Espionage-based Knowledge Flows and Firm Outcomes*

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Economic espionage is a pervasive phenomenon around the world. We study how espionage-based knowledge flows alter the production structure and performance of firms in the perpetrating country. Exploiting a historical East German database that traces the flows of scientific-technical information from their sources in the West to their destinations in the East, we show that economic espionage during the Cold War had a significant positive impact on firms' output and productivity. We document that this impact is driven by intelligence reports that were internally assessed as "valuable", and that those pieces of information tended to be relatively labor-augmenting. We also show that a higher inflow of information in the past is associated with a higher likelihood of successful privatization after German reunification.

Keywords: *Espionage, Knowledge Flows, Firm Adjustments, Productivity*

JEL Codes: *L2, N4, O3, P2*

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I. Introduction

Economic espionage is a pervasive phenomenon around the world. While countries like China and Russia are widely believed to engage in large-scale economic espionage (e.g. IP Commission, 2013), the practice appears to be widespread, with even countries that are formally considered allies collecting information about each other to give their economies a competitive edge in the global market.[1] It is therefore not surprising that the damages due to economic and industrial espionage are thought to be substantial: estimates amount to 350 billion dollars per year for the United States and 55 billion euros per year for Germany, figures expected to further increase in the future (IP Commission, 2017; Bitkom, 2017).[2] Despite its pervasiveness, there hardly exists any quantitative evidence of the effects of economic espionage on society.

In this paper, we address the question of how economic espionage benefits the perpetrating country's firms. Our analysis relies on historical data from the Cold War period during which the East German Ministry for State Security (the so-called *Stasi*) engaged in comprehensive economic espionage in the Western world, in particular in West Germany. Relying on an extensive network of spies, the Stasi kept an accurate picture of the economic situation and technological advances there. The centerpiece of our empirical analysis is the so-called SIRA database (Konopatzky, 2007) which contains complete records of almost all the intelligence East Germany (the GDR) obtained from its Western informants between 1968 and 1989. Over this period, the Stasi gathered 189,725 pieces of scientific-technical information, reflecting the enormous scale on which it was spying in the West. For most of these pieces of intelligence, SIRA contains information on the precise date they was received, the code name of the informant who provided the information, an assessment of the information's economic value on an ordinal scale from 1 to 5, and a list of keywords describing each item's content.

Based on these unprecedented data, we assess the impact of East Germany's economic espionage activities on the performance of its firms. We take advantage of the fact that one can accurately trace the flow of scientific-technical information from its original source in the West to the final recipients in the East. Usually, those recipients were specialized research institutes or state-owned establishments (*VEB*) or firms (*Kombinate*). Using newly digitized and formerly classified archival data on a wide range of economic indicators for these firms, we provide a comprehensive bottom-up evaluation of the impact of economic espionage on the East German economy. In addition to standard measures of firm-level output and productivity, the data allow us to separately study employment and investment responses to espionage-based knowledge flows as well as adjustments in

[1] See, for example, the WikiLeaks revelations in 2013 about the NSA's surveillance operations abroad.

[2] Note the distinction between "industrial espionage" which refers to activities conducted by individual companies against their competitors for commercial purposes, and "economic espionage" which refers to activities in the economic domain conducted on behalf of foreign governments and for reasons that are not exclusively commercial (Nasheri, 2005).

the workforce composition and export behavior of firms. As a catch-all measure of firms' closeness to the technological frontier, we also study how the receipt of espionage information in the past affected East German firms' likelihood of being privatized after German reunification in 1990.

Our findings show that economic espionage had a significant positive impact on East German firms' output and productivity. According to our preferred specification, a 10 percentage-point increase in the inflow rate of espionage-based information increases annualized output growth by 0.77 log points and output per worker growth by 0.81 log points. Distinguishing between inflows of information that were a priori assessed as "valuable" and "non-valuable", we show that these effects are exclusively driven by valuable pieces of information. The key role of these valuable intelligence reports is also salient for other outcomes. While we find no significant impact of general espionage on the level and composition of employment or the capital stock, the arrival of high quality pieces of information leads to a significant expansion of both capital and employment: a 10 percentage-point increase in the inflow rate of valuable information raises the growth in capital stock by 3.91 log points and the growth in employment by 1.88 log points. Since capital and labor are gross complements in production, this suggests that successful economic espionage induced labor-augmenting technical change at the recipient firms. Furthermore, we document a significant positive effect of espionage inflows on East German firms' export activities. This effect is solely driven by an increase in exports to other socialist countries, especially the Soviet Union. Finally, we show a strong association between the past inflow of intelligence and the likelihood of successful privatization in the aftermath of German reunification, which is once again largely driven by the arrival of valuable pieces of information.

Despite its long history as an illicit channel of technology transfer (see e.g. Laiou, 2002; Ben-Atar, 2004), economic espionage is still an understudied phenomenon. While there is a small theoretical literature in economics on the rationale for economic espionage and its welfare implications (e.g. Whitney and Gaisford, 1999; Billand, Bravard and Sarangi, 2010; Barrachina, Tauman and Urbano, 2014; Chen, 2016), there exists almost no reliable empirical evidence on the topic. An important exception is the work of Glitz and Meyersson (2020), who exploit the information recorded in SIRA to show that economic espionage in the West had a significant positive impact on sectoral TFP growth in East Germany. Our analysis substantially deepens this work by zooming in on the level of the individual firm. This enables us to not only better understand how exactly espionage-based knowledge flows translate into productivity growth – something that remained unexplored in Glitz and Meyersson (2020) – but also to learn more about the nature of such knowledge flows. By analyzing the responsiveness of different factor inputs to the arrival of new information from the West, we are able to deduce the degree of complementarity between these inputs and espionage-based information and assess whether the latter tend

to be factor-augmenting or skill-biased (Acemoglu, 2003; Doraszelski and Jaumandreu, 2018).

Our analysis speaks to several existing literatures in economics. Most importantly, since economic espionage inherently involves the flow of technological knowledge from the targeted to the perpetrating country, our findings contribute to the extensive work on international technology diffusion (Jones, 2005; Keller, 2010; Comin and Mestieri, 2014). This literature has either focused directly on international R&D spillovers (e.g. Jaffe, Trajtenberg and Henderson, 1993; Griffith, Harrison and van Reenen, 2006; Coe, Helpman and Hoffmaister, 2009) or studied the role of international trade (e.g. Eaton and Kortum, 2002; Cameron, Proudman and Redding, 2005; Buera and Oberfield, 2016), foreign direct investment (e.g. Javorcik, 2004; Keller and Yeaple, 2009; Guadalupe, Kuzmina and Thomas, 2012) or migration (e.g. Hornung, 2014; Hunt and Gauthier-Loiselle, 2010; Moser, Voena and Waldinger, 2014) as possible conduits of international knowledge spillovers. In contrast to most of this work, we are able to observe knowledge flows directly, both in terms of quantity and quality, which allows a more accurate assessment of their impact on firms' production structures and productivity growth.

Viewing economic espionage as an alternative way of acquiring new scientific-technical knowledge, our work is also related to the literature on the role of innovation and imitation in explaining productivity growth (e.g. Aghion and Howitt, 1992; Aghion et al., 2001; Hall, Mairesse and Mohnen, 2010*a*). Comparing the estimated returns to economic espionage with those to traditional R&D, we can analyze their relative effectiveness in generating productivity growth, even though a full cost-benefit analysis is difficult due to a lack of reliable information on the cost side.

II. Historical Background

At the onset of the Cold War, and in response to the West's implementation of strict economic containment policies against the Communist East (Jackson, 2001), East Germany initiated its economic espionage program which was then steadily expanded over subsequent decades. Most of the spying activities were overseen by the so-called HVA (*Hauptverwaltung Aufklärung*), the Stasi's foreign intelligence unit, which counted some 3,300 full-time staff members leading around 1,550 informants in West Germany alone in 1989. Within the HVA, a dedicated branch was tasked with the acquisition of scientific-technical information, the so-called Sector for Science and Technology (*Sektor Wissenschaft und Technik*, SWT). This branch comprised around 260 full-time staff members by the end of 1988. The SWT itself consisted of three specialized departments covering the fields of Energy, Biology and Chemistry (*Abteilung XIII*), Electronics and Electrical Engineering (*Abteilung XIV*) and Machine Building and Embargo Goods (*Abteilung XV*), which were supported by a department responsible for the evaluation of all incoming information (*Abteilung V*) and several smaller working groups (Müller-Enbergs, 1998).

For its spying in the West, the Stasi relied on an extensive network of informants, most of whom were located in West Germany. Internal documents show that 60 percent of the Stasi's collaborators there were recruited based on their political-ideological convictions, 27 percent due to material interests and only less than 1 percent "under pressure" (Müller-Enbergs, 1998). Most of the informants involved in economic espionage in the West were middle-aged male employees, predominantly engineers or employees with science degrees, although a few also worked in personnel departments or as businessmen. In its effort to keep up with the West, the Stasi gathered scientific-technical information in almost all sectors of the targeted countries. The electronics sector was of particular interest and, according to Glitz and Meyersson (2020), accounted for around 66.1 percent of all the information collected. Other important sectors were the Chemicals sector (22.0 percent), the Utilities sector (15.5 percent), and the Machine Building sector (15.3 percent). However, information was also gathered in niche sectors such as Textiles and Clothing, Coking and Petroleum, and Woodworking.

III. Empirical Framework

The aim of our empirical analysis is to understand how different firm-level input and output variables respond to the inflow of scientific-technical information from the West. To this end, we estimate a series of reduced-form models in which we relate the annualized change in each variable of interest to the lagged espionage inflow received by the respective firm. We lag our inflow variable to allow for a sufficiently long gestation period as it is unlikely that East German firms would be able to immediately take advantage of any new information received. Our estimation equation is given by

$$\Delta y_{it} = \alpha + \beta \left(\frac{\Delta E_{it-1}}{Y_{it-2}} \right) + \gamma \left(\frac{\Delta G_{it-1}}{Y_{it-2}} \right) + \theta_{st} + \varepsilon_{it}, \tag{1}$$

where Δy_{it} is the annualized change of outcome y in firm i between period t and $t-1$. Our main regressor of interest is $\Delta E_{it-1}/Y_{it-2}$, which represents the (normalized) change in the espionage-based knowledge stock in firm i and is computed as the number of pieces of information received between (the end of) periods $t-1$ and $t-2$ divided by the firm's output in period $t-2$. By normalizing our inflow variable with lagged output, we follow the closely related literature on the impact of R&D on productivity growth (e.g. Hall, Mairesse and Mohnen, 2010*b*). In the appendix, we will also present our main findings using the log of the number of pieces of information at the main regressor. To proxy for changes in a firm's regular R&D-based knowledge stock, we also include the regressor $\Delta G_{it-1}/Y_{it-2}$ which is computed as the number of a firm's patent applications between (the end of) periods $t-1$ and $t-2$ divided by the firm's output in period $t-2$. Finally, we also include a full set of sector $\times$ year fixed effects θ_{st} in our preferred specification. Our parameter of interest is therefore estimated from within-sector variation in espionage inflows between firms and over time.

In the main analysis, we estimate the regression model of Equation (1) for different outcome variables. To obtain unbiased estimates, we rely on the assumption that the inflow of spy information is exogenous conditional on the controls included in the model. Espionage activities are unlikely to be exogenous if the East German government intentionally directed them to support particular types of firms or industries. By estimating the model in first differences, we address some of this concern by differencing out factors such as average productivity levels or fixed firm characteristics. In the full specification, we also control for sector $\times$ year effects which account for any trends and shocks within broader industry groups. Even within those groups, however, specific firms may have received differential treatment, for example, because the East German authorities decided to prioritize a particular technology. In those cases, both the covert gathering of information and the firm's own overt R&D activities would likely be intensified simultaneously. To account for this relationship, we include a firm's own patenting activity as a key regressor in our estimations. Overall, the set of included control variables account for several important influences that might generate a spurious correlation between our regressor of interest and the different outcome variables. Given the high degree of uncertainty surrounding economic espionage activities, random influences in terms of gaining access to valuable information, for instance, likely constitute an important part of the identifying variation.

To address further endogeneity concerns, we also implement an instrumental variable approach similar to Glitz and Meyersson (2020), in which we instrument the observed espionage inflows received by an East German firm with the predicted inflow one would expect this firm to receive in the absence of any contemporaneous changes in the strategic preferences of the Stasi. Specifically, the predicted inflow rate is constructed as

$$Z_{i\Delta t} = \frac{\theta_{i,69-71} \cdot \text{Inflow}_{j\in[1969,1971],\Delta t-1}}{Y_{t-2}}, \tag{2}$$

$$\theta_{i,69-71} = \frac{\text{Inflow}_{i,69-71}}{\text{Inflow}_{tot,69-71}} = \frac{\sum_s \text{Inflow}_{is,69-71}}{\text{Inflow}_{tot,69-71}} = \sum_s \frac{\text{Inflow}_{is,69-71}}{\text{Inflow}_{i,69-71}} \frac{\text{Inflow}_{i,69-71}}{\text{Inflow}_{tot,69-71}}$$
$$= \sum_s \theta_{is,69-71}\theta_{i,69-71} \tag{3}$$

$$Z_{i\Delta t} = \sum_s \theta_{is,69-71} \cdot \frac{\theta_{i,69-71} \cdot \text{Inflow}_{j\in[1969,1971],\Delta t-1}}{Y_{t-2}}, \tag{4}$$

where the first part of the sum is the share and the second part the shock.

where $\theta_{i,69-71}$ is the share of information received from (identifiable) informants between 1969 and 1971 that was transmitted to firm i, and $\text{Inflow}_{j\in[1969,1971],\Delta t-1}$ is the total inflow of information between two periods $t-1$ and $t-2$ that stem from informants who were already active in 1969–1971. The identifying assumption is thus that the initial distribution of spies across firms (or, more precisely, each firms' reliance on the early group of spies)

around the year 1970 is conditionally exogenous (Goldsmith-Pinkham, Sorkin and Swift, 2020). By construction, this instrument excludes all variation in espionage inflows that is driven by the placing of new spies into targeted firms, arguably the main channel through which the Stasi endogenously steered its espionage activities in the desired direction.

IV. Data

A. Sira Data

To measure the extent of espionage information received by East German firms, we exploit information recorded in Subdatabase 11 (*Teildatenbank 11*) of the HVA's electronic database SIRA (*System der Informationsrecherche der Hauptverwaltung Aufklärung*). Painstakingly reconstructed by the Agency of the Federal Commissioner for the Stasi Records (BStU) during the 1990s (Konopatzky, 2007), this unique database contains detailed records of almost all scientific-technical information that the Stasi received from its informants in the West during the 1970s and 1980s. It survived the turmoils after the fall of the Berlin Wall in November 1989 only by accident: in the process of a comprehensive data conversion in 1988/1989, the HVA made safety copies of the original SIRA data which were then overlooked when the Stasi hastily disbanded at the beginning of 1990. Between 1968 and 1989, 189,725 distinct pieces of information were recorded in SIRA's Subdatabase 11, the vast majority of which came from West Germany (Müller-Enbergs, 2011). After the information reached the Stasi's headquarters in East Berlin, specialist internal evaluators created an electronic entry in the SIRA database for each incoming piece of information in which they recorded, among other things, the date of arrival of the information, the source of the information and a list of keywords describing each information's content. After this initial registration and evaluation, the received material was then passed on to potentially interested parties, typically state-run enterprises (*Kombinate*) or East German research facilities, for further assessment and economic exploitation. This "mailing list" was also meticulously recorded in the SIRA system, enabling us to link the volume of espionage-based knowledge flows with archival information on key indicators of the receiving East German firms. While the tangible materials accompanying many of the incoming intelligence reports (documents, photos, tapes, disks, blueprints etc.) were destroyed in early 1990, we observe a qualitative assessment by the Stasi evaluators for many reports.[3] Besides the raw volume of espionage information obtained, we can therefore distinguish between "valuable" and "non-valuable" information and study their differential impact on East German firms.

Table 1 provides summary statistics on the volume of espionage information recorded in

[3]In the raw data, 0.6 percent of all pieces of information were given a quality assessment of "no value", 2.3 percent of "low value", 26.5 percent of "average value", 9.6 percent of "valuable", and 1.1 percent of "very valuable". The remaining 59.9 percent have "missing" quality information. Below we describe the imputation procedure through which we assign quality information to at least some of those pieces of information with a "missing" quality assessment.

Table 1—Summary Statistics Espionage Activity

	Mean	SD	P10	P50	P90	N
Espionage Inflows						
Total	108.2	281.6	0	14	279	279
Non-Valuable	88.1	233.1	0	12	207	279
Valuable	20.0	56.9	0	1	36	279
Espionage Inflow Rate						
Total	0.051	0.129	0.000	0.005	0.154	279
Non-Valuable	0.041	0.106	0.000	0.005	0.109	279
Valuable	0.010	0.028	0.000	0.000	0.021	279

Notes. Descriptive statistics cover combines in the main estimation sample, spanning the periods 1976 to 1980 and 1981 to 1985. Espionage inflow is defined as the inflow of spy information over each 5-year period annualized as the yearly average. Espionage rate is defined as the inflow of spy information over the 5-year periods per a thousand of combine output in the base year and are annualized as the yearly average. Non-valuable espionage includes pieces with either missing valuation or a valuation of at most 3 on a scale of 1–5. Valuable espionage includes pieces with a valuation of at least 4.

the SIRA data that was passed on to the East German firms included in our analysis. On average, each combine received 108.2 pieces of information per year. Not surprisingly given the enormous scale of the information flow, most of the intelligence reports from the West were considered "non-valuable", indicating that they either received an evaluation of "no value", "low value" or "average value", or had missing quality information. The average espionage inflow rate – our main regressor of interest, defined as the number of pieces of information received relative to the firm's base year output in thousand (annualized over the time interval considered) – amounts to 5.1 percent. There is substantial variation across firms, however, with a standard deviation of 12.9 percent, an inflow rate of zero percent at the 10^{th} percentile and an inflow rate of 15.4 percent at the 90^{th} percentile. The average inflow rates of non-valuable and valuable information were 4.1 and 1.0 percent, respectively.

B. East German Firm Data

Our firm-level data were compiled by the East German Statistical Office as part of an effort to construct consistent time series of key economic indicators across East German combines (*Langfristige Reihen*). Originally for internal use only, the tabulations report up to 43 distinct economic indicators for the years 1975/76, 1980/81 and 1985–1989 for each of the 144 combines considered. Figure B1 in the appendix shows a scan of the data sheet for the *Kombinat VEB Carl Zeiss Jena*, a world-renowned East German manufacturer of optical instruments at the time. The data contain detailed information on various indicators related to output, employment, capital, exports and costs. To ensure comparability over time, the East German Statistical Office went to great lengths to ensure a constant composition of each combine in terms of its constituent establishments (at the reference date 1 January 1990). In compiling the data, the authorities followed a bottom-up approach in which the individual establishments were responsible for providing

Table 2—Summary Statistics Combine Production

	Mean	SD	P10	P50	P90	N
Annual change in ...						
Log Production	0.040	0.035	0.008	0.033	0.070	296
Log Labor Productivity	0.039	0.032	0.009	0.033	0.069	298
Log Capital Total	0.050	0.026	0.026	0.044	0.081	298
Log Capital Equipment	0.068	0.036	0.033	0.063	0.125	300
Log Capital Other	0.031	0.021	0.011	0.026	0.060	298
Log Capital Over Labor	0.048	0.024	0.025	0.046	0.079	300
Log Employment	0.001	0.012	-0.011	0.000	0.016	298
Log Blue-Collar	0.002	0.015	-0.013	0.001	0.019	294
Log White-Collar	-0.020	0.014	-0.036	-0.019	-0.004	300
Log Avg. Monthly Wage	0.029	0.011	0.017	0.027	0.045	296
Log Avg. Monthly Wage Blue-Collar	0.030	0.013	0.015	0.027	0.049	296
Log Costs Management	-0.004	0.020	-0.023	-0.006	0.019	300
Log Working Hours	0.002	0.006	-0.002	0.001	0.005	292
Log Absence Time	0.002	0.012	-0.012	0.001	0.017	291
Log Hour Productivity	0.038	0.033	0.008	0.032	0.069	291
Log Exports Total	0.053	0.163	-0.044	0.044	0.134	283
Log Exports West	0.060	0.178	-0.107	0.046	0.205	268
Log Exports East	0.048	0.125	-0.037	0.042	0.134	256
Log Exports Soviet Union	0.044	0.166	-0.085	0.039	0.163	214
Log Exports East w/o SU	0.039	0.130	-0.068	0.034	0.179	249

Notes. Descriptive statistics cover combines in the main estimation sample, spanning the periods 1981 to 1985 and 1986 to 1988. Annual change is calculated as the difference of each outcome in the last year to the first year of a period, divided by the number of years.

consistent time series of their indicators which were then aggregated at the level of the combine.[4]

Table 2 reports summary statistics for the outcome variables considered in our analysis. Consistent with the model specification in Equation (1), we provide information on the mean annualized changes of the different indicators as well as the distribution of those changes across combines and over time. Log total production increased, on average, by 4.0 log points per year, similar in magnitude to the annual increase in log labor productivity (output per worker) of 3.9 log points. In terms of factor inputs, while total employment remained relatively stable over time with an average growth rate of only 0.1 log points per year, the capital stock across combines increased quite substantially, by 5.0 log points per year on average. Exports also expanded over time, with an average annual increase of 5.3 log points, albeit with significant variation across combines.

[4]A detailed description of how the reported time series were compiled can be found in the *Richtlinie fuer die Bildung, Speicherung, Pflege und Auswertung rechnergestuetzt ermittelter langfristiger Reihen im Bereich der Industriekombinate*, which was published by the East German Statistical Office (Staatliche Zentralverwaltung fuer Statistik) on 1 January 1988 and is available in the German federal archives.

C. Patent Data

To proxy for East Germany's own innovation activities, we use data on the annual number of patent applications of each combine. We extract these numbers for the period 1970 to 1989 from formerly confidential publications of the East German Statistical Office (*Ergebnisse der Erfindertätigkeit und Schutzrechtsarbeit*). While the nature of East German patenting differed in some key aspects from that in market-based economies, the GDR generally adhered to common international IP practices, routinely protecting its own intellectual property against foreign competitors through patenting at home and abroad, and offering a traditional "exclusive patent" (*Ausschließungspatent*) to foreign applicants in order to benefit from international knowledge transfers. One important difference to patenting practices in the West was that the exploitation rights granted by a standard "economic patent" (*Wirtschaftspatent*) – essentially the only type of patent available for domestic inventors – were not held by the individual inventor but rather by the state (Wiessner, 2013). Concerned about the potential impacts on innovation incentives, East German patent law, however, granted the individual inventors the right to a one-off financial compensation that depended on the economic benefit derived from the patent. While this regulation ensured some alignment between the incentives of the inventors and those of the central planning authorities, it did little to incentivize state-owned firms to modernize in the absence of market pressures. Overall, despite the peculiarities of the system, we consider East German firms' patent applications a reasonable proxy for their R&D activities.

D. East German Firm Register

[LM: Should we also have a section on this? (right now it is only mentioned in the Data Linkage section)]

E. Input-Output Matrices

We rely on input-output matrix to investigate productivity spillovers of espionage on firms through value chains. For this purpose, we retrieve input-output matrices from the East German Statistical Office (*Verflechtungsbilanz der Volkswirtschaftlichen Gesamterzeugung*) for all available years within our sample period (1972, 1977, 1982, 1987). Each matrix shows a given industry's value of outputs by destination industry in rows and the respective inputs sourced from other industries in columns. The number of industries employed is different for each matrix. The matrix for 1972 contains 164 industries while the matrix for 1982 only uses 106 industries. Harmonizing these categories across years, we manually create a classification of 51 industries that we then match with the more finely grained classification of the East German Establishment Register.

F. Data Linkage

To link the SIRA and firm-level data from the archives, we use the information provided in SIRA on the group of recipients to whom an individual information was forwarded after its initial registration. Generally, those recipients were either individual establishments (VEB) or the firms (Kombinate) they belonged to. Using the East German Establishment Register, we match each VEB to its parent combine, and then count the number of pieces of information that a given combine received within a given year.

Figure 1 illustrates the structure of the available data after the record linkage. The top left panel, for example, depicts for the *Kombinat VEB Carl Zeiss Jena* the annual number of intelligence reports received (bars, left axis) and its output and capital stock per worker, measured in constant 1985 East German Mark (lines, right axis). As one of the flagship companies of the GDR, *Carl Zeiss Jena* received an exceptionally high volume of espionage information from the West: from 176 pieces of information in 1970 to 1,288 pieces of information in 1988 (the last year for which the SIRA data are complete). As indicated by the grey-shaded areas, there was also a significant number of high quality pieces of information among the intelligence received. This growing inflow of espionage information was accompanied by a rapidly increasing labor productivity (which almost tripled from 29,275 mark in 1975 to 83,568 mark in 1988; red line) and capital-labor ratio (which almost doubled from 78,248 to 142,533 mark per worker; blue line).

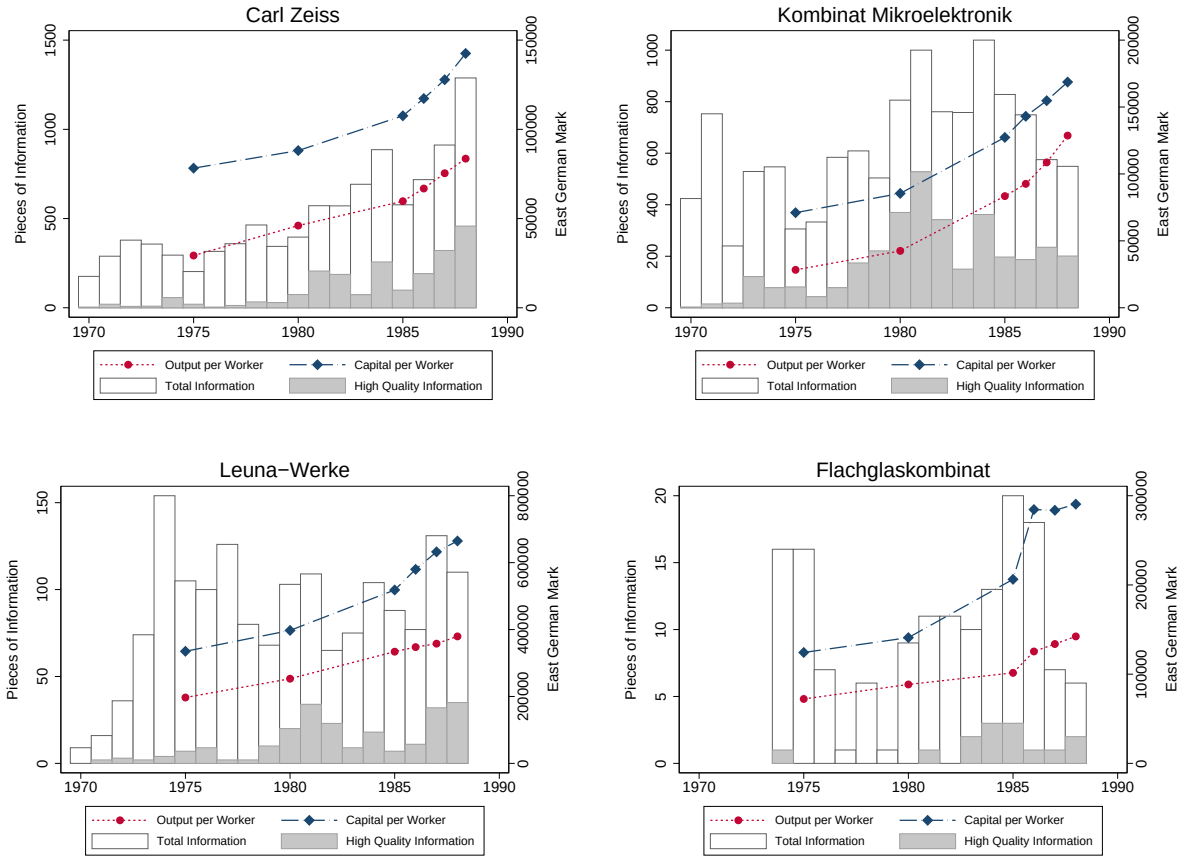
The top right panel shows the corresponding information for another key combine, the *Kombinat Mikroelektronik*, which was the main manufacturer of electronic components in the GDR, famously cloning various Intel and Zilog microprocessors for use in East German computers. However, not all combines benefited equally from the Stasi's espionage in the West. The bottom two panels provide information for the *VEB Kombinat Leuna-Werke* and the *VEB Flachglaskombinat*, which were the main producers in the East German chemical and industrial glass sectors, respectively. Evidently, the inflow of espionage information was much more limited. In the case of the *Flachglaskombinat*, for instance, it never exceeded 20 pieces of information per year.

V. Results

A. Main Outcomes

Productivity. Table 3 summarizes the estimation results for firm output growth and labor productivity growth. The former is measured as the change in the log production value at constant prices, and the latter is measured as the change in log output per worker. Column 1 shows that, without controlling for firms' own R&D activities, an increase of the inflow rate by 10 percentage points (which is slightly less than a standard deviation; see Table 1) is associated with a 1.24 log-points higher output growth. When including patent applications as a control variable in column 2, we find a somewhat weaker relationship between espionage inflows and output growth, suggesting that at least some of the spying

FIGURE 1. CASE STUDIES



Notes. Output per worker is measured in constant 1985 East German Mark. Capital per worker is measured in 1986 prices. High quality information refers to pieces of information that have been qualified as either "valuable" or "very valuable".

effort was directed towards combines with substantial own research activity. As expected, patenting is positively related with output growth, with an increase in the patenting rate by 10 percentage points being associated with a 2.41 log-points higher output growth. The inflow of 2.5 intelligence reports is thus, on average, as effective as the development of one patent.

In column 3, we present the results from our instrumental variable regression, using the predicted inflow of espionage information from old informants who were already active in 1969-1971 as an instrument (see Section III). The relationship between espionage and output remains positive and statistically significant. The estimate implies that a 10 percentage-point increase in the inflow rate leads to 0.77 log-points higher output growth. The first stage results show that the instrument has strong predictive power for actual espionage inflows, with an effective F-statistic (Montiel Olea and Pflueger, 2013) of 67.21. For completeness, we also report the p-value of the Anderson-Rubin Wald F-stat, confirming that our parameter of interest is statistically different from zero.

Turning to the results for labor productivity, we find that the pattern is similar to that for overall output, with the estimate declining from 0.116 in column 4 to 0.092 once we

Table 3—Output and Productivity

	Δ Log Production			Δ Log Labor Productivity		
	OLS	OLS	IV-2S	OLS	OLS	IV-2S
	(1)	(2)	(3)	(4)	(5)	(6)
Espionage Inflow	0.124***	0.097***	0.077***	0.116***	0.092***	0.081***
	(0.034)	(0.020)	(0.020)	(0.022)	(0.016)	(0.018)
Patenting		0.241***	0.267***		0.222***	0.234***
		(0.063)	(0.068)		(0.043)	(0.044)
1st Stage: Old Informants			2.713***			2.716***
			(0.368)			(0.366)
Anderson-Rubin F-stat (p-value)			0.005			0.002
Effective F-stat			67.21			67.55
Ministry x Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	261	261	261	263	263	263

Notes. Dependent variables are the annualized change of the log production value to constant prices in columns 1–3, and labor productivity defined as production value over number of employees in columns 4–6. Espionage activity is defined as the annualized inflow of espionage information over lagged output. Patenting is defined as the annualized number of patents over lagged output. Estimation weighted by the average number of workers within a combine. Effective F-statistic of Montiel Olea and Pflueger (2013). Standard errors in parentheses are clustered at the combine level: * p<0.10, ** p<0.05, *** p<0.01.

control for firms' patenting in column 5. The IV coefficient in column 6 implies that a 10 percentage-point increase in the espionage inflow rate raises labor productivity growth by 0.81 log points. These findings suggest that combines can translate espionage information into more output and a more efficient production process.

Capital and Employment. In Table 4, we explore the effects of espionage on different factor inputs. Neither in the OLS nor IV regressions do we find any evidence that espionage inflows change future capital stocks or employment levels, with all coefficients statistically insignificant and small in magnitude. This result holds both for overall changes in capital and employment and for capital and employment subgroups. Consequently, we do not find any effect on the capital-labor ratio either. This sluggish response is not limited to espionage inflows. When considering the impact of patenting, the coefficient estimates are statistically insignificant for most of the outcomes as well, although generally larger in magnitude. We interpret these results as reflecting important rigidities in the East German economy, where central-planning and widespread resource shortages may have inhibited the shifting of input factors to the most productive combines.

Table B1 in the appendix presents evidence for additional employment-related outcomes. Again, there is no evidence for espionage-based knowledge flows having any significant impact. Neither wages, proxied for white-collar workers by the total costs of their jobs, nor workers' actual working time or absence time respond to the flows. In contrast, hourly productivity growth does increase, with coefficient estimates similar in magnitude to those for overall labor productivity. The IV results suggest that a 10 percentage point increase

Table 4—Capital and Employment

	Δ Log Capital			Δ Log Employment			Δ Log
	Total	Equip-ment	Else	Total	Blue-Collar	White-Collar	Capital/ Labor
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A. OLS							
Espionage Inflow	0.006	0.023	0.001	0.006	0.007	0.017	-0.000
	(0.026)	(0.022)	(0.023)	(0.015)	(0.015)	(0.011)	(0.014)
Patenting	0.062	0.060	0.050	0.012	0.018	0.014	0.051
	(0.060)	(0.051)	(0.052)	(0.031)	(0.035)	(0.034)	(0.037)
Observations	261	263	261	261	260	263	263
Panel B. IV							
Espionage Inflow	-0.017	-0.002	-0.013	-0.004	-0.003	0.006	-0.013
	(0.018)	(0.019)	(0.017)	(0.011)	(0.012)	(0.010)	(0.013)
Patenting	0.091	0.092*	0.067	0.026	0.030	0.028	0.067*
	(0.064)	(0.056)	(0.053)	(0.033)	(0.037)	(0.037)	(0.038)
Observations	261	263	261	261	260	263	263

Notes. Dependent variables are the annualized difference of the log total capital stock in column 1, log equipment capital stock in column 2, log of any other capital stock in column 3, log total employment in column 4, log blue-collar workers in column 5, log white-collar workers in column 6 and log capital-labor ratio in column 7. Espionage activity is defined as the average yearly inflow of espionage information over lagged output. Additional control variables are patenting activity defined as the average number of patents in a period over lagged output and ministry-year fixed effects. Estimation weighted by the average number of workers within a combine. Standard errors in parentheses are clustered at the combine level: * p<0.10, ** p<0.05, *** p<0.01.

in the espionage inflow rate leads to 0.85 log-point higher hourly productivity growth. As a comparison, the same increase in the patenting rate implies a 2.06 log-point higher growth rate.

Exports. As a final outcome, we study firms' exporting behavior in Table 5. For the OLS results, column 1 shows a positive impact of economic espionage on the overall volume of exports. Since not all combines export in any given year, the number of observations is smaller compared to the previous estimations. An increase in the espionage rate by 10 percentage points implies an increase in the growth of exporting by 0.78 log points. When distinguishing between export destinations, we observe differential patterns for Western and Eastern countries. While the coefficient estimate for exports to non-socialist Western countries in column 2 is close to zero, column 3 shows a significant increase in the growth of exports to socialist Eastern countries. When further distinguishing between the Soviet Union and all other Eastern countries, we observe a particular strong response for exports to the Soviet Union. The IV results largely confirm these findings. We find that a 10 percentage-point higher espionage inflow rate raises export growth to Eastern countries and the Soviet Union by 0.67 and 1.22 log points, respectively.

The results suggest that East Germany's espionage activities did not enable them to compete with the countries where the knowledge originated and make inroads into Western

Table 5—Export

	Δ ln Export				
	Overall	West	East	SU	E wo/ SU
	(1)	(2)	(3)	(4)	(5)
Panel A. OLS					
Espionage Inflow	0.078**	0.025	0.104**	0.126*	0.057
	(0.034)	(0.068)	(0.048)	(0.071)	(0.081)
Patenting	-0.016	0.409	-0.193	-0.088	-0.220
	(0.168)	(0.277)	(0.180)	(0.424)	(0.244)
Observations	247	235	233	200	228
Panel B. IV					
Espionage Inflow	0.044	-0.013	0.067**	0.122*	0.016
	(0.034)	(0.079)	(0.033)	(0.070)	(0.059)
Patenting	0.028	0.456*	-0.144	-0.082	-0.164
	(0.169)	(0.266)	(0.175)	(0.387)	(0.234)
Observations	247	235	233	200	228

Notes. Dependent variables are the annualized change of log total export in column 1, and log exports to non-socialist economies in column 2, socialist economies (including Soviet Union) in column 3, the Soviet Union in column 4 and socialist economies excluding the Soviet Union in column 6. Espionage activity is defined as the average yearly inflow of espionage information over lagged output. Additional control variables are patenting activity defined as the average number of patents over lagged output and ministry-year fixed effects. Estimation weighted by the average number of workers within a combine. Standard errors in parentheses are clustered at the combine level: * p<0.10, ** p<0.05, *** p<0.01.

markets. Nevertheless, there is evidence for combines expanding exports to countries that were equally hit by the containment policies of the Cold War. In contrast to the effects of economic espionage, patenting generates distinct exporting patterns, leading to higher export growth to Western countries and a shift away from Eastern countries. East German firms thus seem to have been able to access Western markets if they offered a genuinely new product or technology, but were unable to compete with Western firms that sold the same products and had the same technologies.

B. Robustness

Besides the outcomes discussed in the previous section, the East German firm-level data include several other economic indicators. Most of these are closely related to the firm outcomes of our main analysis. For completeness, Appendix Table B2 presents the OLS results for all remaining indicators. The effects of espionage on firm output and productivity are robust to using value added instead of total production. Measuring production in current rather than constant prices does not lead to significant changes either. As an additional outcome variable, we observe total costs of production, which increase in response to espionage inflows but less so than total output. Economic espionage thus encourages higher firm production but, at the same time, also raises firms' productivity through more efficient input usage.

Table B3 in the appendix presents several robustness checks. In Panel A, we consider

the influence of contemporaneous espionage inflows as opposed to the lagged inflows of our main specification. The results turn out to be quite similar. In particular, we continue to find a significant positive effect on the growth of output and labor productivity. For exporting, the coefficient estimates suggest a positive impact as well. However, they are not statistically significant. Within a 5-year period, the effects of espionage are unlikely to fully materialize. To capture longer-term effects, we focus on the lagged inflows in our main specification.[5] Panel B shows results for a specification where the main regressor of interest is the log number of intelligence reports rather than the espionage inflow rate. While this functional form does not have a theoretical foundation, we generally observe qualitatively similar effects, with espionage leading to higher growth in output, labor productivity and exports (particularly to the Soviet Union). In this specification, we also find some evidence for a positive effect on capital growth and the capital-labor ratio, but no evidence of an employment response.

C. Information Quality

So far, the analysis aggregates all espionage information to an overall espionage inflow rate. However, the value of economic espionage is likely to depend on the quality of the information obtained. The Stasi's systematic assessment of the quality of incoming information allows us to explore this important dimension of heterogeneity. As discussed in Section IV.A, we distinguish between valuable and non-valuable pieces of information. In the early years of the SIRA database, the Stasi's assessment procedures were not fully implemented yet. To reduce the number of observations with missing quality information, we impute missing values using the average quality of all the intelligence reports sent by the same informant. As spies could not easily move across West German firms, the quality of information provided was largely determined by the relevance of the firm's technology for East Germany and the spies' ability to access relevant information.

In Table 6, we first consider output and labor productivity. The quality of information has an important influence on the estimated parameters. The OLS result in column 1 of Panel A shows that non-valuable intelligence reports had no impact on output growth. In contrast, valuable reports had a large impact, with a 10 percentage-point higher inflow rate raising output growth by 5.95 log points. While this effect is substantially larger than for average patenting (1.59 log points), inflows with valuable information were relatively rare, making up only about 20 percent of the total information received (see Table 1). Column 2 of Panel A reports the corresponding estimates for the effects on labor productivity. The results show similar patterns, with non-valuable information having a small impact and valuable information having a large and statistically significant impact. The heterogeneous responses to the quality of the information received strongly suggest

[5] In a horse race between current and lagged espionage inflows, we also find strong support in favor of the lagged inflow as the dominant driver of outcomes.

Table 6—Output Effects By Quality of Espionage Information

	Δ Log Output	Δ Log Labor Productivity
	(1)	(2)
Panel A. OLS		
Non-Valuable	0.003	0.031
	(0.022)	(0.023)
Valuable	0.595***	0.411***
	(0.121)	(0.098)
Patenting	0.159***	0.170***
	(0.055)	(0.051)
Observations	261	263
Panel B. IV		
Non-Valuable	-0.241*	-0.233
	(0.125)	(0.147)
Valuable	2.089**	2.082**
	(0.910)	(0.981)
Patenting	-0.123	-0.146
	(0.371)	(0.405)
Anderson-Rubin F-stat	0.000	0.000
Sanderson-Windmeijer F-stat non-val	2.79	2.78
Sanderson-Windmeijer F-stat val	3.05	3.04
Kleibergen-Paap F-stat	1.27	1.25
Observations	261	263

Notes. Dependent variables are the annualized difference of the log production value to constant prices in column 1, and labor productivity in column 2. Espionage activity is defined as the average yearly inflow of espionage information over lagged output. Additional control variables are patenting activity defined as the average number of patents over lagged output and ministry-year fixed effects. Estimation weighted by the average number of workers within a combine. Standard errors in parentheses are clustered at the combine level: * p<0.10, ** p<0.05, *** p<0.01.

that our findings are not spuriously picking up other unobserved drivers of output and productivity growth since, in that case, one would not expect to see such stark differences.

In Panel B, we report the corresponding IV results. To instrument for the endogenous regressors, we employ two shift-share variables that use the share of total inflows during the years 1969 to 1971 from spies active during that period interacted with the aggregate inflow of either valuable or non-valuable information from these spies during the previous period (similar to Equation (2)). The results confirm that the quality of inflows is important for assessing the effects of espionage on output and productivity. However, in this setting with two endogenous regressors, the different diagnostic tests for weak instruments all have relatively small F-statistics. While the literature on weak instruments has not yet established critical values for the case of multiple endogenous regressors with clustered standard errors, the IV results should be interpreted with caution. For this reason, we focus on the OLS results for the remainder of this section.

Table 7 presents results for capital and labor usage. Starting with valuable espionage inflows, we find that these inflows lead to an increase in capital and employment growth.

Table 7—Capital and Employment Effects By Quality of Espionage Information

	Δ Log Capital			Δ Log Employment			Δ Log
	Total (1)	Equip-ment (2)	Else (3)	Total (4)	Blue-Collar (5)	White-Collar (6)	Capital / Labor (7)
Non-Valuable	-0.067***	-0.051***	-0.047***	-0.028**	-0.026*	-0.005	-0.039***
	(0.015)	(0.015)	(0.017)	(0.012)	(0.014)	(0.013)	(0.013)
Valuable	0.391***	0.413***	0.255**	0.188***	0.180***	0.129	0.205***
	(0.089)	(0.076)	(0.109)	(0.052)	(0.068)	(0.086)	(0.051)
Patenting	0.000	-0.003	0.009	-0.017	-0.010	-0.005	0.018
	(0.035)	(0.044)	(0.033)	(0.016)	(0.017)	(0.023)	(0.030)
Observations	261	263	261	261	260	263	263

Notes. Dependent variables are the annualized difference of the log total capital stock in column 1, equipment capital stock in column 2 and any other capital stock in column 3. Espionage activity is defined as the average yearly inflow of espionage information over lagged output. Additional control variables are patenting activity defined as the average number of patents over lagged output and ministry-year fixed effects. Estimation weighted by average number of workers within a combine. Standard errors in parentheses are clustered at the combine level: * p<0.10, ** p<0.05, *** p<0.01.

A 10 percentage point increase in the espionage inflow rate of valuable information leads to 3.91 log-point higher growth in the capital stock (column 1) and a 1.88 log-point higher employment growth (column 4). These results imply a shift of combines towards production technologies with higher capital intensity, a result that we confirm for the growth in the capital-labor ratio in column 7. As shown in Appendix A, if capital and labor are gross complements in production (see e.g. Oberfield and Raval, 2014), this finding is consistent with espionage-based knowledge flows being relatively labor-augmenting.

Distinguishing by different capital and labor types, we find that combines show particularly large adjustments for equipment capital and blue-collar workers. Taken together, valuable information thus encourages investments into new machinery. Since these investments also reduce the costs of production through productivity gains, combines expand output and hire more workers.

For non-valuable espionage inflows, the effects on the capital stock and employment are in fact negative, with capital growth decreasing more than employment growth. A 10 percentage-point increase in the non-valuable espionage rate implies a change in capital growth by -0.67 log points and employment growth by -0.28 log points. These reductions in inputs have to be viewed in conjunction with the zero effect on output shown in Table 6. Rather than expanding production, the small productivity gains (albeit statistically insignificant) result in input savings. These distinct patterns can be rationalized for combines with different production outputs. While non-valuable information may pertain to the production of commodities without strong product demand elasticities and export potential, valuable information may improve goods at the technological frontier (of the Communist East). Combines may find it optimal to shift resources as much as possible

towards such high-value output.

In Appendix Table B4, we present the estimation results for various additional labor outcomes. The analysis suggests that the quality of espionage inflows does not influence wages, with estimates being close to zero. However, employment at the intensive margin appears to react to espionage inflows. While non-valuable inflows tend to increase the growth in both average working time and absence time, valuable inflows have the opposite effect. Taken together, however, these effects only have a minor influence when adjusting productivity for hours worked (column 6), with coefficient estimates similar to those found for overall labor productivity. In Table B5 in the appendix, we consider firms' exporting behavior. Once again, valuable espionage inflows are clearly the driving force, significantly raising export growth to Eastern countries.

VI. Privatization and Espionage

Having established that espionage inflows increase the competitiveness of East German firms within the socialist system, we now ask whether these inflows also altered the fate of socialist firms in their transition towards a market economy. In particular, we assess their chances for successful privatization.

A. Institutional Background

German reunification in 1990 and the ensuing transition from state-owned enterprises to a system of private ownership was unexptected. Most Germans did not anticipate that they would experience reunification within their lifetime (Herdegen, 1992). However, the uprising of the East German population along with an extraordinary geopolitical constellation enabled German reunification. East Germany decided to adopt the West German institutions overnight, forming an economic and monetary union. The government founded the *Treuhandanstalt* ("trust agency", short: Treuhand) to assume ownership of all East German companies outside the core public sector. The agency's legal mandate was to privatize viable firms and liquidate non-viable ones (Treuhandgesetz, 1990). The sheer number of Treuhand firms, low levels of productivity relative to Western firms (Akerlof et al., 1991; Glitz and Meyersson, 2020), and the collapse of former trade links with Eastern bloc countries made this a Herculean task (Dornbusch and Wolf, 1994).

Tackling its mission, the Treuhand's first step was to dissolve the East German combines by separating the individual establishments constituting the combines. In special cases, these establishments were further subdivided to market them more easily. After these preparations, the Treuhand used direct sales to divest East German firms. This implied that every firm was individually marketed to investors. Companies assessed as having no realistic prospect of survival were liquidated. The privatization program therefore effectively served as a screening device for former East German firms (Mergele, Hennicke and Lubczyk, 2020). Enjoying high levels of protection from political interference, the

Treuhand systematically screened and supported firms according to their market potential (Dyck, 1997; Hau, 1998). This screening was further amplified by the investment decisions on the demand side. Most firms were acquired by non-East-German investors who were familiar with business opportunities in a market economy (Mergele, Hennicke and Lubczyk, 2020). Some firms were also restituted to previously expropriated owners following legal procedures outside the Treuhand's control. In a few sectors (e.g., public transport), it was also possible for companies to be handed over to the local municipalities.

The privatization program ended in December 1994 – only four years after reunification. Within that period, the Treuhand privatized about 60 percent of all East German firms and liquidated almost 30 percent (Mergele, Hennicke and Lubczyk, 2020). The remainder was either restituted or municipalized.

B. Data

The data for this analysis combine information about espionage flows to East German firms and these firms' success in the privatization program following German reunification. We view privatization as a proxy for the closeness of East German firms to the technological frontier. To date, there is no data set systematically linking East German firms active in the GDR with their post-reunification identities. We close this gap in several steps.

Our starting point is the administrative firm register of the Treuhand's successor organization, the *Bundesanstalt für vereinigungsbedingte Sonderaufgaben* (*BvS*), as introduced by Mergele, Hennicke and Lubczyk (2020). The register includes all Treuhand firms that were created through the breakup of the former GDR firms. For each Treuhand firm, the register states whether it was privatized, liquidated, restituted, or municipalized. We exclude restitution and municipalization cases as these decisions were based on legal rather than economic grounds.[6] The remaining two potential program outcomes, successful privatization or liquidation, then represents a meaningful economic measure that we employ in our analysis. The register contains 9,923 Treuhand firms with these program outcomes. The register also indicates the East German state in which the Treuhand firms were located as well as, if applicable, their affiliation with respective GDR establishments (VEBs).

In a second step, we manually match the GDR affiliation of Treuhand firms with the entries of the East German Establishment Register; it contains all economically active units in the GDR as of 1989[7]. This register provides direct information on the parent entity of each GDR establishment which was typically a combine but might have been a

[6]Restitution decisions were made by property offices instead of the Treuhand, and municipalizations only occurred in specific sectors (public utilities, public transport) and in very small numbers.

[7]The matching is primarily based on a comparison of company names. We use probabilistic string matching based on bigram similarity scores to detect potential matches and verify each match manually. For this purpose, we also use company location and industry information.

Table 8—Descriptive Statistics (THA firm level)

	Mean	SD	Min	Max	Count
Firm successfully privatized (Dummy)	0.63	0.48	0.00	1.00	7,038
Received Espionage Inflow	0.07	0.25	0.00	1.00	7,038
Received Non-Valuable Espionage Inflow	0.06	0.25	0.00	1.00	7,038
Received Valuable Espionage Inflow	0.05	0.22	0.00	1.00	7,038
Received Espionage Inflow in 70s	0.05	0.22	0.00	1.00	7,038
Received Espionage Inflow in 80s	0.06	0.24	0.00	1.00	7,038
Log Espionage Inflows	0.25	1.09	0.00	10.49	7,038
Log Non-Valuable Espionage Inflows	0.24	1.05	0.00	10.33	7,038
Log Valuable Espionage Inflows	0.14	0.72	0.00	8.61	7,038
Log Espionage Inflows in 70s	0.17	0.87	0.00	9.85	7,038
Log Espionage Inflows in 80s	0.21	0.96	0.00	9.72	7,038
Employment After Reunification	188.29	335.15	72.00	2093.00	7,038
Observations	7038				

Notes. Sample includes privatized and liquidated Treuhand firms that were matched with the GDR's firm registry and have state and industry information available.

ministry or other administrative unit as well. We are able to trace 7,038 Treuhand firms to their GDR identities and their position within the the GDR economy's organizational structure.

As outlined in Section IV.F, we finally link these firm data with the SIRA database, which allows us to compute the number and quality of intelligence reports received from the Stasi for each East German establishment (VEB). As the resulting data set is based on Treuhand firms, it does not consider spy information provided to research institutes or other non-firm entities. Table 8 presents summary statistics.

C. Results

We examine whether industrial espionage conducted during the period of German separation had a lasting imprint of firms' chances to be privatized. Table 9 presents our findings. Each column within a panel contains results from a separate OLS regression of a binary privatization indicator on a measure of espionage with varying combinations of state and industry fixed effects. State fixed effects (six categories) control for potential economic policy differences across the six East German states. Industry fixed effects (22 categories) capture sectoral clusters potentially targeted by the Stasi and the Treuhand. The estimations are at the Treuhand-firm level; whereas standard errors are clustered at the combine level or an equivalent administrative unit to account for within-cluster correlations.

Panel A presents the relationship between privatization and whether a firm received any espionage inflows during the previous two decades. The most conservative specification with state $\times$ industry fixed effects indicate that having received espionage is associated

with a 6.3 percentage point higher chance of successful privatization (column 3). Panel B distinguishes between valuable or non-valuable espionage reports. The results consistently show higher effect sizes for valuable information, with column 3 indicating an effect of receiving valuable spy inflows of 8.0 percentage points. Panel C distinguishes between the impact of receiving spy information in the 1970s versus the 1980s. In line with the idea that the value of information depreciates over time, the results show that espionage inflows in the 1980s play a significant role whereas receiving information in the 1970s does not affect privatization chances. As shown in column 3, having received information in the 1980s is associated with an 8.9 percentage point higher likelihood of privatization. The following three panels then assess how the quantity of spy reports received alters privatization prospects. Panel D uses the simple log number of spy reports a firm received, suggesting that a ten percent increase in spy inflows (which roughly corresponds to a one standard deviation increase, see Table 9) raises the privatization probability by 0.18 to 0.15 percentage points; depending on the specification considered. Panel E reflects the previous finding that valuable inflows are more important than non-valuable ones; albeit here the point estimates are not statistically different from zero at conventional levels. Similarly, Panel F confirms that the more recent espionage inflows of the 1980s are more strongly related to privatization chances than those of the 1970s. Again, however, the effects are not statistically significant. Together, our findings suggest that economic espionage drew East German firms closer to the technological frontier and had a lasting impact on their fate beyond the Socialist era.

Table 9—Successful privatizations and espionage (OLS)

	Firm Successfully Privatized (Dummy)		
	(1)	(2)	(3)
Panel A. Receiving information			
Received Espionage Inflow	0.0866***	0.0614***	0.0628***
	(0.0199)	(0.0204)	(0.0194)
Observations	7,038	7,038	7,038
Panel B. Receiving information, by quality			
Received Non-Valuable Espionage Inflow	0.0374	0.0115	-0.0006
	(0.0394)	(0.0399)	(0.0381)
Received Valuable Espionage Inflow	0.0607	0.0629	0.0804**
	(0.0413)	(0.0412)	(0.0402)
Observations	7,038	7,038	7,038
Panel C. Receiving information, by time			
Received Espionage Inflow in 70s	-0.0058	-0.0258	-0.0268
	(0.0324)	(0.0322)	(0.0337)
Received Espionage Inflow in 80s	0.0944***	0.0866***	0.0894***
	(0.0251)	(0.0247)	(0.0269)
Observations	7,038	7,038	7,038
Panel D. Quantity of espionage reports			
Log Espionage Inflows	0.0181***	0.0146***	0.0147***
	(0.0037)	(0.0038)	(0.0039)
Observations	7,038	7,038	7,038
Panel E. Quantity of espionage reports, by quality			
Log Non-Valuable Espionage Inflows	0.0052	-0.0043	-0.0034
	(0.0151)	(0.0142)	(0.0145)
Log Valuable Espionage Inflows	0.0196	0.0284	0.0271
	(0.0195)	(0.0188)	(0.0192)
Observations	7,038	7,038	7,038
Panel F. Quantity of espionage reports, by time of arrival			
Log Espionage Inflows in 70s	0.0061	0.0007	-0.0022
	(0.0130)	(0.0122)	(0.0126)
Log Espionage Inflows in 80s	0.0150	0.0162	0.0186
	(0.0122)	(0.0115)	(0.0116)
Observations	7,038	7,038	7,038
State FEs	yes	yes	yes
Industry FEs	no	yes	yes
State x Industry FEs	no	no	yes
Outcome mean	0.63	0.63	0.63

Notes. The outcome variable is a dummy equaling 1 if a firm was successfully privatized and 0 if it was liquidated by the Treuhand. Standard errors in parentheses are clustered at the combine level. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

VII. Conclusion

Using previously classified data, we track the information flows of East German spies and analyze the effects on the production of recipient firms. Our results show a considerable impact on East German firms' labor productivity and output, with a ten percentage point increase in the espionage inflow rate leading to 0.81 log point and 0.77 log point higher annual growth rate, respectively. These effects are driven by spy information assessed as valuable by the Stasi. After receiving such information, firms adjust their production structure, increasing both their capital stock and employment. With the effects on the growth rate of the capital stock exceeding those for employment growth, this finding suggests labor-augmenting productivity gains from espionage-based knowledge flows. We also demonstrate that East German firms receiving espionage information from the West experience higher export growth, primarily by expanding ties with the Soviet Union.

To substantiate our findings beyond the setting of a centrally planned economic system, we exploit the unexpected end of German separation, which led to the reintegration of firms into a market economy through a formal privatization process. We find that firms with espionage inflows during separation are more likely to be privatized. In line with our main findings, valuable information inflows are the strongest predictor for successful privatization.

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Appendix A: Derivation from Production Function

Assume that each East German combine produces its output with a CES production function that permits factor-augmenting technical change (Antràs, 2004):

$$Y_{it} = \left[\delta(A_{it}^K K_{it})^{\frac{\sigma-1}{\sigma}} + (1-\delta)(A_{it}^L L_{it})^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \tag{A1}$$

where i and t index combines and time periods; Y_{it}, K_{it}, and L_{it} are value added, capital services and labor services; and δ and σ are constant parameters, the latter representing the elasticity of substitution between capital and labor. We assume that technical change is factor-augmenting and evolving in the following way

$$A_{it}^K = A_{i0}^K E_{it}^{\beta_K} G_{it}^{\gamma_K} \exp(u_{it}^K) \quad \text{and} \quad A_{it}^L = A_{i0}^L E_{it}^{\beta_L} G_{it}^{\gamma_L} \exp(u_{it}^L) \tag{A2}$$

where E_{it} denotes the knowledge stock accruing from economic espionage, G_{it} the traditional R&D knowledge stock, and $\exp(u_{it})$ an unobserved disturbance term. The parameters β_K and β_L capture the extent to which economic espionage increases the efficiency of capital and labor. If $\beta_K = \beta_L$, then economic espionage induces Hicks-neutral technical change. Each combine maximizes profits, taking the price of capital and wages in the economy as given. This leads to the following two relationships:

$$\ln(Y_{it}/L_{it}) = \alpha_2' + \sigma \ln(W_{it}/P_{it}^Y) + (1-\sigma)\beta_L \ln E_{it} + (1-\sigma)\gamma_L \ln G_{it} + u_{it}^L \tag{A3}$$

$$\ln(K_{it}/L_{it}) = \alpha_3' + \sigma \ln(W_{it}/R_{it}) + (1-\sigma)(\beta_L - \beta_K) \ln E_{it} + (1-\sigma)(\gamma_L - \gamma_K) \ln G_{it} + u_{it}^{K/L} \tag{A4}$$

Taking first differences over time of these two equations yields:

$$\Delta \ln(Y_{it}/L_{it}) = \sigma \Delta \ln(W_{it}/P_{it}^Y) + (1-\sigma)\beta_L \Delta \ln E_{it} + (1-\sigma)\gamma_L \Delta \ln G_{it} + \Delta u_{it}^L \tag{A5}$$

$$\Delta \ln(K_{it}/L_{it}) = \sigma \Delta \ln(W_{it}/R_{it}) + (1-\sigma)(\beta_L - \beta_K) \Delta \ln E_{it} + (1-\sigma)(\gamma_L - \gamma_K) \Delta \ln G_{it} + \Delta u_{it}^{K/L} \tag{A6}$$

In our empirical analysis, we proxy for $\Delta \ln E_{it}$ and $\Delta \ln G_{it}$ by (the one-period lags of) $\Delta E_{it}/Y_{it-1}$ and $\Delta G_{it}/Y_{it-1}$. From Equation A6, one can see that a positive coefficient on the espionage inflow regressor in a regression in which the dependent variable is the change in the log capital/labor ratio indicates that $(1-\sigma)(\beta_L - \beta_K) > 0$. Since capital and labor are likely to be gross complements ($\sigma < 1$) in production (see e.g. Oberfield and Raval, 2014), this implies that $\beta_L - \beta_K > 0$ and, therefore, that espionage inflows are relatively labor-augmenting.

FIGURE B1. EXAMPLE PAGE – ARCHIVE DATA

A/ BLATT: -0049 STRUKTUR 1.1.90/6.1-52

STATISTISCHES AMT DER DDR — L A N G F R I S T I G E R E I H E N — HERSTELLUNGSDATUM: 12.05.90

KOMBINAT: CARL ZEISS MINISTERIUM: BER.E/E

KENNZIFFER	ABSOLUT 1975/76	1980/81	1986	1987	1988	1989	ENTWICKLUNG VORJAHR=100 1986	1987	1988	1989	%DURCHSCHNITT JAEHRLICH 75(76)/1985	1985/END J.
IND. WP ZU KP85	1674897	2648757	4130721	4641904	5140184	4944005	112,2	112,4	110,7	96,2	108,2	107,6
IWP ZU IAP (AK.PR)	1738564	2734073	3926476	4470437	4871139	4726803	106,6	113,9	109,0	97,0	107,8	106,4
FER.F.D.BEV.(AK.PR)	296620	394201	298396	355305	359355	398139	99,4	119,1	101,1	110,8	100,1	107,3
ANTEIL FE AN IWP	6,5	4,7	3,6	3,9	4,0	8,4	94,7	108,3	102,6	210,0	94,2	121,9
STD.-PROD.AA KP85	18	30	40	45	50	49	111,1	112,5	111,1	98,0	107,2	108,0
EXP.SW VER.BP(AK.PR)	603960	940481	1344269	1418750	1484883	1278549	106,0	105,5	104,7	86,1	107,7	100,2
EX.NSW VER.BP(AK.PR)	239182	485910	588948	561784	540996	442086	115,3	95,4	96,3	81,7	107,9	96,5
EXP.SU VER.BP(AK.PR)	310967	543354	761999	767362	785242	638777	104,6	100,7	102,3	81,3	108,9	96,8
EXPORTQU. SW BP		33,5	25,9	21,6	22,8	17,8	96,6	83,4	105,6	78,1		90,3
EXPORTQU. NSW BP		12,1	11,1	8,4	8,3	6,2	132,1	75,7	98,8	74,7		92,7
MAT.INVESTIT. INSG.	142190	323076	703227	923108	952533	895777	139,2	131,3	103,2	94,0	113,5	115,4
MAT.INVESTIT. BAU	12504	64959	180609	157136	118157	105696	151,3	87,0	75,2	89,5	125,3	97,0
MAT.INVESTIT. AUSR.	88072	219074	488386	735266	805259	763885	137,5	150,6	109,5	94,9	115,0	121,1
GRUNDMITTEL INSG.	4476781	5066711	7247431	7868188	8767045	9758439	109,3	108,6	111,4	111,3	104,0	110,1
GRUNDMITTEL AUSR.	1991670	2381551	4015392	4508462	5241122	6126316	111,5	112,3	116,3	116,9	106,1	114,2
ANT.BAU-INV.AN INSG	8,8	20,1	25,7	17,0	12,4	11,8	108,9	66,1	72,9	95,2	110,4	84,1
ANT.AUSR-INV.AN INS	61,9	67,8	69,4	79,7	84,5	85,3	98,7	114,8	106,0	100,9	101,3	105,0
ANT.NUTZ-INV.AN INS	92,7	77,0	91,0	92,3	102,4	91,9	67,8	101,4	110,9	89,7	104,2	91,0
ANT.RAT-INV.AN INSG		35,8	47,1	46,7	72,2	72,7	90,4	99,2	154,6	100,7		108,7
GRUNDFONDSQU.85/86	374,1	522,3	570,0	590,0	586,3	506,6	102,7	103,5	99,4	86,4	104,0	97,7
GRUNDF-QU.NP AK/86	142,7	203,6	243,2	260,7	258,0	228,5	105,5	107,2	99,0	88,6	104,9	99,8
GFA PR86 /AA	78248	88097	117272	127801	142533	160678	109,0	109,0	111,5	112,7	103,2	110,6
NETTOPR. (AK.PR)	639033	1031421	1762300	2051153	2261626	2229548	115,3	116,4	110,3	98,6	109,1	109,9
ARB.-PROD. KP85	29275	46055	66840	75397	83568	81406	111,9	112,8	110,8	97,4	107,4	108,1
ARB.-PROD.NP AK.	11169	17934	28516	33316	36769	36711	115,0	116,8	110,4	99,8	108,3	110,3
STD.-PROD.AA NP AK	7	11	17	20	22	22	113,3	117,6	110,0	100,0	107,9	110,0
ARBEIT.U.ANG.IN VBE	57213	57513	61800	61566	61509	60733	100,2	99,6	99,9	98,7	100,8	99,6
BRUTTOLOHNSUMME A/A	498611	607930	750123	778945	797489	814427	103,4	103,8	102,4	102,1	103,8	102,9
PROD.PERSONAL IN VBE	31267	30172	31837	31255	31177	30517	98,4	98,2	99,8	97,9	100,3	98,6
LEITG.U.VERW. IN VBE	10896	10818	9924	9586	9011	8600	100,3	96,6	94,0	95,4	99,0	96,6
ANTEIL PP AN AA	54,7	52,5	51,5	50,8	50,7	50,2	98,3	98,6	99,8	99,0	99,6	98,9
ANTEIL LVP AN AA	19,0	18,8	16,1	15,6	14,6	14,2	100,6	96,9	93,6	97,3	98,3	97,1
MONATSLOHN AA	726	881	1011	1054	1080	1117	103,2	104,3	102,5	103,4	103,0	103,3
MONATSLOHN PP	678	813	932	968	994	1020	102,5	103,9	102,7	102,6	103,0	102,9
NOMINELLE AZ JE AA	2062,23	2043,60	2185,03	2192,39	2200,19	2191,82	100,3	100,3	100,4	99,6	100,5	100,2
TATS.ARBEITSZ.JE AA	1657,57	1602,84	1731,03	1738,23	1750,38	1738,98	100,1	100,4	100,7	99,3	100,4	100,1
AUSFALLZEITEN JE AA	251,50	268,36	273,76	269,48	266,70	262,77	103,4	98,4	99,0	98,5	100,5	99,8
MAT.KO.SENK.O.ABP			414,51	396,45	380,13	381,19	93,9	95,6	95,9	100,3		96,4
KOSTEN LUV (AK.PR)		293833	309062	308221	281944	272604	107,4	99,7	91,5	96,7		98,7
RFWP (OIAB/AK.PR)	1786200	2702329	4296636	4667732	5101965	4939278	111,7	108,6	109,3	96,8	108,9	106,5
GSK RFWP(OIAB/AK.PR)	1906673	2730157	3999291	4136528	4293443	4228365	107,6	103,4	103,8	98,5	107,7	103,3
KOSTENSATZ AK/OIAB	106,74	101,03	93,08	88,62	84,15	85,61	96,3	95,2	95,0	101,7	98,9	97,0

APPENDIX B: ADDITIONAL TABLES AND FIGURES

Table B1—Labor Outcomes

	Δ Log Wage		Δ Log Costs	Δ Log		
	All	Blue-Collar	White-Collar	Working Time	Absence Time	Hourly Productivity
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. OLS						
Espionage Inflow	-0.004**	-0.004	0.001	0.003	0.001	0.092***
	(0.002)	(0.003)	(0.008)	(0.002)	(0.004)	(0.017)
Patenting	0.001	-0.003	0.009	0.019*	-0.027	0.198***
	(0.007)	(0.008)	(0.028)	(0.011)	(0.017)	(0.047)
Observations	259	262	263	262	261	261
Panel B. IV						
Espionage Inflow	-0.002	-0.001	-0.013	-0.003	-0.002	0.085***
	(0.003)	(0.005)	(0.014)	(0.005)	(0.005)	(0.018)
Patenting	-0.002	-0.007	0.027	0.025**	-0.024	0.206***
	(0.007)	(0.009)	(0.029)	(0.012)	(0.016)	(0.046)
Observations	259	262	263	262	261	261

Notes. Dependent variables are the annualized difference of the log wage in column 1, log wage of blue-collar workers in column 2, log of total costs of white-collar worker jobs and administration in column 3, log of average working time in column 4, log of average absence time in column 5 and log hour productivity (output at constant prices per worker hour) in column 6. Espionage activity is defined as the annualized inflow of espionage information over lagged output. Additional control variables are patenting activity defined as the average number of patents over lagged output and ministry-year fixed effects. Estimation weighted by the average number of workers within a combine. Standard errors in parentheses are clustered at the combine level: * p<0.10, ** p<0.05, *** p<0.01.

Table B2—Other outcomes

	(1)	(2)	(3)	(4)	(5)
	Δ Log Production (current prices)	Δ Log Final Goods for Population	Δ Share Final Goods	Δ Log Investments Total	Δ Log Investments Structure
Espionage Inflow	0.078***	-0.135**	-0.004	0.127***	0.248***
	(0.016)	(0.058)	(0.003)	(0.037)	(0.062)
Observations	263	259	228	263	261
	Δ Log Investments Equipment	Δ Share Investments Structure	Δ Share Investments Equipment	Δ Share Investments Completed	Δ Share Investments Rationalization
Espionage Inflow	0.101**	0.027***	-0.021*	-0.047	-0.030
	(0.042)	(0.009)	(0.012)	(0.052)	(0.027)
Observations	263	260	262	262	262
	Δ Log Output over Capital (1985 prices)	Δ Log Output over Capital (current prices)	Δ Log Value Added (current prices)	Δ Log Value Added (1985 prices, own calculation	Δ Log Labor Productivity (value added)
Espionage Inflow	0.092***	0.102***	0.107***	0.126***	0.101***
	(0.016)	(0.029)	(0.024)	(0.028)	(0.025)
Observations	262	262	261	259	263
	Δ Log Hour Productivity (value added)	Δ Log Total Wage Bill	Δ Share Blue-Collar Workers	Δ Share White-Collar Workers	Δ Log Contracted Working Time
Espionage Inflow	0.094***	0.002	0.000	0.001	0.002
	(0.029)	(0.017)	(0.001)	(0.002)	(0.002)
Observations	261	259	260	261	263
	Δ Share Costs Intermediates	Δ Log Total Production (current prices)	Δ Log Total Costs	Δ Share Costs	
Espionage Inflow	-0.006	0.101***	0.062***	-0.041***	
	(0.011)	(0.018)	(0.012)	(0.010)	
Observations	125	260	260	260	

Notes. Additional control variables are patenting activity defined as the average number of patents over lagged output and ministry-year fixed effects. Estimation weighted by average number of workers within a combine. Standard errors in parentheses are clustered at the combine level: * p<0.10, ** p<0.05, *** p<0.01.

Table B3—Robustness Tests

	(1)	(2)	(3)	(4)	(5)
Panel A. Contemporaneous Inflows					
	Δ Log Production	Δ Log Labor Productivity	Δ Log Capital	Δ Log Capital Equipment	Δ Log Capital Other
Espionage Δt	0.112***	0.105**	0.010	0.044*	-0.001
	(0.038)	(0.042)	(0.027)	(0.026)	(0.025)
Observations	286	287	285	287	285
	Δ Log Employment	Δ Log Blue-Collar	Δ Log White-Collar	Δ Log Capital Labor Ratio	Δ Log Exports
Espionage Δt	0.006	0.006	0.013	0.004	0.017
	(0.015)	(0.015)	(0.015)	(0.018)	(0.085)
Observations	285	283	287	287	270
	Δ Log Exports West	Δ Log Exports East	Δ Log Exports SU	Δ Log Exports East wo SU	
Espionage Δt	0.118	0.019	0.138	-0.007	
	(0.113)	(0.067)	(0.131)	(0.065)	
Observations	256	247	207	240	
Panel B. Log Specification					
	Δ Log Production	Δ Log Labor Productivity	Δ Log Capital	Δ Log Capital Equipment	Δ Log Capital Other
Log Espionage $\Delta t - 1$	0.005***	0.005***	0.002**	0.003**	0.003**
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Observations	253	255	263	264	262
	Δ Log Employment	Δ Log Blue-Collar	Δ Log White-Collar	Δ Log Capital Labor Ratio	Δ Log Exports
Log Espionage $\Delta t - 1$	0.001	0.001	0.000	0.002*	0.006
	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)
Observations	253	254	255	255	254
	Δ Log Exports West	Δ Log Exports East	Δ Log Exports SU	Δ Log Exports East wo SU	
Log Espionage $\Delta t - 1$	0.012	0.008*	0.012*	0.003	
	(0.008)	(0.004)	(0.007)	(0.005)	
Observations	249	248	225	243	

Notes. Additional control variables are patenting activity defined as the average number of patents over lagged output and ministry-year fixed effects. Estimation weighted by the average number of workers within a combine. Standard errors in parentheses are clustered at the combine level: * p<0.10, ** p<0.05, *** p<0.01.

Table B4—Labor Outcomes By Quality of Espionage Information

	Δ Log Wage		Δ Log Costs	Δ Log		
	All	Blue-Collar	White-Collar	Working Time	Absence Time	Hour Productivity
	(1)	(2)	(3)	(4)	(5)	(6)
Non-Valuable	-0.005*	-0.007	0.001	0.010**	0.012***	0.024
	(0.003)	(0.004)	(0.009)	(0.004)	(0.004)	(0.027)
Valuable	0.001	0.009	0.002	-0.034**	-0.057***	0.449***
	(0.018)	(0.023)	(0.044)	(0.017)	(0.022)	(0.088)
Patenting	0.000	-0.006	0.009	0.024*	-0.017	0.140**
	(0.008)	(0.010)	(0.030)	(0.013)	(0.018)	(0.055)
Observations	259	262	263	262	261	261

Notes. Espionage activity is defined as the annualized inflow of espionage information over lagged output. Additional control variables are patenting activity defined as the average number of patents over lagged output and ministry-year fixed effects. Estimation weighted by the average number of workers within a combine. Standard errors in parentheses are clustered at the combine level: * p<0.10, ** p<0.05, *** p<0.01.

Table B5—Export Effects By Quality of Espionage Information

	Δ Log Export				
	Overall	West	East	SU	E wo/ SU
	(1)	(2)	(3)	(4)	(5)
Non-Valuable	0.030	0.073	0.020	0.130*	-0.064
	(0.034)	(0.061)	(0.039)	(0.067)	(0.063)
Valuable	0.333**	-0.225	0.553***	0.105	0.707*
	(0.167)	(0.351)	(0.209)	(0.465)	(0.407)
Patenting	-0.057	0.448	-0.273	-0.083	-0.335
	(0.179)	(0.299)	(0.179)	(0.465)	(0.214)
Observations	247	235	233	200	228

Notes. Dependent variables are the annualized change of log export to any country in column 1, non-socialist economies in column 2, socialist economies (including Soviet Union) in column 3, the Soviet Union in column 4, and socialist countries excluding the Soviet Union in column 5. Espionage activity is defined as the average yearly inflow of espionage information over lagged output. Additional control variables are patenting activity defined as the average number of patents over lagged output and ministry-year fixed effects. Estimation weighted by the average number of workers within a combine. Standard errors in parentheses are clustered at the combine level: * p<0.10, ** p<0.05, *** p<0.01.