

Ivanov, Denis

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## Transition and path-dependence in knowledge-intensive industry location: Case of Russian professional services

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**TRANSITION AND PATH-DEPENDENCE  
IN KNOWLEDGE-INTENSIVE INDUSTRY LOCATION:  
CASE OF RUSSIAN PROFESSIONAL SERVICES<sup>2</sup>**

**Abstract**

The paper examines the link between human endowments accumulated in research institutions under the centrally planned economy and ensuing development of Russian professional services in the market era. Human capital created to meet needs of the military, the space program and heavy industry under the Soviet rule abruptly became redundant after 1991. Many researchers left traditional state-owned institutions because of public spending cuts. They build their careers in other industries, including professional services, thus creating labor market supply shock. I argue that late Soviet-era R&D sector was the pool of high-skilled labor located exogenously with respect to the market. I find that regions with greater employment in research and development at the end of the Soviet regime do better in the development of professional services two decades later when controlled for economic determinants of industry location. This effect is also distinct from those of contemporary universities and R&D sector. I emphasize human capital externalities as a possible explanation for persistence of knowledge intensive industries location patterns under the shock of the transition.

JEL codes: N74, R12.

Keywords: professional services, post-socialist transition, path dependence, Russia.

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<sup>1</sup>National Research University Higher School of Economics, International Center for the Study of Institutions and Development, Research Fellow. E-mail: [dsivanov@hse.ru](mailto:dsivanov@hse.ru)

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## 1. Introduction

Industries like IT, engineering, accounting, auditing, management consulting labeled as “professional services” or “knowledge intensive business services” are crucial for modern economy. Typically, professional services firms are heavily concentrated in places with great human capital endowments. However, it is necessary to establish a direction of causality in this nexus.

To overcome the problem of endogeneity, I propose to exploit labor supply shock related to mass exodus of skilled workforce from R&D sector and academia during post-socialist transition in Russia. Under the Soviet rule, independent professional services providers were unknown due to limitations on private entrepreneurship. Industrial enterprises relied on its own R&D departments or large publicly owned research institutions. Military-related topics dominated government-sponsored research. Spending cuts after 1991 pushed many professionals out of Soviet-style research institutions. Emerging opportunities attracted them to market-oriented industries like IT, consulting or finance.

When the central planning system was abolished in 1992, people were agglomerated in certain places due to reasons loosely related to the market, and central planners evidently were unable to anticipate which places would be favorable when market forces are allowed to operate. Pre-existing ties to industry was also unlikely to drive professional services’ development because of deteriorating financial condition of former R&D sponsors.

I use number of staff involved in R&D in 1991 across Russian regions as a measure of Soviet-era legacy and employment in various professional services industries in 2011 as outcome variables. Although the locational decisions in Soviet-era R&D sector were unrelated to the market, they obviously were not random. To meet exogeneity assumption, I rely on controls for crucial economic variables (GRP, total size of labor force, urbanization) and for present-day human capital, including current number of researchers in remaining Soviet-style institutions and annual number of fresh graduates from universities. The system of universities and R&D institutions in contemporary Russia has been derived from the Soviet one, so it is expected to bear the impress of unobservable effects dating back to the Soviet-era locational decisions. This allows distinguishing between permanent human capital and professional services nexus (current human capital) and the pure effects of transition shock (1991 number of researchers).

I find that spatial agglomeration of skilled professionals under the centrally planned economy has given push to development of professional services during the transition. Regions with greater R&D-related employment in 1991 now have greater employment in architecture, engineering and IT. Results remain when I re-run regressions using shares of R&D sector and

professional services in employment structure instead of absolute scores. The effect is clearly distinct from possible influence of present-day human capital variables, including universities with their annual supply of fresh graduates. Present-day number of researchers (mainly those who still work at Soviet-style government-owned institutions) affects professional services employment negatively, thus making assumption of some omitted region-specific variables acting both through historic and contemporary R&D sector employment doubtful.

I also find that no evidence of path-dependence is found in auditing, accounting and management consulting. In these industries it was arguably more difficult to apply expertise earned in the Soviet-era R&D sector; any Soviet-era experience was disadvantage rather than advantage.

Interpretation of these findings requires additional scrutiny. In some industries like manufacturing and transportation, Soviet-era legacy included physical capital, which is extremely costly to relocate even if the market requires this. For tertiary industries, this was not the case: professional services are not capital intensive but rely on human capital, which is relatively mobile. I believe that human capital externalities could become a cohesion force, which has precluded spatial dispersion of ex-researchers and thus has enhanced advantages of those regions, which were favored by the Soviet location policy. Entrepreneurship is a plausible transmission mechanism to impose path-dependence. I find that regions where more people were engaged in R&D still have greater number of small and medium enterprises in service sector.

There is vast amount of papers which intent to found evidence of positive human capital externalities and to develop theoretical underpinnings for them (for contemporary theories see, e.g., Lucas (1988), Acemoglu & Angrist (2001), Venables (2011)). As argued in these papers, skilled workers may benefit from spatial co-location with skilled mates due to number of reasons. Spatial clustering may improve matching workers when undertaking mutual projects and may act as reputation device. Endogeneity, self-selection and omitted variables are major challenges to the study of spatial dimension of human capital externalities.

However, human capital externalities are not the only plausible cohesion force. It might be the case that surplus of skilled labor led to poverty traps, which precluded migration of ex-researchers to regions with better employment conditions. Shepotylo (2012) points out great distortions in Russian urban system caused by the central planning, specifically by subsidizing urban development in insulated areas and imposing restrictions on growth of Moscow and other old large cities. He emphasizes imperfect housing markets and underinvestment in urban infrastructure as explanations for low internal migration within post-socialist countries, which he claims to impede convergence of the urban system to a new equilibrium. To test for

implications of this theory, I regress labor productivity in professional services on number of R&D-involved staff in 1991 and find no evidence of negative relationship, which could signalize about poverty traps.

Alternatively, one may recall insights from Florida (2002), arguing that high-skilled (creative) professionals may value urban society and environment in places with pre-existing concentration of their peers. However, given absence of path-dependence in location of auditing, accounting and management consulting it is unlikely that Florida's style explanation is applicable in this case. Clustering of skilled professional with background in technology failed to attract another segments of "creative class" like management consultants or auditors. This result contradicts the assumption of some omitted region-specific factors favoring the development of all sub-sectors of professional services.

Furthermore, I fail to find higher overall employment growth in regions with greater number of R&D staff in 1991. It seems that Soviet-era knowledge endowments paid minor contribution to regional economic development during the transition outside some knowledge-intensive industries.

This paper also contributes to the literature on path-dependence and natural experiments in economic geography. One of the most intriguing questions of economic geography is whether industry location pattern is uniquely determined by some fundamental factors or there are multiple equilibria, and that spatial catastrophes can switch between them. Conventional view dates back to Krugman (1991) and emphasizes increasing returns due to spatial agglomeration of firms even when agglomeration is due to idiosyncratic reasons. To find such a reasons, economists turned to the study of exogenous shocks of non-economic nature.

A number of studies concluded that spatial distribution of population and even individual industries quickly recovers after short-term shocks like war-related destruction. Davis and Weinstein (2002) pioneered the field showing that Allied bombing of Japan proved impossible to change relative size of Japanese cities. In (Davis, Weinstein, 2008) similar results were obtained with data on city-level employment in aggregate manufacturing as well as individual industries. Other students came to similar conclusions with evidence from other countries which experienced war-related shocks: Germany (Brakman et al., 2004), Vietnam (Miguel and Roland, 2011) and Russia (Mikhailova, 2012).

These papers gave reasons to see location patterns of population and economic activity as tremendously persistent and path-dependent: even nuclear bombings were unable to change spatial equilibrium in long run. However, one can argue that war-related destruction was not a proper shock to test the hypothesis of path-dependence: people in cities devastated by bombing nevertheless could be sure that hostilities eventually would cease, dwellings they and their

neighbors used to live in and factories they used to work at will be reconstructed in a relatively short time.

Another kind of empirical studies investigates consequences of long-term exogenous constraints on spatial equilibrium as well as shocks caused by unexpected collapses of such constraints. Some papers treat division of Germany as a shock of this kind. Redding and Sturm (2008) found that West German cities close to the East-West border grew substantially slower relatively to other cities and that their catch-up caused by German reunification was much more gradual. In another paper (Redding et al., 2011) it was shown that the division of Germany led to a shift of major country's airline hub from Berlin to Frankfurt-am-Main and that there is no evidence of reverse movement after the fall of Berlin Wall. Crafts and Wolf (2013) found evidence of strong path-dependence in the case of XIX century British cotton industry: cotton mills remained heavily concentrated in Lancashire even while location factors related to water power become obsolete. They emphasize sunk costs and agglomeration economies as the explanation.

Papers mentioned dealt with "hard" shocks like bombing cities or physical separation of a country with a heavily guarded border. Location factors employed in theory are also tend to be "hard" like disadvantage in accessibility in Redding and Sturm (2008) or sunk investment in physical capital in Redding et al. (2011), Crafts and Wolf (2013). This paper comes to conclusion that human capital clustering is also able to cause path-dependence at least with respect to knowledge-intensive industries. This result is consistent with recent evidence from economic history. Cantoni and Yuchtman (2012) show that university foundation in Germany following 1386 Papal Schism, which they treat as exogenous shock, caused increased rate of market establishment in those areas where distance to an university shrank most.

The paper is organized as follows. In Section 2 I consider historical roots of the impact development of academia under the Soviet rule might cause for modern-day professional services. In Section 3 I motivate the selection of variables and describes the data. Section 4 discusses empirical results. Section 5 concludes.

## **2. Historical background: Russian professional services and Soviet academia**

In the Soviet centrally planned economy, professional services were a minor sector and were not relevant for the market; some service industries simply did not exist (Bradshaw, 2008). State-owned R&D sector was highly militarized: in 1983, more than 70% USSR R&D expenses were incurred for purposes related to national defense and the space program. Overall

R&D expenses to GDP ratio was very high (3.6% in 1983) but it looked much smaller when only civil fraction was taken into account (Freeman, 1995).

Another key feature of the Soviet R&D sector was its unique institutional structure. Universities, except several elite schools, were committed primarily to teaching while research was carried out in specialized institutions working under umbrellas of various government agencies, industrial enterprises or Academies of Sciences<sup>3</sup>. The system of R&D planning was highly centralized and bureaucratized, and individual industrial enterprises as well as academic community lacked direct influence on it (Radosevich, 2003).

Geography of the Soviet-era knowledge-intensive industries also was shaped without taking into account viability of industries and even cities under market conditions. Instead, ideological, political and military reasons were given high priority (Rodgers, 1974; Hill and Gaddy, 2003; Mikhailova, 2004; Kumo, 2004). WWII-related evacuations also left imprints when academic institutions were relocated to the cities, which were believed to be invulnerable for German invasion. Noticeable case was evacuation of the Academy of Sciences of USSR to Kazan on Volga, which has given rise to Kazan branch of the Academy. The specific feature of Soviet-era science after WWII were closed towns (*ZATOs*) devoted to military-oriented research and manufacturing. *ZATOs* were typically located in sparsely populated rural areas but with relatively easy access to large cities<sup>4</sup>.

I consider location of academic institutions near the end of the Soviet regime to be exogenous with respect to the market era. Obviously, location of R&D establishments under the Soviet rule was not a random process in a strict sense. One can easily see that regions with the highest number of researchers were also most urbanized ones. But it seems that Soviet location policy favored some large cities more than others. Considering pairs of “rival” cities yields some evidence. Thus, Yekaterinburg (Sverdlovsk in 1924-1991) and Chelyabinsk are located near Ural mountains and separated by a distance of 200 kilometers. Both were major cities with comparable population size (in 1989, 1.3 million in Sverdlovsk and 1.1 million in Chelyabinsk); economies of both were dominated by heavy industries, including arms production. However, in 1991 number of R&D staff in Sverdlovskaya oblast was twice and half as much as in Chelyabinskaya oblast (52 vs. 21 thousand). Another comparison are Novosibirskaya and Omskaya oblasts, both in the south of Siberia. Both regions had similar

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<sup>3</sup> In addition to the most prominent Academy of Sciences of the USSR, there have been established other Academies committed to research in health, pedagogy, agriculture, architecture as well as Academies of Sciences of constituent republics.

<sup>4</sup> *ZATOs* not be confused with some major cities of the USSR with restricted access of foreigners. *ZATOs* typically were relatively small settlements kept secret even for Soviet citizens. Some visit and settlement restrictions in *ZATOs* have not been lifted until now though *ZATOs* location has been declassified.



economic profile with specialization in agriculture and machinery manufacturing. Omsk (1.1 million inhabitants in 1989) and Novosibirsk (1.4 million) were the sole major cities in each oblast. However, the number of R&D staff in Novosibirskaya oblast was three times more than in Omskaya oblast (53 vs. 18 thousand) due to locational decision of the Soviet government: choosing Novosibirsk and not Omsk or Tomsk as the seat of Siberian branch of Academy of Sciences of USSR.

To find additional underpinning for exogeneity of Soviet-era R&D sector location, I regress on 1991 number of researches the respective year's electricity consumption which I claim to be relevant measure of economic development under centrally planned economy. No effect is found in such a setting thus implying that there were no systematic correlation between presence of R&D sector and overall economic development at the regional level. Therefore, it is unlikely that regions with greater number of researchers had greater initial demand for professional services.

After 1991, dramatic decrease in public spending on basic research, space exploration and military was a tremendous shock for the Soviet R&D sector. According to SIPRI database, military budget of USSR/Russia decreased from 371 billion constant 2011 USD in 1988 to 23 billion in 1998. Number of researchers in Russia decreased more than twofold during two post-socialist decades and the sharpest decline occurred during the first several years after the abolition of central planning: from 1.6 million in 1991 to 855 thousand in 1998 and then to 735 thousand in 2011. At the same time, there was significant lack of workforce in market-oriented knowledge-intensive industries, which were undeveloped under the Soviet rule – like professional services. Ex-researchers possessed high cognitive and social skills, broad fundamental knowledge as well as dim view of communist ideology. So, they used to bridge this gap even if their background was not directly related to their new career path (Yurevich, 1998, p. 107-110).

Pre-existing ties between academia and industry do not seem to assist the development of professional services in long run. Firstly, Soviet military-industrial complex was the main sponsor of R&D. During transition to the market, economic importance of arms production felt drastically. The same was for other R&D-intensive industries like indigenous electronics, civil aerospace, machine tools. Instead, industries producing raw materials came out on top (Bradshaw, 2008; Gaddy and Ickes, 2005; Zubarevich and Safronov, 2011). Secondly, as noted in Yurevich (1998, p.103), researchers who opted to leave academia typically were relatively young and without high merit: 70% of them had never authored paper cited by anyone else. So, it is unlikely for them to possess significant social ties with old industries and to own anything but their personal competence.



Recent history of Miass, Chelyabinskaya oblast, is a symptomatic anecdote reinforcing my story. In 1955, Miass was a rather typical medium industrial town near Ural Mountains in thousand kilometers from the seashores. Despite all these facts, it has been chosen for location of Makeyev design bureau, which has been put in charge of submarine-launched missiles development. After 1991, engineers who previously worked for the missile design bureau founded several startups in Miass. Among those startups was Papillon Systems, which developed fingerprints identification hardware and software – a kind of field almost unrelated to missilery. Despite the town’s backward location, Papillon Systems gained commercial success due to contracts with Russian and foreign law enforcement agencies.

### **3. Data and variables**

In this paper, I use region-level data. Currently Russian Federation consists of 85 regions also known as federal subjects or *oblasts*. Three of them are autonomous districts, which are included into other regions for statistical purposes, so I do not consider them to avoid duplicating observations. I exclude from the sample Chechnya that experienced a war shock since 1991 and lacks reliable statistics, and Ingushetiya that constituted the joint region with Chechnya during the Soviet era. Due to historic reasons, Crimea and Sevastopol City are not included in the sample. I drop Chukotskiy autonomous district and Evreyskaya autonomous oblast, which had zero number of academic scholars in 1991 thus making impossible to take logarithm of this variable. Both regions gained full federal subject status after 1991, being integrated in larger regions in the last years of the Soviet rule. Therefore, I am left with 76 regions in the sample.

Data on the number of researchers by region in 1991 are obtained from 1999 Rosstat yearbook “Regiony Rossii”. This data does not include university lecturers but do cover those who performed research tasks on campus as well as employees of research establishments of various kind and R&D departments of industrial enterprises. Number of R&D staff reported by the federal statistical service in years after 1991 captures primarily remaining Soviet-style research institutions but not modern professional services. Russian R&D sector as defined by the statistical services is still dominated by public sector. In 2011, 76 per cent of total R&D staff were in fully publicly owned organizations, including 75 per cent in those owned by the federal government. Additional 11 per cent worked for institutions in mixed public-private ownership. Professional services are a strikingly different industry. As of 2011, establishments in full or partial public ownership hired only 23 per cent employees in engineering, architecture, IT, auditing, accounting and management consulting. As opposed to R&D sector, federal government was not the prime contributor to public sector professional services

employment. Only 6 per cent employees in professional services worked for federal government while 14 per cent worked for local and regional governments and 3 per cent for companies in mixed public-private ownership.

In 1991, R&D sector was a spatially agglomerated industry: almost third of total employment was in Moscow City and Moscow Oblast and more than quarter was in St. Petersburg (then Leningrad). Outside the two metropolises, the highest degree of researchers' clustering was found in regions like Nizhegorodskaya, Novosibirskaya, Sverdlovskaya, Rostovskaya oblasts. Some regions had disproportionately high employment share of researchers: e.g., 5% employees in Kaluzhskaya oblast were R&D-involved staff working mainly at nuclear research institutions in Obninsk.

Secrecy is the matter of caution when dealing with Soviet-era government statistics. It is expected to conceal data on number of scholars in physics, mathematics or technology to a greater extent than in social sciences, humanities or life sciences thus raising concerns of measurement error. However I rely on data released long after the fall of the Soviet regime when much information on defense-related research was declassified (precisely, Rosstat yearbook I borrowed the data from was published in 1999). Region-level pairwise correlation between official estimates of number of researchers in 2011, when secrecy is apparently not an issue, and in 1991 is also high (0.96 when Moscow and St. Petersburg are included and 0.91 when these two cities are excluded). Therefore, I believe the data I use do not suffer from measurement error caused by government secrecy policy.

In my baseline specifications, I use as dependent variables 2011 employment in three industries defined by statistical classification (OKVED):

- Engineering and architecture (OKVED 74.20.1);
- Accounting, auditing and management consulting (OKVED 74.1 minus OKVED 74.11 "Legal services")
- Information technology and computer-related services (OKVED 72).

Employment data are obtained from official Russian website of EMISS (Edinaya Mezhhvedomstvennaya Informatsionno-Statisticheskaya Sistema).

Employment in professional services in Russia in 2011 equals about one million. 376 thousand worked in auditing, accounting and management consulting, 312 thousand in IT and 300 thousand in architecture and engineering. Even naïve comparison reveals similarity of spatial patterns of employment in R&D sector in 1991 and in professional services today. Regions leading in employment in professional services, apart from Moscow and St. Petersburg metropolitan areas, include Republic of Tatarstan, Sverdlovskaya, Nizhegorodakaya,

Novosibirskaya, Rostovskaya oblasts, which were also leading by number of R&D-involved staff in 1991.

Finding control variables requires examining key factors, which are likely to influence location pattern of professional services. I scrutinize these factors below.

Relationship between size and thickness of local market and demand for business services is well established. Theoretical foundation is provided in Francois (1990) and empirical evidence can be found in (Ono, 2007; Jabbour, 2013). Greater market size promotes division of labor and contracting-out. I lack data on actual size of individual product markets, so I control for this with cost of living adjusted gross regional product (GRP). Adjustment for cost of living is essential to get rid of “cost of cold” – exceptional consumer prices appreciation in northern regions of Russia with their high transportation, construction and heating costs. As outlined in Hill and Gaddy (2003), Mikhailova (2004), this costs pose a significant burden to Russian economy. As a robustness check, I substitute this variable with overall employment by region in 2011.

There is also rich evidence that professional services are attracted to big cities (Bennett et al., 1999; Keeble and Nachum, 2002; Shearmur and Doloreux, 2008). In Kolko (2010) it was pointed out that the services are urbanized rather spatially agglomerated industries. Explanations for this fact often feature intangible location factors like creative environment, tacit knowledge or localized knowledge spillovers as well as more traditional ones like proximity to clients and suppliers, labor pooling and transport accessibility (Howells, 2002; Keeble and Nachum, 2002; Muller and Doloreux, 2009).

I control for region-level urbanization with specially constructed urbanization index. This index for region  $i$  is indeed the expected population of settlement region’s inhabitant resides. Formally, this is as follows:

$$URBAN_i = \sum s_{ij}P_j$$

Where:

$s_{ij}$  – share of settlement  $j$  in region  $i$ ’s aggregate population<sup>5</sup>

$P_j$  – population of settlement  $j$

I prefer this index to more simple urbanization rate (share of people who reside in cities and towns) because the latter does not allow to distinguish between concentration of people in a

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<sup>5</sup> I lack data on number of inhabitants in individual rural settlements, so I assign them equal weights obtained from number of rural settlements and their aggregate population. Russia is a highly urbanized country (73% population are in cities and towns), so it is unlikely to cause much bias.

few large cities and more dispersed urbanization pattern. In addition, it has some advantages over population density. Many Russian regions, especially those in Siberia and in the North, have economic activity clustered in relatively small territory around a regional capital, which is often a large city, while the vast territory with less comfortable conditions to live is sparsely populated.

The drawbacks of this index may become apparent when the same metropolitan area is divided between a number of municipalities. However, such a situation is not common in Russia. Boundaries between local government areas allow for relatively easy revision and a city may be amalgamated with its suburbs without many lengthy legal formalities if regional or federal government backs such amalgamation (see examples of Moscow city limits expansions in 1960 and 2012).

The next factor to be accounted for is present-day human capital. Firms specialized in professional services typically seek for well-educated specialists and managers. Numerous studies have shown higher region-level educational attainment to be associated with higher new firm formation and survival, especially among those in knowledge-intensive industries (Acs et al., 2007; Lee et al., 2004; Qian et al., 2013). I control for current human capital endowment with number of researchers in 2011, number of fresh graduates from public universities in 2011 and number of employees with university degree in 2009-2011.

2011 number of researchers is variable of special interest due to lack of regional fixed effects in my specifications. Russia has inherited organization of its R&D sector from the Soviet era, and pairwise correlation between number of researchers in 1991 and 2011 is very high. Thus, any time-invariant region-specific factors, which are not captured by the controls, are likely to affect both variables. If the number of R&D-involved staff has no direct effect on present-day employment in professional services but omitted variables have, I expect to observe very similar coefficients at the number of researches both in 1991 and in 2011. Otherwise, if great divergence in coefficients' sign and magnitude is found, this does not conform to third-variable theory and thus affords ground to believe that the genuine effect of the variables is found.

Number of university graduates enables to control for regional specialization in high-tech industries, which also may be connected to demand for advanced producer services.

Co-location of major universities and research establishments may also induce spurious correlation. Fresh graduates are a valuable talent pool for professional services. Due to lack of obsolete Soviet-era professional experience, they might have better prospective during the first years of transition. Since Russian university system has much to be inherited from the Soviet era, persistence of its spatial pattern may also appear in professional services' one. To test for

this, I control for 2011 number of fresh graduates. I restrict my attention to public universities since private schools in Russia typically have lower standards of teaching and do not provide training in science and engineering. Public universities carry on Imperial and Soviet academic traditions and appear to be more comprehensive in their curriculum.

Reverse causality is also an issue of caution when designing the model. Services is very propulsive sector and a source of externalities for the rest of economy. Several studies found positive effect of increased services inputs on manufacturing firms productivity in different countries of the World, including post-socialist economies (Arnold et al., 2007, 2011, 2012; Fernandes and Paunov 2012; Shepotylo and Vakhitov, 2012), so I cannot rule out reverse causality between the development of professional services and economic development, urbanization, peoples' incentives to enroll universities. While I believe the number of academics in 1991 to be exogenous variable, reverse causality on other variables may bias estimates of all the coefficients.

I instrument number of employees with university degree and urbanization index with the respective variables obtained from 1989 census. GRP is instrumented with electricity consumption in 1991 due to lack of credible national accounts statistics for the Soviet era. Instrument for number of academics in 2011 is a problematic because Soviet-era data cannot be used directly. I argue that academia's losses in human capital due to braindrain after 1991 was slowed down in those regions where more funds was directed to R&D. Therefore, I instrument number of academics in 2011 by region with spending for basic research in the respective year. Basic research funding is appropriated primarily on federal, not regional level. It is unlikely for regional economic condition directly to translate itself into basic research funding. Due to nature of basic research, direct economic payoff is also unlikely. Although number of scholars in *past* years could be used as an argument while bargaining for government research funding, academic staff in *current* year is likely to adjust to size of budget allotted.

All the variables are given in logs. The full list of variables is provided in table 1. Descriptive stats are shown in table 2.

#### **4. Results**

Firstly, to assure exogeneity of academic institutions location under the Soviet rule, I regress electricity consumption in 1991 by region on number of researchers controlling for total employment. Finding measure of economic development with respect to Soviet era is problematic because of lack of market prices, although electricity consumption can serve as substitute for GRP in a command economy dominated by heavy industries, a typical example of which was the USSR. However, this may not be the case in service economy. To deal with

this, I add urbanization index since larger cities were more likely to be the centers of service provision in the Soviet Russia. I also re-run regressions excluding Moscow and Leningrad (St.Petersburg).

Estimation results are provided in table 3. In all the specifications number of researchers has negative but small and insignificant effect on electricity consumption. So, it is unlikely that regions with stronger presence of research institutions had greater potential demand for professional services due to differences in overall economic development.

#### *4.1. Baseline model: Absolute numbers of employees*

I start with estimating effects for current employment in three sub-sectors of professional services. Results of OLS estimation for engineering and architecture are reported in table 2 and those for IT are in table 4. IV-based estimates are reported in tables 3 and 5, respectively. I experiment with several measures of size of regional economies. I employ either GRP or size of workforce. When I use size of workforce instead of GRP, I also omit number of employees with university degree to avoid strong multicollinearity.

Both OLS and IV results confirm that there is significant positive relationship between R&D employment in 1991 and present-day knowledge-intensive services employment.

Taking into account the paramount status of Moscow and St. Petersburg within the Russian urban system, I am concerned with possibility that the relationship found in the overall dataset is actually driven by some effects specific to just the couple of cities. I run additional regressions excluding Moscow and St. Petersburg. Results are robust to exclusion and inclusion of the two largest Russian cities. Results for the truncated sample are shown in columns 3 and 4 in tables 4-7.

Current number of R&D staff always has negative effect though it is significant in selected specifications only. This result is consistent with the view that better opportunities to stay in academia caused lesser talent exodus towards industry. As it was noted earlier, pairwise correlation between log numbers of researchers in 1991 and 2011 by region is about 0.9, so omitted variable bias should act in a uniform way for both variables. Strikingly different coefficients for past and contemporary employment in R&D sector cast doubt on possibility for some confounding time-invariant variables to drive the observed effects. Therefore, it is unlikely that the positive relationship between 1991 number of R&D staff and present-day professional services may be attributed to some long-term association between scientific sector and other knowledge-intensive services.

The effect is also distinct from those of other human capital variables like annual graduation from universities and number of university graduates in regional workforce.

As opposed to engineering and IT, there is no significant effect of past R&D-related employment on current employment in auditing, accounting and management consulting (tables 8-9). The effect is also small in magnitude and has its sign changed when I drop Moscow and St.Petersburg. However, GRP, employment, urbanization, and number of university graduates in workforce occur to have significant effect.

Lack of effect of Soviet-era R&D employment on present-day consulting employment allows me to believe that the number of R&D staff is not merely a proxy for some omitted factors determining general location pattern of professional services. I think so because I expect factors of such kind to affect “economic” services as well as “technological”, not being confined in their effect to specific sub-sectors.

#### *4.2. Robustness checks: Shares of employment*

Results I report are under suspicion to be hypersensitive to the measure of regions’ size. Russian regions are tremendously heterogeneous, and various dimensions of their heterogeneity are crucial to be properly controlled for. If GRP or size of workforce are not perfect measures of variation in regional economies size, regressions may actually reveal a trivial “fact” that large and populous regions simply remain on top and thus have greater number of *both* researchers and professional services employees.

More encompassing robustness check focuses on structure of regional employment instead of absolute numbers of employees. An industry’s share in overall employment has no direct relationship to the size of economy (although larger regions may enjoy deeper division of labor and have greater share of business services in employment, so variations in regions’ size should also be controlled for). I use share of architecture and engineering and of IT in overall employment in 2011 as the dependent variables. The main independent variables are shares of employees involved in R&D in 1991 and in 2011. I also provide controls for share of employees who hold university degree and ratio of fresh graduates to overall workforce. I add urbanization index, GRP or overall employment to control for possible scale effects. I estimate regressions both with OLS and IV; instrumentation strategy is identical to the one used when dealing with absolute employment numbers.

Results are reported in tables 10-15. I show share of R&D-related staff in employment in 1991 to significantly increase present-day share of professional services. As well as in the case of absolute scores, 2011 share of researchers affects contemporary professional services negatively but this effect is never statistically significant. Urbanization has statistically significant effect on IT employment and GRP/workforce size on engineering and architecture’s



one. Thus, I find the effect of Soviet-era locational decisions on present-day geography of knowledge-intensive industries again.

#### *4.3. Possible explanations*

I carry out several additional inquiries to investigate possible explanations for the facts I discover.

I argue that knowledge endowments created under the Soviet rule were unlikely to be directly transmitted into economic growth and to push employment in professional services alongside with overall economy. Sadly, in Russia there is lack of adequate measure of economic development covering the final years of the Soviet era. Gross regional product estimates were published firstly in 1998. As a remedy, I consider logarithm of employment growth rate. I regress log of employment growth rate in 1991-2011 on number of R&D-involved staff or share of R&D staff in employment in 1991, initial size of workforce, 1990 birth-to-death ratio and a set of controls (table 16). I find negative effect of Soviet-era R&D sector on ensuing employment growth although it is significant only in specification with shares in employment as independent variables.

Low rates of residential mobility due to market rigidity and poverty traps are often blamed in preserving distortions in the urban systems of Russia (Hill & Gaddy, 2003; Shepotylo, 2012). Low mobility may explain path dependence in the location of professional services as well as human capital externalities. I cannot assess this directly, but it is possible to test some implications of different hypothesis. Human capital externalities emphasize productivity gains due to greater labor pool. Poverty traps imply possibility of lesser productivity in places with heavier Soviet heritage. This follows from assumptions of fixed local demand on professional services and varying sizes of immobile labor force pools.

I regress log sales per worker (cost-of-living adjusted) in professional services on number of researchers in 1991 as well as in 2011. I control for cost of living adjusted GRP per capita, urbanization and the standard set of controls for present-day human capital. Results for engineering and architecture are reported in table 17 and those for IT are in table 18. I do not estimate productivity regressions for auditing, accounting and management consulting since there is no evidence of path-dependence in spatial pattern on these industries.

For engineering and architecture, positive relationship is found at conventional significance levels. For IT, effect is negative although small in magnitude and statistically insignificant. Therefore, I rule out low mobility traps hypothesis while human capital externalities theory seems plausible.

Entrepreneurship is likely to be a powerful transmission mechanism for human capital externalities. There is some evidence demonstrating how crucial social ties are for entrepreneurship after lifting legal restrictions for private initiative (Burchardi and Hassan, 2013). Enhanced exchange in ideas may result in greater number of startups in knowledge-intensive services. Data on the overall number of firms provided by the official statistics is not disaggregated by industry, so I employ number of SMEs with 16 to 100 employees in OKVED code “Real estate, leasing and services”. Emphasis on firms with a substantial number of workers also allows to get rid of fly-by-night firms and enterprises which have ceased operation but remain to be counted by the statistics and tax authorities.

I estimate effect of Soviet-era R&D sector on number of SMEs in the business services sector (table 19). The results confirm evidence obtained from employment data. Number of researchers in 1991 has substantial positive effect on number of small and medium enterprises in business services.

## **5. Conclusions**

In this paper I examine whether Soviet-era pattern of R&D-sector location could influence modern-day location of professional services. Under central planning, decision about location of R&D institutions were made in manner exogenous to the market, thus creating a natural experiment.

During transition, there was severe spending cuts in academia and R&D sector, which forced many people to move to industry. Ex-researchers might bridge the shortage of skilled professionals in the service sector due to their high human and social capital.

Did this, however, mean that regions where greater number of researchers were gathered under the Soviet rule are ahead in development of professional services now? In addition to number of researches in 1991 – the variable of interest, I provide controls to capture present-day human capital, economic development and urbanization. I find the effect for employment in engineering and architecture as well as in information technology and computer-related services. I find no significant effect for employment in accounting, auditing and management consulting. I obtain similar findings when not absolute numbers but shares of architecture, engineering and IT in present-day employment structure are used as dependent variables and the share of researchers in overall employment in 1991 is used as a predictor.

Various explanations for this fact can be proposed. I show that regions with greater 1991 R&D-related employment do not have lesser sales per worker in professional services now, so it is unlikely that labor market distortions due to central planning locked ex-researchers in poverty traps. Number of small and medium enterprises is also greater in those regions in

which more people involved in R&D were gathered under the Soviet rule. Enhanced entrepreneurship in regions with greater size of R&D sector in 1991 is a plausible mechanism for transmitting human capital externalities and imposing path dependence.

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## Appendix

**Tab.1**

<b>Label</b>	<b>Description</b>	<b>Type</b>
log_eng	Log number of employees in engineering and architecture, 2011	Dependent
log_it	Log number of employees in computer-related services and information technology, 2011	Dependent
log_cons	Log number of employees in accounting, auditing and management consulting, 2011	Dependent
log_eng_share	Log share of engineering and architecture, per cent of total employment, 2011	Dependent
log_it_share	Log share of computer-related services and information technology, per cent of total employment, 2011	Dependent
log_cons_share	Log share of accounting, auditing and management consulting, per cent of total employment, 2011	Dependent
log_emplchange	Log aggregate employment growth rate from 1991 to 2011	Dependent
log_prod_eng	Log sales per employee in engineering and architecture, cost of living adjusted, 2011	Dependent
log_prod_it	Log sales per employee in computer-related services and information technology, cost of living adjusted, 2011	Dependent
log_firms_services	Log number of SME's minus microenterprises in industry "Real estate, renting, leasing and business services" (16-100 employees), 2012	Dependent
log_sci_1991	Log number of staff involved in R&D, 1991	Independent
log_sci_2011	Log number of staff involved in R&D, 2011	Independent
log_sci_share_1991	Log share of staff involved in R&D, per cent of total employment, 1991	Independent
log_sci_share_2011	Log share of staff involved in R&D, per cent of total employment, 2011	Independent
log_freshgrad	Log number of fresh graduates from public universities, 2011	Independent
log_freshgrad_peremp	Log fresh graduates to labor force ratio, 2011	Independent
log_highed	Log number of employees who hold an university degree, 2011	Independent
log_highed_share	Log share of employees who hold an university degree, per cent of total employment, 2011	Independent
log_grp	Log cost of living adjusted GRP, 2011	Independent



<b>Label</b>	<b>Description</b>	<b>Type</b>
log_empl	Log size of labor force, 2011	Independent
log_urbindex	Log urbanization index, 2010	Independent
log_natincr	Log birth-to-death ratio, 1990	Independent
log_rdspending	Log spending of basic research, 2011	Instrument
log_rdspending_peremp	Log spending of basic research per employee, 2011	Instrument
log_highed_1989	Log number of people who hold an university degree, 1989	Instrument
log_highed_share_1989	Log number of people who hold an university degree, 1989	Instrument
log_freshgrad_1990	Log number of fresh graduates from public universities, 1990	Instrument
log_freshgrad_peremp_1990	Log fresh graduates to labor force ratio, 1990	Instrument
log_ec_1991	Log electricity consumption, 1991	Instrument
log_empl_1991	Log size of labor force in 1991	Instrument
log_urbindex_1989	Log urbanization index, 1989	Instrument

**Tab.2**

<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>
log_eng	7.35	1.36	3.58	11.24
log_it	7.46	1.21	4.44	11.41
log_cons	7.82	1.08	5.48	11.44
log_eng_share	-6.01	0.72	-8.32	-4.40
log_it_share	-5.90	0.57	-8.14	-4.27
log_cons_share	-5.53	0.54	-7.96	-4.25
log_emplchange	-0.13	0.17	-1.17	0.32
log_prod_eng	6.57	0.94	4.73	9.42
log_prod_it	5.63	1.26	0.94	7.93
log_firms_services	5.90	1.09	3.18	8.81
log_sci_1991	8.88	1.46	4.57	13.01
log_sci_2011	7.75	1.55	4.69	12.38
log_sci_share_1991	-4.47	0.85	-6.85	-2.25
log_sci_share_2011	-5.61	0.99	-7.97	-3.31
log_freshgrad	9.14	0.98	6.68	12.01
log_freshgrad_peremp	-4.22	0.36	-5.87	-3.40
log_highed	12.04	0.86	10.21	14.94
log_highed_share	3.28	0.17	3.00	3.86
log_grp	12.64	1.04	10.19	15.76
log_empl	13.36	0.83	11.40	15.68
log_urbindex	12.06	0.98	9.69	16.26
log_natincr	0.26	0.38	-0.35	1.44
log_rdspending	19.65	1.45	16.23	24.09
log_rdspending_peremp	6.29	1.14	3.52	8.71
log_highed_1989	11.60	0.84	9.27	14.46
log_highed_share_1989	2.29	0.23	1.98	3.27
log_freshgrad_1990	8.01	0.98	5.96	11.30
log_freshgrad_peremp_1990	-5.34	0.40	-6.48	-4.27

<b>Variable</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min</b>	<b>Max</b>
log_ec_1991	9.10	1.01	5.88	11.04
log_empl_1991	13.49	0.76	11.41	15.45
log_urbindex_1989	12.35	0.91	10.55	15.99

**Tab.3 (OLS)**

<b>VARIABLES</b>	(1) log_ec_1991	(2) log_ec_1991	(3) log_ec_1991	(4) log_ec_1991
log_empl_1991	1.440*** (0.186)	1.407*** (0.185)	1.463*** (0.188)	1.415*** (0.191)
log_urbindex_1989			-0.131 (0.0863)	-0.0317 (0.0823)
log_sci_1991	-0.136 (0.104)	-0.0774 (0.107)	-0.0846 (0.107)	-0.0690 (0.109)
Constant	-9.123*** (1.699)	-9.171*** (1.650)	-8.276*** (1.737)	-8.965*** (1.636)
Observations	76	74	76	74
R-squared	0.831	0.842	0.836	0.842

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Tab.4 (OLS)**

VARIABLES	(1)	(2)	(3)	(4)
	log_eng	log_eng	log_eng	log_eng
log_sci_1991	0.384** (0.180)	0.344* (0.205)	0.390** (0.187)	0.355* (0.209)
log_sci_2011	-0.131 (0.106)	-0.104 (0.106)	-0.132 (0.106)	-0.116 (0.106)
log_freshgrad	0.365 (0.258)	0.158 (0.278)	0.397 (0.281)	0.177 (0.278)
log_highed	0.0375 (0.432)		-0.00393 (0.484)	
log_grp	0.512*** (0.174)		0.523*** (0.179)	
log_urbindex	0.0330 (0.0933)	0.105 (0.111)	-6.71e-05 (0.151)	0.0488 (0.156)
log_empl		0.840** (0.349)		0.845** (0.354)
Constant	-5.695*** (1.959)	-8.826*** (2.777)	-5.287* (2.768)	-8.409*** (3.008)
Observations	76	76	74	74
R-squared	0.850	0.840	0.818	0.807

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.5 (IV)**

VARIABLES	(1)	(2)	(3)	(4)
	log_eng	log_eng	log_eng	log_eng
log_sci_1991	0.484* (0.261)	0.528** (0.255)	0.557** (0.253)	0.578** (0.262)
log_sci_2011	-0.199 (0.258)	-0.222 (0.214)	-0.246 (0.254)	-0.284 (0.226)
log_freshgrad	1.139* (0.602)	1.170* (0.692)	1.356** (0.688)	1.065* (0.639)
log_highed	-0.223 (0.708)		-0.638 (0.851)	
log_grp	0.0955 (0.320)		0.263 (0.295)	
log_urbindex	-0.134 (0.177)	-0.157 (0.220)	-0.286 (0.270)	-0.216 (0.249)
log_empl		-0.173 (0.620)		-0.0305 (0.579)
Constant	-2.750 (3.271)	-2.126 (4.205)	-0.346 (4.621)	-2.336 (4.111)
Observations	75	75	73	73
R-squared	0.837	0.828	0.801	0.795

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.6 (OLS)**

VARIABLES	(1) log_it	(2) log_it	(3) log_it	(4) log_it
log_sci_1991	0.381*** (0.131)	0.336** (0.159)	0.389*** (0.135)	0.349** (0.161)
log_sci_2011	-0.0825 (0.0747)	-0.0713 (0.0700)	-0.0828 (0.0752)	-0.0786 (0.0712)
log_freshgrad	0.0911 (0.150)	-0.210* (0.106)	0.114 (0.161)	-0.190* (0.104)
log_highed	-0.0970 (0.313)		-0.129 (0.341)	
log_grp	0.587*** (0.136)		0.589*** (0.138)	
log_urbindex	0.185*** (0.0643)	0.275*** (0.0649)	0.168* (0.0937)	0.242*** (0.0809)
log_empl		0.919*** (0.158)		0.903*** (0.163)
Constant	-4.607*** (1.300)	-8.655*** (1.458)	-4.321** (1.762)	-8.285*** (1.615)
Observations	76	76	74	74
R-squared	0.912	0.899	0.889	0.873

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.7 (IV)**

VARIABLES	(1) log_it	(2) log_it	(3) log_it	(4) log_it
log_sci_1991	0.581*** (0.176)	0.368* (0.195)	0.592*** (0.169)	0.385* (0.201)
log_sci_2011	-0.390** (0.189)	-0.154 (0.154)	-0.395** (0.182)	-0.175 (0.163)
log_freshgrad	-0.0630 (0.353)	-0.655** (0.299)	-0.0492 (0.447)	-0.691** (0.290)
log_highed	0.0742 (0.450)		0.0482 (0.569)	
log_grp	0.699*** (0.221)		0.704*** (0.197)	
log_urbindex	0.235** (0.109)	0.371*** (0.0936)	0.225 (0.182)	0.351*** (0.111)
log_empl		1.419*** (0.323)		1.468*** (0.319)
Constant	-6.676*** (2.344)	-12.06*** (2.469)	-6.489* (3.451)	-12.14*** (2.503)
Observations	75	75	73	73
R-squared	0.886	0.889	0.855	0.857

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.8 (OLS)**

VARIABLES	(1)	(2)	(3)	(4)
	log_cons	log_cons	log_cons	log_cons
log_sci_1991	0.0948 (0.188)	0.0458 (0.223)	0.109 (0.193)	0.0650 (0.225)
log_sci_2011	0.0735 (0.0880)	0.0908 (0.0995)	0.0727 (0.0877)	0.0783 (0.0990)
log_freshgrad	-0.0673 (0.147)	-0.416*** (0.137)	-0.0181 (0.168)	-0.385*** (0.141)
log_highed	-0.141 (0.351)		-0.208 (0.398)	
log_grp	0.761*** (0.158)		0.770*** (0.163)	
log_urbindex	0.207*** (0.0708)	0.311*** (0.0819)	0.165 (0.112)	0.254** (0.106)
log_empl		1.117*** (0.223)		1.097*** (0.234)
Constant	-3.390** (1.591)	-8.159*** (2.044)	-2.769 (2.248)	-7.568*** (2.254)
Observations	76	76	74	74
R-squared	0.836	0.802	0.795	0.752

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.9 (IV)**

VARIABLES	(1)	(2)	(3)	(4)
	log_cons	log_cons	log_cons	log_cons
log_sci_1991	0.184 (0.232)	-0.0104 (0.271)	0.233 (0.222)	0.0173 (0.276)
log_sci_2011	-0.0709 (0.223)	0.112 (0.199)	-0.101 (0.217)	0.0757 (0.209)
log_freshgrad	0.164 (0.424)	-0.719* (0.404)	0.292 (0.606)	-0.783** (0.392)
log_highed	-0.357 (0.534)		-0.601 (0.771)	
log_grp	0.848*** (0.266)		0.942*** (0.246)	
log_urbindex	0.166 (0.138)	0.348*** (0.135)	0.0760 (0.249)	0.314** (0.160)
log_empl		1.497*** (0.412)		1.584*** (0.414)
Constant	-3.196 (2.959)	-10.57*** (3.112)	-1.743 (4.703)	-10.72*** (3.192)
Observations	75	75	73	73
R-squared	0.825	0.795	0.771	0.739

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.10 (OLS)**

VARIABLES	(1)	(2)	(3)	(4)
	log_eng_share	log_eng_share	log_eng_share	log_eng_share
log_sci_share_1991	0.370*	0.351*	0.372*	0.352*
	(0.204)	(0.205)	(0.207)	(0.207)
log_sci_share_2011	-0.131	-0.115	-0.124	-0.109
	(0.113)	(0.113)	(0.114)	(0.114)
log_freshgrad_peremp	0.275	0.141	0.324	0.191
	(0.275)	(0.285)	(0.290)	(0.300)
log_highed_share	0.0773	0.0924	-0.101	-0.0875
	(0.465)	(0.477)	(0.598)	(0.607)
log_grp	0.264***		0.273***	
	(0.0901)		(0.0916)	
log_urbindex	0.0274	0.104	-0.0263	0.0437
	(0.112)	(0.114)	(0.163)	(0.167)
log_empl		0.242		0.261*
		(0.148)		(0.154)
Constant	-7.841***	-9.274***	-6.492	-7.966*
	(2.866)	(3.269)	(4.207)	(4.323)
Observations	76	76	74	74
R-squared	0.459	0.431	0.380	0.349

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.11 (IV)**

VARIABLES	(1)	(2)	(3)	(4)
	log_eng_share	log_eng_share	log_eng_share	log_eng_share
log_sci_share_1991	0.735**	0.630**	0.740**	0.627*
	(0.338)	(0.317)	(0.348)	(0.326)
log_sci_share_2011	-0.547	-0.425	-0.550	-0.415
	(0.344)	(0.318)	(0.363)	(0.335)
log_freshgrad_peremp	0.950	0.695	0.956	0.712
	(0.615)	(0.624)	(0.670)	(0.661)
log_highed_share	0.991	0.876	0.997	0.760
	(0.897)	(0.806)	(1.248)	(1.146)
log_grp	0.314**		0.313**	
	(0.148)		(0.147)	
log_urbindex	-0.148	-0.0732	-0.149	-0.0915
	(0.229)	(0.207)	(0.276)	(0.261)
log_empl		0.326**		0.326**
		(0.160)		(0.161)
Constant	-7.254	-9.018	-7.206	-8.302
	(5.564)	(5.524)	(8.168)	(7.877)
Observations	75	75	73	73
R-squared	0.351	0.383	0.250	0.296

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.12 (OLS)**

VARIABLES	(1) log_it_share	(2) log_it_share	(3) log_it_share	(4) log_it_share
log_sci_share_1991	0.338** (0.163)	0.324** (0.157)	0.350** (0.161)	0.335** (0.157)
log_sci_share_2011	-0.0694 (0.0794)	-0.0502 (0.0775)	-0.0617 (0.0799)	-0.0448 (0.0783)
log_freshgrad_peremp	-0.105 (0.123)	-0.183* (0.109)	-0.0233 (0.126)	-0.116 (0.113)
log_highed_share	-0.135 (0.303)	-0.192 (0.312)	-0.381 (0.404)	-0.386 (0.409)
log_grp	0.0704 (0.0645)		0.0816 (0.0635)	
log_urbindex	0.189** (0.0773)	0.281*** (0.0714)	0.109 (0.0973)	0.212** (0.0884)
log_empl		-0.0345 (0.0888)		-0.0186 (0.0845)
Constant	-7.945*** (1.893)	-7.802*** (2.063)	-5.892** (2.778)	-6.195** (2.888)
Observations	76	76	74	74
R-squared	0.546	0.540	0.455	0.445

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.13 (IV)**

VARIABLES	(1) log_it_share	(2) log_it_share	(3) log_it_share	(4) log_it_share
log_sci_share_1991	0.558** (0.257)	0.472** (0.238)	0.562** (0.265)	0.474* (0.249)
log_sci_share_2011	-0.377 (0.255)	-0.265 (0.239)	-0.379 (0.272)	-0.264 (0.261)
log_freshgrad_peremp	-0.399 (0.283)	-0.621** (0.303)	-0.394 (0.312)	-0.613* (0.326)
log_highed_share	0.845 (0.651)	0.510 (0.576)	0.848 (0.921)	0.480 (0.869)
log_grp	0.184* (0.101)		0.182* (0.0959)	
log_urbindex	0.140 (0.135)	0.310*** (0.0952)	0.139 (0.151)	0.304** (0.123)
log_empl		0.0278 (0.0957)		0.0269 (0.0949)
Constant	-13.99*** (3.492)	-13.67*** (3.845)	-13.94*** (5.302)	-13.44** (5.594)
Observations	75	75	73	73
R-squared	0.420	0.463	0.289	0.345

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1



**Tab.14 (OLS)**

VARIABLES	(1)	(2)	(3)	(4)
	log_cons_share	log_cons_share	log_cons_share	log_cons_share
log_sci_share_1991	0.0555 (0.234)	0.0390 (0.219)	0.0701 (0.233)	0.0519 (0.220)
log_sci_share_2011	0.0750 (0.109)	0.104 (0.104)	0.0862 (0.107)	0.111 (0.104)
log_freshgrad_peremp	-0.311* (0.160)	-0.398*** (0.134)	-0.198 (0.169)	-0.312** (0.143)
log_highed_share	-0.00334 (0.383)	-0.113 (0.376)	-0.352 (0.501)	-0.367 (0.489)
log_grp	0.0170 (0.0855)		0.0333 (0.0842)	
log_urbindex	0.177 (0.109)	0.313*** (0.0842)	0.0647 (0.142)	0.224* (0.116)
log_empl		-0.167 (0.112)		-0.146 (0.110)
Constant	-8.512*** (2.565)	-7.636*** (2.764)	-5.638 (3.690)	-5.565 (3.700)
Observations	76	76	74	74
R-squared	0.194	0.218	0.119	0.137

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Tab.15 (IV)**

VARIABLES	(1)	(2)	(3)	(4)
	log_cons_share	log_cons_share	log_cons_share	log_cons_share
log_sci_share_1991	0.205 (0.386)	0.112 (0.323)	0.201 (0.396)	0.103 (0.337)
log_sci_share_2011	-0.117 (0.361)	0.00779 (0.291)	-0.0964 (0.388)	0.0351 (0.321)
log_freshgrad_peremp	-0.284 (0.387)	-0.529 (0.360)	-0.234 (0.441)	-0.488 (0.394)
log_highed_share	0.930 (0.907)	0.482 (0.681)	0.664 (1.296)	0.185 (1.038)
log_urbindex	0.172 (0.157)	0.232* (0.137)	0.181 (0.147)	0.186 (0.173)
log_grp	0.0108 (0.216)		-0.0425 (0.231)	
log_empl		-0.0549 (0.132)		-0.0542 (0.130)
Constant	-11.83** (4.766)	-10.87** (4.424)	-10.12 (7.471)	-9.066 (6.590)
Observations	75	75	73	73
R-squared	0.103	0.186	0.024	0.109

**Tab.16 (OLS)**

VARIABLES	(1) log_ emplchange	(2) log_ emplchange	(3) log_ emplchange	(4) log_ emplchange
log_sci_1991	-0.0564 (0.0372)	-0.0517 (0.0375)		
log_sci_2011	0.0377* (0.0199)	0.0351* (0.0197)		
log_freshgrad	0.276*** (0.0849)	0.279*** (0.0833)		
log_sci_share_1991			-0.121** (0.0554)	-0.125** (0.0581)
log_sci_share_2011			0.0161 (0.0204)	0.0142 (0.0207)
log_freshgrad_peremp			0.0803 (0.0607)	0.0581 (0.0569)
log_highed_share			0.278** (0.110)	0.367*** (0.107)
log_empl_1991	-0.481*** (0.136)	-0.475*** (0.149)	-0.188* (0.104)	-0.208* (0.111)
log_grp	0.233*** (0.0610)	0.227*** (0.0673)	0.215*** (0.0805)	0.222*** (0.0823)
log_urbindex	-0.0644** (0.0282)	-0.0738*** (0.0273)	0.0106 (0.0277)	0.0401 (0.0425)
log_natincr	-0.0888 (0.0756)	-0.0842 (0.0795)	-0.126 (0.0932)	-0.141 (0.0986)
Constant	1.899** (0.793)	1.959** (0.764)	-1.431* (0.793)	-2.014** (0.855)
Observations	76	74	76	74
R-squared	0.611	0.587	0.498	0.475

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.17 (OLS)**

VARIABLES	(1)	(2)	(3)	(4)
	log_prod_eng	log_prod_eng	log_prod_eng	log_prod_eng
log_sci_1991	0.348** (0.174)	0.331* (0.183)		
log_sci_2011	-0.0289 (0.135)	-0.0216 (0.139)		
log_freshgrad	0.234 (0.349)	0.204 (0.360)		
log_sci_share_1991			0.384** (0.173)	0.365** (0.179)
log_sci_share_2011			-0.0988 (0.159)	-0.112 (0.161)
log_freshgrad_peremp			0.128 (0.389)	0.00325 (0.436)
log_highed_share			0.723 (0.803)	1.097 (1.012)
log_urbindex	-0.0668 (0.180)	-0.0255 (0.241)	-0.0846 (0.176)	0.0507 (0.251)
log_grp	0.819* (0.462)	0.829* (0.471)	0.781 (0.479)	0.809* (0.479)
log_empl	-1.262** (0.592)	-1.241** (0.601)	-0.643 (0.628)	-0.704 (0.632)
Constant	8.843*** (3.158)	8.305** (3.414)	5.614 (5.021)	2.552 (6.561)
Observations	73	71	73	71
R-squared	0.229	0.196	0.239	0.215

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.18 (OLS)**

VARIABLES	(1) log_prod_it	(2) log_prod_it	(3) log_prod_it	(4) log_prod_it
log_sci_1991	-0.0293 (0.313)	-0.0434 (0.300)		
log_sci_2011	0.108 (0.232)	0.111 (0.222)		
log_freshgrad	-0.325 (0.495)	-0.346 (0.507)		
log_sci_share_1991			-0.0767 (0.311)	-0.0820 (0.306)
log_sci_share_2011			0.195 (0.229)	0.207 (0.234)
log_freshgrad_peremp			-0.185 (0.464)	-0.126 (0.476)
log_highed_share			-0.833 (0.950)	-1.113 (1.057)
log_urbindex	0.151 (0.189)	0.163 (0.241)	0.165 (0.198)	0.0764 (0.246)
log_grp	-0.241 (0.393)	-0.243 (0.414)	-0.199 (0.409)	-0.226 (0.417)
log_empl	1.423 (0.932)	1.461 (0.957)	1.101** (0.482)	1.162** (0.501)
Constant	-9.799 (5.911)	-10.14 (6.288)	-5.896 (5.877)	-4.109 (6.725)
Observations	74	72	74	72
R-squared	0.427	0.380	0.435	0.391

Robust standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

**Tab.19**

VARIABLES	(1) OLS log_firms	(2) OLS log_firms	(3) IV log_firms	(4) IV log_firms
log_sci_1991	0.363*** (0.128)	0.339** (0.138)	0.492*** (0.166)	0.449*** (0.171)
log_sci_2011	-0.0498 (0.0549)	-0.0482 (0.0548)	-0.295* (0.162)	-0.269* (0.156)
log_freshgrad	0.0987 (0.125)	0.00644 (0.128)	0.0266 (0.275)	-0.0832 (0.312)
log_highed	-0.0693 (0.265)	0.0543 (0.293)	0.0853 (0.410)	0.295 (0.487)
log_grp	0.530*** (0.107)	0.509*** (0.110)	0.621*** (0.193)	0.541*** (0.195)
log_urbindex	0.0629 (0.0656)	0.145* (0.0809)	0.0885 (0.103)	0.166 (0.134)
Constant	-4.470*** (1.281)	-5.630*** (1.617)	-6.377*** (1.925)	-7.631*** (2.568)
Observations	76	74	75	73
R-squared	0.923	0.911	0.904	0.893

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

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