * do not use specialization imputation. Dotted lines are locally weighted scatterplot smoothers. Respondent clustered 95% confidence intervals are shown.
*Source:* RLMS.

## 4.6 Connection with output decline

The previous section identifies a transitory wage differential that indicates that firms were making investments into organizational technologies; however, there is another remarkable similarity between the transformational recession and SBTC.

During the transformational recession, former Republics of the Soviet Union experienced a much stronger output drop in industries that produced more complex goods (see Figure 4.13). Blanchard and Kremer (1997) hypothesize that this drop is the result of a coordination failure. During the transition period, the Central Planner was dismissed but contractual institutions (e.g., reputation, vertical integration) were still not developed. Firms that manufactured intermediary products within the same chain of production in the command economy found options for alternative uses of their products (outside of their established uses) after decentralization. Ultimately, a product – generating profit for all firms in the chain – will only be produced within a chain of production if no

Figure 4.13: Output decline across sectors




*Notes:* Replication of estimates from Blanchard and Kremer (1997, Table II, (1)) with binscatter regressions (Stepner 2013). For example, medical equipment production has a complexity index of 0.94, while cotton production has 0.19.
*Source:* Blanchard and Kremer (1997).

firm uses an alternative option, and firms continue to not supply their intermediary product outside the established production chain. The more producers in a chain of production, the higher the chance of defection; hence, the observed pattern of output decline. Later, Roland and Verdier (1999) argue that this pattern could also be the result of higher search frictions in more complex industries.

This paper complements these arguments and notes that this pattern of output decline could be a manifestation of SBTC. Most economic theories that explicitly formulate an economic mechanism to explain SBTC adopt Nelson and Phelps's (1966) view of human capital. In their view, workers' education positively affects the speed of the practical implementation of available technologies. Their theory further suggests that any increase in the wage premium is transitory. Only in the early adoption phase of a new technology can those workers who adapt more quickly reap some benefits. As time goes by, enough workers will know how to work with the new technology to offset the wage differential (Caselli 1999; Galor and Moav 2000; Greenwood and Yorukoglu 1997).

This conceptual interpretation emphasizes the effects of learning during episodes of radical technological change, which is in line with the productivity decline that occurred in most developed economies in the 1980s. At the beginning of the deployment of a new technology, output may temporarily decrease as workers and firms learn how to use the new technology (Aghion 2002; Hornstein and Krusell 1996).

If indeed an economic transition is viewed to be an economy-wide investment into new organizational technologies, then there should be a rapid creation of a class of better paid jobs complementary to the new technologies. This is the key empirical finding of this paper, as summarized in Figure 4.7. However, there should also be a period of learning/adaptation of new technologies. The transformational recession may have been exactly that. Industries that produced more complex goods, thus requiring more organizational technologies, would

have been more affected, thus falling more in performance. Hence, the pattern seen in Figure 4.13. A similar pattern was noticed in the United States, where the greatest initial productivity slowdown in the 1980s occurred in industries that adopted semiconductors to a larger extent.

The SBTC modeling approach was convenient when demonstrating the wage differential, but it is also convenient when demonstrating the output decline pattern during the transformational recession. The same result can be shown in the original model used by Card and Lemieux (2001). Output comparative statics is ambiguous and depends on the composition of skills, $N_{\ell b}^{\rho} - N_{\overline{\ell b}}^{\rho}$, and a degree of complementarity, $\rho$:

$$\frac{\partial Y}{\partial \alpha} = \frac{\partial Y}{\partial L_s}\frac{\partial L_s}{\partial \alpha} = \frac{\partial Y}{\partial L_s}\left(N_{\ell b}^{\rho} - N_{\overline{\ell b}}^{\rho}\right)\left(\alpha N_{\ell b}^{\rho} + (1-\alpha)\, N_{\overline{\ell b}}^{\rho}\right)^{\frac{\rho-1}{\rho}}\frac{1}{\rho}. \tag{4.12}$$

It is sufficient to study the effect of $\alpha$ on $L_s$ because the production function is assumed to be increasing in all arguments. Finding the root of $\frac{\partial L_s}{\partial \alpha}$ treated as a parametric function of $\alpha$ yields the following proposition.

**Proposition 4.2.** *Whenever $\rho$ approaches zero (i.e., the graduates' skills are perfect complements), a change of $\alpha$ of any magnitude decreases output. Whenever $\rho$ is different from 0 or 1, the sufficiency inequality is increasingly harder to satisfy if $N_{\ell b}$ increases:*

$$\frac{\partial Y}{\partial \alpha} < 0 \quad \textit{if} \quad \alpha > \frac{N_{\overline{\ell b}}^{\rho}}{N_{\overline{\ell b}}^{\rho} - N_{\ell b}^{\rho}}. \tag{4.13}$$

Card and Lemieux (2001, p. 726) show that the elasticity of substitution between workers with the same education is relatively stable over time and space (i.e., $\rho$ is a constant). With this being the case, then Proposition 4.2 states that a larger $\alpha$ (it is larger for more complex industries) can adversely affect economic output in the manner documented in Figure 4.13.

Alternatively, if $\alpha$ is fixed then a lack of $\ell b$ graduates can adversely affect

economic output. Therefore, a transformational recession could have been lessened if policy makers had acknowledged the dependency of the implementation of new technologies on the supply of workers with skills complementary to these technologies.

## 4.7 Conclusion

This paper demonstrates a between-groups wage differential in the Russian labor market that suggests a demand-side shock during the major economic reforms of the early 1990s. The differential induced a substantial change among employed professionals and technicians and also had a defining effect on HE returns from 1985 to 2015. Notably, the differential provides a parsimonious explanation for the relatively low college wage premiums from 1994 to 1996 (aka the Market Adjustment Puzzle), and the decrease in college wage premiums from 1998 to 2015. The subsiding of the differential also coincides with a decrease in income inequality during 1998–2005 demonstrated by Gorodnichenko, Peter, and Stolyarov (2010).

The demand-side shock indicates a large scale adoption of new organizational technologies, which was a response during the transition period to a deliberately rapid desertion by policy makers of deeply entrenched practices of Soviet central planning (i.e., "price shock therapy"). It is further hypothesized that the transformational recession may have had an aspect of being a period of learning/adaptation of the new organizational technologies, and, therefore, an improper mix of skills is a factor that contributed to the transformational recession.

This expressed hypothesis – that a lack of personnel with skills complementary to organizational technologies adversely affected economic performance – also reconciles several existing cross-regional empirical inconsistencies. In China, output increased during the transition period, while in countries that were signatories to the Warsaw Pact the decrease was not as dramatic as in the Soviet republics. This can be explained by the absence of a massive demand-side shock for skills that was left unmatched with an appropriate supply, as hypothesized in this paper. The shock could have been avoided if: (1) complex industries had been decentralized gradually; (2) there had been no complex in-

dustries; or (3) the degree of penetration of the centralized planning was not extreme. All three conditions were violated by the Soviet republics. Conversely, in the Chinese economy, the transitional decentralization was gradual, there was a lower level of industrialization, and the penetration of centralized control was also relatively low. Similarly, while Warsaw Pact countries were decentralized quickly and had complex capital-intensive industries, their reliance on central planning was relatively short-lived and selective, as they only joined the socialist camp after World War II, whereas the Soviet republics were centralized in the 1920s.

Data from the Russian labor market is used in this paper to demonstrate the demand shock; however, similar results would likely be found in Ukraine and Kazakhstan, at least. Both countries had complicated centralized economies and experienced a drastic output decline. No high-quality microlevel datasets exist with the necessary information for these countries; however, similar to Russia, a disproportionately large enrollment into $\ell b$ degrees. This level of enrollments is unlikely to have happened by accident. It is indicative of a price signal that persisted on a labor market that in turn implies a supply and demand mismatch analogous to the one exposed in this paper.

## 4.8 Details on the Definitions and the Imputation

### 4.8.1 Human capital definitions and descriptive statistics

Table 4.3 displays the mapping of the wording used in this paper in relation to those used by the United Nations. For the full structure of degrees obtainable in Russia and their international counterparts, see HSE Data Books (2013, p. 19). It should be noted that masters' degrees are classified as HE, not as a form of graduate study. This might seem unusual; however, this approach is largely adopted for the purpose of the comparability of time series. Government official statistics also adhere to this classification, as, before 2012, there were no master's degrees whatsoever; however, a degree called "specialist", with a duration of five years, comprised both bachelor's and master's levels of education. The Russian education system also allows individuals to acquire an initial vocational education rather than only acquiring a secondary school diploma. This explains the overlap in relation to level 3.

Table 4.3: Education levels definitions

| ISCED 2011 level | Current Discussion |
|---|---|
| 3 | Secondary school |
| 3-5 | Vocational diploma |
| 6-7 | Higher education |
| 8 | Graduate school |

*Notes:* The International Standard Classification of Education (ISCED) is a UNESCO classification of educational levels.

Table 4.4 summarizes the mapping of the defined specializations into the International Standard Classification of Occupations.

Table 4.4: Specialization definitions

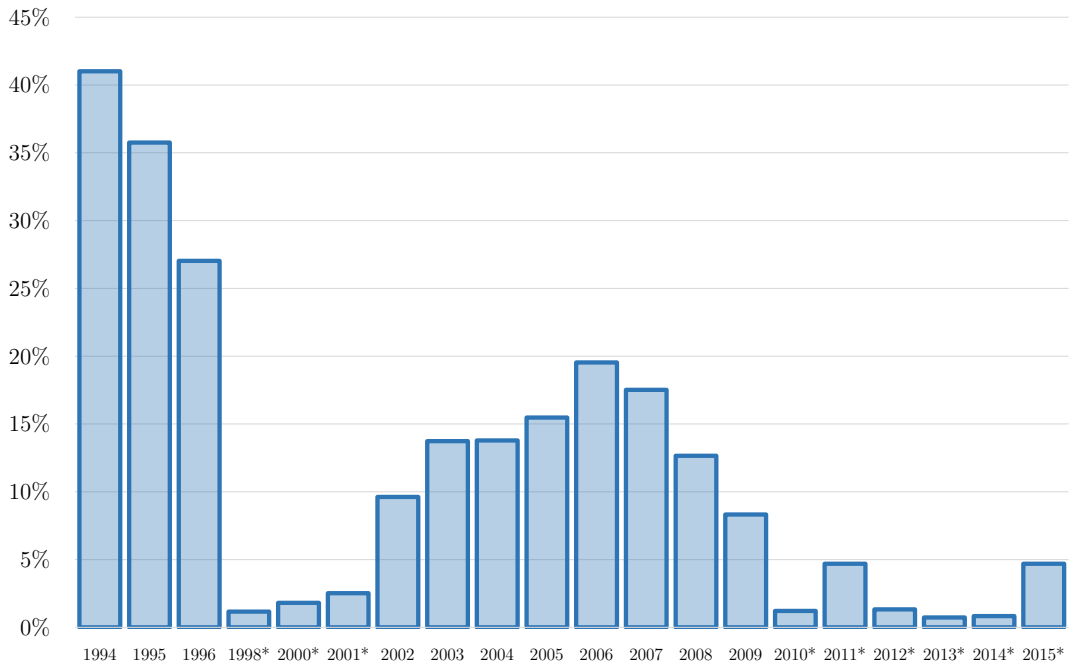
| Current discussion | ISCO 88 | Example |
|---|---|---|
| STEM | 2111-49; 2213; 3111-43; 7241-2. | Computer programmer. |
| Medical | 2211-2; 2219-29; 3221-42; 3475. | Medical doctor, dentist. |
| Law or business | 2411; 2419-29; 2441; 3411-39. | Financial consultant, insurer. |
| Liberal arts | 2412; 2431-2; 2442-60. | Philosopher, sculptor. |
| Public sector | 110; 2230-52; 3151-2; 3441-60. | Fire inspector, police detective. |

*Notes:* International Standard Classification of Occupations (ISCO) is an International Labour Organization definition of occupations. An example of the coding used in the middle column is $3113-5 \equiv 3113-3115$.

### 4.8.2 Assessment of specialization imputation

Figure 4.14 depicts the portion of missing information on specializations among respondents with HE after data is imputed across the waves. The full availability of the information for the last six years allows for an assessment of the imputation.

Figure 4.14: Fraction of category *Unspecified*

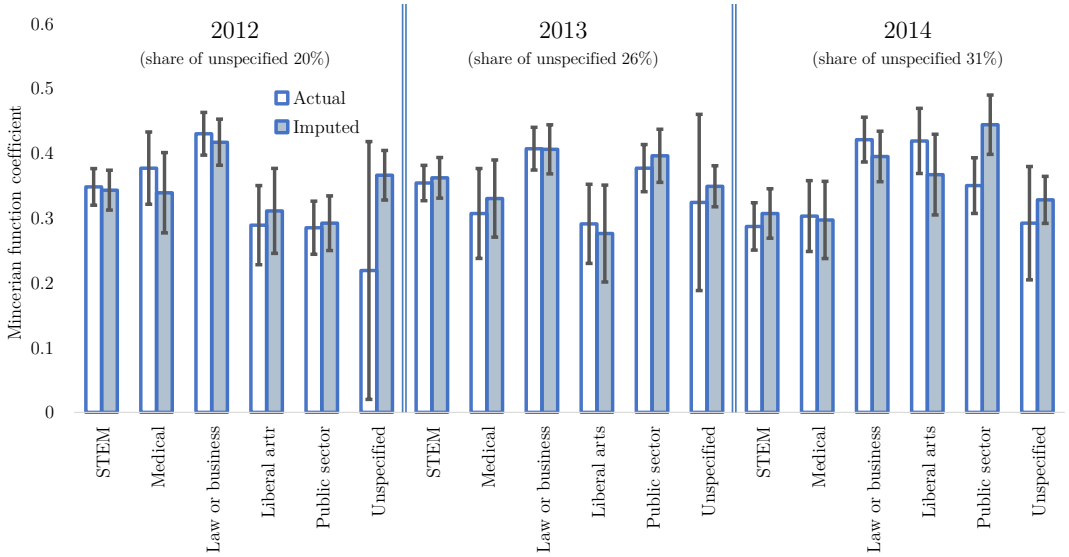



*Notes:* Years with a star contain actual information on specializations of higher education; information for other years is taken from the closest year with information, with priority given to later years.
*Source:* RLMS.

Figure 4.15 depicts the returns in relation to all defined groups of special-

izations (Specification (4.9)) using the actual data and the data that is imputed from the years 2010 and 2011, pretending that information for the years 2012 to 2014 is missing. The coefficients are identical. It should be noted that the estimate for the *Unspecified* category becomes more precise with the imputed information, but has no interpretation, as it includes a non-random collection of graduates. The assessment shows that no significant problem arises even if the figure reaches 31%. Somewhat unfortunately, more than 31% of information on specializations is missing for the 1994 and 1995 waves. Luckily, for the 1996 wave, only 27% is missing, which permits a probing of the transition period with confirmed certainty.

Figure 4.15: Comparing estimates with actual and imputed information




*Notes:* Last 5 years have information on specializations which permits imputation assessment. Coefficients are estimated with Specification (4.8). Black vertical lines are respondent clustered 95% confidence intervals.
*Source:* RLMS.

Finally, Table 4.5 shows the sample structure of graduates with HE if the *Unspecified* category is excluded. As the composition clearly remains almost identical, the *Unspecified* category is excluded to generate Figure 4.4.

Table 4.5: Assessment of specialization imputation in aggregate

| | Law or business | STEM | Medical | Liberal arts | Public sector | Unspecified |
|---|---|---|---|---|---|---|
| | 2012 (share of *Unspecified* 20%) | | | | | |
| Actual | 31.4% | 34.3% | 5.9% | 9.2% | 17.9% | 1.4% |
| Imputed | 27.3% | 26.5% | 4.2% | 8.3% | 13.6% | 20.2% |
| Dropping | 33% | 34% | 5% | 10% | 18% | 0% |
| | 2013 (share of *Unspecified* 26%) | | | | | |
| Actual | 33.2% | 33.0% | 5.9% | 9.5% | 18.0% | 0.4% |
| Imputed | 26.2% | 23.8% | 4.2% | 7.7% | 12.4% | 25.7% |
| Dropping | 34% | 32% | 6% | 10% | 18% | 0% |
| | 2014 (share of *Unspecified* 31%) | | | | | |
| Actual | 34.1% | 33.0% | 5.4% | 9.1% | 17.8% | 0.6% |
| Imputed | 25.3% | 21.9% | 3.6% | 7.3% | 11.0% | 30.9% |
| Dropping | 36% | 32% | 5% | 10% | 17% | 0% |

*Notes:* *Actual* proportions are taken from the data; *Imputed* contains proportions generated from information contained in 2010 and 2011, ignoring actual information in years 2012, 2013 and 2014; *Dropping* represents proportions of *Imputed* after dropping category *Unspecified*.
*Source:* RLMS.

# Chapter 5

# Concluding remark

Chapter 2 of this dissertation shows that comparing measurements of Australian income mobility, inequality and polarization with other countries may be misleading, as Australians "hide" a substantially higher portion of their income in real estate. These results support the previously made recommendation that all in-kind income sources should be considered in cross-country comparisons (Canberra Group 2001). The results also challenge the best available calculations of income mobility based on tax data, as they do not account for IR. It is also noted that the peculiarities of the Australian social security system may affect inequalities among elderly Australians.

Chapter 3 focuses on a different source of income mobility and inequality: unequal access to HE. The findings show that the CCA system, which is highly regarded and promoted by economists of today, assumes away fee-based TP activities; however, such activities may make colleges reluctant to participate in CCA systems.

Chapter 4 focuses further on education. It identifies a demand-side shock for specific types of college graduates in Russia in the early 1990s. This discovery consolidates the diverse literature on the Russian wage structure into one coherent narrative, spanning the period from 1985 to 2015. Specifically, it explains the occurrence of low college returns during the transition period, and

the decrease in college returns and general wage inequalities in Russia today. It is also noted that a pattern of output decline during the transition supports the hypothesis that an improper mix of skills was a factor contributing to the transformational recession.

The remainder of the present chapter discusses future areas for research.

In Chapter 2, it is argued that the absence of a universal governmental pension induces inequalities among elderly Australians, who rationally respond by accumulating assets that they are encouraged to buy due to the nature of the pension asset test. While a number of other studies have attempted to measure the effects of various aspects of the Australian Social Security system on behavioral responses (e.g., Atalay and Barrett 2015; Cho and Sane 2013; Kudrna and A. Woodland 2011; Kudrna and A. D. Woodland 2011), the findings of Chapter 2 on the effects of the system in relation to inequality and intergenerational mobility appear to be entirely novel. As such, the findings suggest a number of future potential research areas. Similar to the aforementioned papers, it may be possible to develop an explicit structural model to determine how both inequality and mobility are affected by, for example, the termination of negative gearing on the real estate sector, the introduction of bequest taxes, or the direct taxing of housing income.

In a narrow and technical sense, the motivation for Chapter 2 could be traced to Table 4.1: "Components of Disposable Income" of the Canberra Group (2001, p. 61). This table explicitly states that if income distributions are to be compared across time and space, IR should be included; however, there is another item that researchers rarely consider that also systematically prevents the proper comparison of income distributions: the goods and services bartered or produced for home consumption. There can be little doubt that a recent measure of intergenerational mobility for Russia (Borisov and Pissarides 2019) is skewed due to its exclusion of these items. This exclusion is somewhat surprising, as a number of influential studies (e.g., Gorodnichenko, Peter, and

Stolyarov 2010) have shown the importance of bartered or home produced goods and services to Russian income measurements. Russia is only one example; it is likely that this skewness would exist in any study that focused on a developing country.

As the availability of data across nations continues to increase substantially, recommendations by the Canberra Group become even more important. One such area in which these recommendations appear to have been ignored is the aggregation of the distribution of economic outcomes and opportunities for the 36 OECD member countries (OECD 2018). The OECD compares measurements for various countries by different authors that often do not share common methodologies or income definitions. In a step forward, a recently released Global Database on Intergenerational Mobility comprises estimates of intergenerational mobility covering 148 economies (Narayan et al. 2018). Authors use similar definitions and methodologies across countries; however, they fail to consider measurements of IR and goods and services bartered or produced for home consumption.

The recognition that income is deceptively hard to measure motivates an influential paper by Filmer and Pritchett (2001). To proxy a respondent's position in income distribution, they construct a linear index from household characteristics and asset ownership and use principal-components analysis to derive weights. They apply this method to several datasets and show that this "wealth index" predicts many social outcomes as accurately as expenditures (which is very hard to measure, as it requires information on market prices). The wealth index has standard uniform distribution (Fry et al. 2014; Rutstein and Johnson 2004); thus, if used in an intergenerational mobility context, it will have the same useful properties as the renowned Spearman rank correlation intergenerational mobility index suggested by Dahl and DeLeire (2008). In addition to disposable income, however, the wealth index also takes into account all assets that heavily influence the position of an individual in wealth distribution, espe-

cially in low and middle-income countries (e.g., piped water supply, cows, etc.). Using the wealth index in intergenerational mobility measures is a potential instrument to overcome the omission of goods and services bartered or produced for home consumption.

Chapter 3 shows that, under CCA systems, college applicants have an incentive to exploit non-universal access to TP commercial materials. The scope of these commercial materials and their effect have proven difficult to measure. The mathematical machinery of Chapter 3 could be re-employed to measure these in a fashion similar to structural econometrics. Alternatively, a closer examination of the institutional environment of one of the countries that recently introduced CCA could be exploited to measure the influence of TP activities. One would need data on applicants' skills measured in different ways, their educational choices, and the intensity of their TP activities.

Mathematical machinery could also be used to demonstrate the effects of an admission test's minimum requirements on the test-taking behavior. Generally, colleges post the minimum requirements for centralized examination marks to discourage weaker applicants and reduce the college's selection costs. This practice affects the information structure of the game. Applicants from a current admission cycle use the examination marks from previous years to learn the level of skills of competing applicants. No problems arise if a model assumes that the examination marks only reflect the skills of the applicants (when TSK is assumed away); however, TSK might create problems. Under this model, examination marks from previous years may be understood as a public signal that correlates with skills. Adopting reasonable assumptions, it could be shown that posting the minimum examination mark requirements encourages a higher engagement of the TP industry, which increases examination marks without an increase in skills, which, in turn, decreases the college's utility, as it complicates the sorting process.

Chapter 4 shows that the Russian government failed to anticipate the conse-

quences of the demand shock on skills supplied by $\ell b$ graduates. The excessive regulation of the education system prevented the high returns of $\ell b$ courses being translated in the supply. Future research should seek to model the consequences of more deliberate increases in the supply of those skills, including how much of the recession could have been avoided.

The stated hypothesis of Chapter 4 (i.e., that a lack of personnel with skills complementary to the organizational technology drove the irregularities in the labor market and economic output) also generates a testable prediction. The transitional economies that had the largest decrease in economic output should have also had a transitory wage premium for graduates who specialized in $\ell b$. Unfortunately, there is no available microlevel dataset for transitional economies to test this hypothesis by adopting methods similar to those used in Chapter 4. The Russian dataset is unique in this respect. The Ukrainian Longitudinal Monitoring Survey covers only several years and, in any event, lacks information on college specialization. Fortunately, the hypothesis is not very data demanding. Chapter 4 shows that the wage differential changed the composition of skills available in the labor market. An unusually high proportion of enrollments into $\ell b$ degrees, therefore, would strongly suggest a persistent price signal, which, in turn, implies a desired transitory wage premium. Thus, the validity and generality of the hypothesis of Chapter 4 could be tested by inverting it. If the hypothesis is valid, then the countries that experienced a strong drop in GDP (i.e., Estonia, Russia, Latvia, Belarus, Lithuania, the Ukraine, Uzbekistan, Kazakhstan, Kyrgyzstan, Armenia, Moldova, Tajikistan, Azerbaijan and Georgia) would also experience a noticeable restructuring of labor market skills. Governmental statistical bodies collect information on the number and type of graduates. If the number of $\ell b$ graduates were noticeably higher, it would imply a change in the composition of skills at the steady state, while the assumption of a competitive market implies the existence of a wage differential. This argument could be made precisely with a mathematical model. Such a model could

be used in a manner similar to that used by Krusell et al. (2000) to inform the identification strategy.

Finally, it is somewhat surprising that the intergenerational mobility literature discussed in Chapter 2 fails to consider the technological shifts discussed in Chapter 4. There is clearly an unexplored analytical connection between intergenerational mobility and SBTC. A technological shock may benefit or harm individuals differently in the labor market in a way that disrupts ordinary intergenerational persistence. A technology that prevails at a certain point in time may reward certain skills over others. Acquiring the skills in demand requires both education (nurture) and certain biological predilections (nature). Thus, when a new general purpose technology is being rapidly diffused, different households might have access to higher paid jobs, which could manifest as a spike in intergenerational mobility. This mechanism could also be studied using a precise mathematical model.

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