INTERNATIONAL MONETARY FUND

Conflicts and Growth: The R&D Channel

Can Sever

WP/24/98

2024
MAY

WORKING PAPER

 WP/24/98

IMF Working Paper
African Department

Conflicts and Growth: The R&D Channel
Prepared by Can Sever*

Authorized for distribution by Pablo Lopez Murphy
May 2024

ABSTRACT: Violent conflicts are typically associated with a long-lasting drag on economic output, yet establishing causality based on macro-data remains as a challenge. This study attempts to build causality in the conflict-growth nexus by exploiting within-country variation across industries' technological intensity. It identifies a channel through which conflicts can impact growth, i.e., by hindering R&D activities. The analysis is based on industry-level data from two-digit manufacturing industries for a large sample of countries over the last four decades. The results show that conflicts lead to a decline in labor productivity growth, particularly in industries with higher technological intensity. The estimated magnitude of the differential effect of conflicts on labor productivity growth in high-tech industries is large. Moreover, the additional labor productivity loss in those industries in the years of conflicts does not seem to be offset in the post-conflict period neither. The findings offer insight into the observed patterns of durable declines in income in the aftermath of conflicts, considering the role of technological progress and innovation in long-term economic growth.

JEL Classification Numbers:	D74, O31, O40
Keywords:	Conflict; war; R&D; innovation; high-tech; economic growth and development

Author's E-Mail Address:	Sever: csever@imf.org

* The views expressed in in this paper are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management. I thank Hany Abdel-Latif, Yueling Huang, Sergii Meleshchuk, Rasmane Ouedraogo, and Ian Stuart for useful comments and suggestions. I also thank the seminar participations at the IMF African Department for feedback. All errors belong to me.

WORKING PAPERS

Conflicts and Growth: The R&D Channel

Prepared by Can Sever[1]

[1] The views expressed in in this paper are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management. I thank Hany Abdel-Latif, Yueling Huang, Sergii Meleshchuk, Rasmane Ouedraogo, and Ian Stuart for useful comments and suggestions. I also thank the seminar participations at the IMF African Department for feedback. All errors belong to me.

Contents

1. Introduction

About one quarter of the world's population lives in conflict-affected areas, with the number of conflicts reaching historical highs worldwide since the end of World War II, according to the UN.[1] Alongside their dire humanitarian costs, violent conflicts stand out as a major development challenge. Hence, the associations between conflicts and economic outcomes have attracted attention from the economics literature, which typically finds a negative and enduring relationship between conflicts and economic performance, particularly for intrastate conflicts. However, establishing causality using macro-data is not straightforward, since the relationship can be bi-directional. Against this background, the present study uses granular data, and attempts to build causality in the conflict-growth nexus by showing that intrastate conflicts have a disproportionate effect on growth in industries that rely more on R&D activities.

This paper explores how conflicts affect economic activity by using industry-level data from two-digit manufacturing industries for a large sample of countries over the last four decades. It identifies a channel through which those episodes impact growth, i.e., by hindering R&D activities. In particular, by exploiting the differences in industries' technological intensity within countries, this paper finds that intrastate conflicts lead to a decline in labor productivity growth, particularly in industries with higher technological intensity. Moreover, the additional labor productivity loss in high-tech industries during conflicts does not seem to be offset in the post-conflict period. The findings provide an explanation for the observed patterns of durable declines in income in the aftermath of conflicts, given the role of technological progress and innovation in long-term economic growth. To the best of my knowledge, this is the first study attempting to establish causality between conflicts and growth using granular data at industry-level in a cross-country setting.

Violent conflicts are followed by poor economic performance, which is generally long-lasting. Data shows that GDP per capita remains about 6 percentage points lower on average, even 10 years after intrastate conflicts (Figure A.1 in the Appendix). Rodrik (1999) argues that conflicts are a major reason for the observed decline in growth in many countries since the mid-1970s.[2] The extant literature documents that conflicts, particularly intrastate events, are associated with significant declines in economic growth (e.g., Collier 1999, Hoeffler and Reynal-Querol 2003, Cerra and Saxena 2008, Gates et al. 2012, Chupilkin and Koczan 2022). This strand of the literature generally finds that the foregone growth during the years of conflicts poses a drag to the post-conflict per capita GDP for a long time, since the accumulated income losses are easily reversed. In this regard, De Groot et al. (2022) estimates that in

[1] See https://press.un.org/en/2022/sgsm21216.doc.htm.

[2] World Development Report (2011) argues that conflicts cost the average developing country about three decades of GDP growth. The economic impact of violent conflicts worldwide, i.e., expenditures and losses related to containing, preventing, and addressing the impact of those events, is estimated to be about 13 percent of global GDP in 2022 (Institute for Economics and Peace 2023).

the absence of conflicts since the 1970s, global GDP would have been 12 percent higher in 2014, with this loss being markedly driven by intrastate conflicts.[3, 4]

There are various direct channels through which conflicts can hinder economic outcomes. The immediate destruction of physical capital, including roads, bridges, and other infrastructure, as well as production facilities, increases transaction and transportation costs, disrupts supply chains, and impedes productive capacity. Conflicts also have negative effects on human capital and workforce, in the form of death toll and displaced people. In addition, Knight et al. (1996) discusses another direct channel through which conflicts can reduce growth, i.e., diversion of public expenditure from productivity-enhancing spending to military. Some of these immediate effects likely hold economies back after the periods of conflicts, since, for instance, it takes time to restore the losses in physical and human capital.

Conflicts can have scarring effects on economies through indirect channels as well, i.e., by exacerbating development and social outcomes. There is extensive evidence on the long-lasting role of conflicts in poverty and inequalities, as well as in longer term human capital accumulation through its adverse effects on skills depreciation ("forgetting by not doing"), undernourishment, infant mortality, access to clean water, and education and health outcomes (e.g., Ghobarah et al. 2003, Alderman et al. 2006, Plümper and Neumayer 2006, Lai and Thyne 2007, Bundervoet et al. 2009, Blattman and Miguel 2010, Iqbal and Zorn 2010, Chamarbagwala and Moran 2011, Shemyakina 2011, World Development Report 2011, Gates et al. 2012, Collier and Duponchel 2013, Crost et al., 2014, Bircan et al. 2017, Corral et al. 2020). In this regard, conflicts are called as "development in reverse" (Collier et al. 2003).

On the other side, poor economic performance increases the risk of conflict. Among others, Collier and Hoeffler (1998), Collier et al. (2003), Humphreys (2003), and Blattman and Miguel (2010) find that lower income levels are a good predictor of conflicts. Bloomberg and Hess (2002) and Bloomberg et al (2006) explore the intertemporal relationship between conflicts and economic performance, and find that recessions are associated with a higher likelihood of conflicts, which in turn increase the probability of a recession. Limited state capacity and lower opportunity cost of rebellion are some explanations for these findings, as proposed by the literature (Fearon and Laitin 2003, Collier and Hoeffler 2004). Overall, such bi-directional associations point to a vicious cycle between conflicts and poor economic performance, leading to "conflict traps". Given this nature of the relationship, it is challenging to claim a causal relationship between conflicts and growth based on macro-data.

[3] There are many other studies showing evidence on a large and long-lasting decline in economic performance following conflicts, e.g., see Fang et al. (2020) and Novta and Pugacheva (2021) for evidence and for reviews of this literature. Beyond the economic costs of conflicts in the domestic economy, there is also evidence on cross-border spillovers (e.g., Sever 2018).

[4] While some papers find evidence on higher economic growth following different sorts of violent events (so called "peace dividend"), the vast majority of the literature as cited above does not show on a distinctively positive growth path in the post-conflict years, leaving income levels below the pre-conflict period due to the accumulated losses during those events.

This paper uses granular data to tackle the issue of causality in the conflict-growth nexus, as opposed to the prior cross-country studies. It fills this gap in the literature by using data from industry panels in a cross-country setting, and exploiting within country variation in industries' technological intensity. It identifies a specific channel through which conflicts can hinder growth, i.e., through their adverse effect on R&D activities. It discusses that conflicts likely have a disproportionate impact on R&D activities, and hypothesizes that those events lead to a decline in growth particularly in industries that rely more on such activities, compared to their peers. The results are consistent showing that conflicts have a larger effect on growth in industries with typically higher technological intensity (i.e., high-tech industries).

There are several channels through which conflicts can have particularly large effects on R&D activities. To start with, violent events in general lead to an increase in economic uncertainty (Collier 1999, Hoeffler and Reynal-Querol 2003, Bloom 2009, Blattman and Miguel 2010, Brodeur 2018). This can be detrimental for innovative activities due to their specific nature. First, R&D investment generally (i) produces outcomes with a longer delay, and (ii) is riskier by nature, compared to the standard investment. Thus, firms can be more responsive to the overall uncertainty and risks in the horizon, when it comes to R&D investment decisions. Second, innovative activities generally require larger scale and lumpy initial investment. In the periods of heightened uncertainty, firms may defer such investment, and rather save, or use, those resources for other purposes. Third, R&D activities encompass highly specialized investment with low redeployability and high irreversibility, making it hard to tap into those assets, in case of a need for immediate expenses to survive the periods of conflicts. Thus, instead of investing in those assets during the periods of heightened uncertainty, firms may choose investing in standard activities which are more redeployable, reversible, and thus cashable. The literature shows that such characteristics of specific types of investment, including in R&D, make it more prone to uncertainty shocks (Dixit and Pindyck 1994, Bhattacharya et al. 2017, Kim and Kung 2017, Fich et al. 2020, Li et al. 2022, Chen and Tang 2023).[5]

Moreover, conflicts can reduce the ability of state to enforce contracts (e.g., by reducing the capacity of the police and judiciary), increase corruption, and erode trust in government, which likely raise issues about the protection of intellectual property (Collier 1999, Blattman and Miguel 2010, Lindberg and Orjuela 2017 Novta and Pugacheva 2021). These can give rise to appropriability problems, and lower the ability of firms to benefit, or profit, from their innovative activities. As a result, firms' will have less incentives to engage in R&D activities, since, they may face obstacles related to compliance, intellectual property protection, and other legal issues, affecting their capacity to operate and grow. Such institutional impediments in turn can lead to underinvestment in R&D (e.g., Anokhin and Schulze 2009, Paunov 2016, Brown et al. 2017, Xu and Yano 2017).

[5] While some studies discuss that technological change can accelerate during wars, this is more relevant for large scale international wars, and when major advanced economies are involved (e.g., Gross and Sampat 2023). The present study focus on intrastate conflicts, which generally take place in less developed countries, and are fought with much lower technology relative to international and full-scale wars, making them unlikely to drive innovation (Collier 1999, Humphreys 2000).

There are various other channels through which conflicts can constrain innovative activities. First, conflicts can result in a decline in consumer and investor confidence. As a result, consumption can decrease, which likely affects the demand for high-tech products more, compared to that of some low-tech products such as food. Moreover, investors can become hesitant to allocate funds for longer term (and riskier) R&D projects, even when they have adequate financial resources, and instead relocate funds to short-term low-risk projects. Second, R&D facilities can be more sensitive to disruptions in some infrastructure than standard production facilities, including reliable electricity and internet. Finally, conflicts can disrupt collaboration both within country and across borders, hindering high-tech activities through reduced knowledge spillovers, technology transfer and diffusion, R&D cooperation between firms, and R&D outsourcing, which are important sources of innovative activities, as reviewed by Aghion and Jaravel (2015).

In thus study, I hypothesize that if some of the channels as discussed above are at play, and thus, if conflicts have a disproportionately large effect on R&D activities, they should affect growth more in industries with typically greater technological intensity. To test this hypothesis, I use industry-level data from the UNIDO database, and focus on industry labor productivity as an equivalent to GDP per capita at the macro-level. Data on the years of intrastate conflicts is from the Major Episodes of Political Violence (MEPV) database. The analysis is based on 2-digit manufacturing industries (ISIC Rev. 3, 15-36) from 114 developing, emerging market, and advanced economies over the period of 1980-2018, restricted by the availability of data.

In the estimation, I adopt an empirical strategy in the spirit of Rajan and Zingales (1998), and exploit within-country variation across 2-digit manufacturing industries based on their technological intensity. In the baseline, technological intensity for each industry is calculated using data on R&D expenditures of large, listed firms from a benchmark country with highly developed financial markets and a strong institutional framework (i.e., the US).[6] Thus, industry-level measures for technological intensity are likely to be driven by the differences in the production processes across industries, rather than being shaped by financing or appropriability problems. Another advantage of benchmarking industry R&D intensity based on data from the US is that it is not affected by the occurrence of conflicts in the countries in the sample, which would lead to endogeneity problems otherwise. To the extent that industries reliance on R&D, as calculated based on the US, carries over other countries and across time, industry-level data allows me to identify the differential effect of conflicts on industry growth within countries based on cross-industry differences in technological intensity.

Another major advantage of using industry-level data is that, as opposed to macro-data, growth pattern of a 2-digit manufacturing industry is not likely to affect the likelihood of conflict in a country, which is important for the identification. Moreover, the use of industry-level data allows me to control for the effects of all underlying factors that a granular level, mitigating concerns about omitted variables to a

[6] I also show that the results remain similar, when industry technological intensity is calculated based on data from other countries with relatively developed financial markets and stronger institutions (e.g., the OECD countries), or by using innovative output (patents, or quality certificates).

large extent. In the estimation, country-industry fixed effects absorb the underlying variation in industry growth in a country arising from some inherent characteristics which work in favor of, or against, a specific industry in that country. The effects of supply or demand shocks that are common across industries in each country-year cell are accounted by country-year fixed effects. Finally, the effects of the changes in industry-specific global conditions, trends, or growth opportunities, are absorbed by industry-year fixed effects.

The results show that conflicts affect industry growth, particularly in industries which rely more on R&D activities. They suggest that the disproportionate impact of conflicts on labor productivity growth in industries with higher technological intensity is large. For instance, labor productivity growth declines 1.5 percentage points more in machinery industry (a relatively high-tech industry, at the industry at the 75th percentile of R&D intensity distribution) compared to paper products (a relatively low-tech industry, at the industry at the 25th percentile of R&D intensity distribution) in each year with conflicts. This differential impact is economically significant considering that the average annual growth rate of labor productivity in the sample is about 4 percent. It is also important to note that the estimation based on Rajan and Zingales (1998) quantifies the disproportionate impact of conflicts on labor productivity growth in industries with higher technological intensity (rather than the overall impact on growth). Thus, the estimated effect is only the additional decline in growth in machinery due to conflicts, relative to that of paper products.

Moreover, high-tech industries do not exhibit a different growth pattern in the pre-conflicts periods, which is reassuring for identification (pointing to similar trends in the pre-conflict period). Next, focusing on the two-year window following conflicts, this additional decline in labor productivity growth in high-tech industries does not appear to persist. However, it is no rebound (i.e., no significantly higher growth in high-tech industries following conflicts) neither, suggesting that the lost labor productivity in high-tech industries in the years of conflicts is not recovered in the aftermath of those events. This suggests that firms do not simply delay some projects during conflicts to redeploy them in the short-term following those episodes. Rather, some productivity enhancing activities in R&D intensive industries seem to be canceled, or at least, shelved for a longer period.[7]

I also rule out various alternative explanations to the previous findings. For this purpose, I test whether technological intensity can indeed be a proxy for some other industry characteristics. First, industries that engage in high-tech activities more may also use physical capital more intensely. To the extent that conflicts hinder investment in physical capital in general (e.g., Knight et al. 1996, Imai and Weinstein 2000), the previous result can be explained by industry's reliance on physical capital. Second, high-tech industries may need a larger variety of inputs for production. If conflicts disrupt supply chains, or increase transportation costs, due to, for instance, damage to the physical infrastructure, input variety can be driving the previous findings. Next, high-tech industries may rely more on external finance, or have

[7] These disruptions in R&D activities can also undermine long-term growth through skills or capital depreciation, even if firms turn to those projects after several years, to the extent that innovative projects need continuity to bear fruit (Ahn et al. 2020).

greater liquidity needs, since R&D investment typically has longer gestation lags and yields output with a longer delay, compared to other investment (Rajan and Zingales 1998, Raddatz 2006). Moreover, R&D funding is generally hard to obtain compared to financing for other projects, making R&D investment more sensitive to the disruptions in available finance (Hall and Lerner 2010, Hardy and Sever 2021). R&D investment is also more intangible and thus less collateralizable, resulting in higher vulnerability to financing frictions (Braun and Larrain 2005, Ahn et al. 2020). Hence, if conflicts squeeze funding, a financial channel can drive the results. Finally, different exposure of high-tech industries to trade (imports and exports) may be the source of the differential effect of conflicts on those. However, I empirically show that these explanations do not undermine the baseline result on the disproportionate impact of conflicts on growth in R&D intensive industries.

The results are also robust to a large set of checks. First, I account for the role of several country-level factors -which may possibly have differential impacts on high-tech industries- in the previous results, including macroeconomic, financial, or institutional development, as well as financial and trade openness. The disproportionate effect of conflicts on high-tech industries also remains similar when tested in various subsamples, including the subsample consisting of emerging markets and developing economies, for which such events are more relevant. Although reverse causality is not very relevant for the present analysis using granular data from manufacturing industries (due to that growth rate of a 2-digit industry is not likely to affect the probability of conflict in a country), I still show that the results stay similar in a sample consisting of 2-digit industries which are smaller in manufacturing in their country. Finally, it is not likely for random country-level shocks to drive the results, as tested through randomization tests, suggesting a systematic relationship between conflicts and growth in high-tech industries.

This paper fills an important gap in the literature on the conflict-growth nexus by attempting to establish causality in a cross-country setting. It identifies a channel for the effect of conflicts on economic performance, i.e., their impact on R&D activities. As cited above, there is a long literature on the conflict-growth nexus using macro-data, where causality remains as a challenge due to the bi-directional relationship. Moreover, the use of macro-data makes it hard to identify specific channels through which conflicts drag economic performance. In this paper, I make a step forward to overcome those challenges by using a novel approach. I adopt an identification strategy as initially proposed by Rajan and Zingales (1998), which has been widely used in the macro-finance literature to identify the impact of financial development on growth. I use cross-country data at industry-level, and exploit cross-industry variation in technological intensity within countries, which allows me to identify the differential effect of conflicts on growth rate in high-tech industries, relative to low-tech industries. To the best of my knowledge, this is the first study attempting to establish causality between conflicts and growth using granular data at industry-level in a cross-country setting.[8]

[8] It is worth noting that there are a few country-specific studies that use micro-data (e.g., at household level) to assess the impact of different types of wars or conflicts on local economic performance (Davis and Weinstein 2002, Miguel and Roland 2011, Collier 2013, Serneels and Verpoorten 2015).

This paper is also related to the broad literature on the role of innovation in productivity and economic growth. The theoretical and empirical strands of this literature show that innovative activities are key for sustained improvements in productivity and long-term growth (e.g., Romer 1990, Aghion and Howitt 1992, Grossman and Helpman 1991, Kogan et al. 2017, and also see Hardy and Sever 2021 for a review). Given the link between innovative activities and economic performance, the findings on the effect of conflicts on R&D activities provide an explanation for the observed long-lasting drag in economic outcomes in the aftermath of conflicts.

The rest of this paper is organized as follows. Section 2 introduces the data. Section 3 presents the empirical methodology. Section 4 illustrates the results. Section 5 concludes.

2. Data

2.1. Episodes of Conflicts

Data on the dates of conflicts is from the Major Episodes of Political Violence (MEPV) database from Center for Systemic Peace. The events in the database are identified by the systematic and sustained use of violence by organized groups, where human toll exceeds 500 deaths. It is available until 2018. In the analysis, I use data from intrastate episodes of political violence to ensure that the event takes place entirely on the country's own soil.[9] For each country, I assign a dummy variable 1 for each year with intrastate conflicts (encompassing civil and ethnic violence and wars).

The database also provides scores for those events to gauge the extent of the episodes based on various quantitative and qualitative evaluation criteria, such as state capacity, intensity, related destruction and displacement. I account for the "size" of conflicts in a separate test. For this purpose, instead of a dummy variable, I assign a variable 1 (2) for the years whenever the score is below (above) the top quartile of the scores across the sample, and 0 when there is no conflict.[10]

2.2. Industry-level Data

Industry-level data is from the UNIDO database, which is compiled largely based on industrial surveys. The database provides information on productive activities for 2-digit (ISIC Rev. 3) manufacturing industries (ISIC 15-36). Labor productivity is calculated as the ratio of industry value added (in US dollars) to the number of employees. Growth rate of industry labor productivity is calculated as the log difference,

[9] Due to the fact that they are fought within the country, intrastate conflicts are discussed to be more relevant for economic performance (Collier 1999, Cerra and Saxena 2008). Another reason why such events are more appropriate to use in the analysis compared to interstate violence is that they are much more widespread across countries and over time.

[10] I prefer this classification for identifying relatively milder and larger events, rather than using the exact values of the scores, since the scores are not straightforward to assess, thereby limiting the comparability of the extent of conflicts across countries and years.

and multiplied by 100.[11] Industry value added share in total manufacturing (a control variable in the estimation) is the ratio of industry value added to total value added in manufacturing (in percent). Summary statistics of the variables as used in the analysis are illustrated the Appendix (Table A.1).

2.3. Industry Technological Intensity

The goal is to explore the effect of conflicts on labor productivity growth across industries that inherently exhibit differences in their technological intensity. For this purpose, I follow an approach that is similar to Rajan and Zingales (1998). In their seminal work, Rajan and Zingales (1998) argue that some industries inherently need more external finance than others. They hypothesize that the effect of financial development on growth should be larger in those industries. To test such differential impact of financial development on growth in industries with greater reliance on external funds, they use a proxy for industries' dependence on external finance, as calculated based on data from large, listed firms in the US. Similarly, I adopt a measure of industry technological intensity, and examine the differential effect of conflicts on growth by exploiting the cross-industry variation in this measure.

In the baseline, I adopt a proxy for industry technological intensity based on R&D expenditures data from publicly listed firms in the US, following the literature (e.g., Ilyina and Samaniego 2011, Brown et al. 2017). There are several reasons why using R&D data from the publicly listed firms in the US is appropriate in gauging the degree of industry's innate technological intensity. First, highly developed financial markets in the US reduce financing-related distortions that can lead to underinvestment in R&D otherwise. Next, strong legal and enforcement institutions, e.g., strong intellectual property protection, or lower levels of corruption, pose fewer impediments to firms' innovative activities by alleviating associated appropriability problems. Third, the US is one of the most technologically advanced economies, including with a large technology consumption market. Moreover, large and listed firms in the US have even easier access to capital markets, are better equipped to protect their intellectual property in case of breaches, and can easily take advantage of the market and technological advancements. Thus, this proxy for industry technological intensity, as calculated based on those firms in the US, provides a good benchmark for innate differences across industries. However, this does not necessarily claim that the proxy for technological intensity from the US represents the "correct" absolute value for each industry, but instead, it is likely to reflect differences in technological intensity across industries, driven by industries' production processes (rather than by financial or institutional frictions).

Benchmarking the heterogeneity in technological intensity across industries based on the data from the US has other advantages as well. First, industry-level data on R&D investment generally is not available for the vast majority of countries, and going back to decades. Moreover, even if it were available, using data on industry R&D activities in each country could lead to endogeneity, since R&D activities can be shaped by the occurrence of conflicts in that country. Thus, this approach in the spirit of

[11] I restrict the change in log labor productivity to 100 and -100 percent, which roughly corresponds to the 1st and 99th percentiles of the sample. I also confirm that this step does not affect or drive any results throughout the paper. The results also stay very similar, if labor productivity growth is winsorized at the 1st and 99th percentile of the sample.

Rajan and Zingales (1998) ensures that industry technological intensity is exogenous to country-specific developments, or shocks, in the sample.

A possible concern about benchmarking industries' technological intensity can be that industry-specific values of R&D intensity may differ across countries, to the extent that the production processes vary based on local conditions. However, this is not likely to alter the results, as long as the ordering of industries regarding technological intensity remains similar across countries. That is, if chemicals industry relies on R&D more than food industry in general (in line with the ordering in the US, see below), this phenomenon does not generate a significant bias in the estimation. Moreover, I use alternative proxies for industry technological intensity based on data from other countries in robustness.

In the baseline, I use the intensity of R&D expenditures in overall capital expenditures, following Ilyina and Samaniego (2011), as a proxy for industry technological intensity. It is from Igan et al. (2022). The measure is based on data from publicly listed companies in the US from the Compustat database. The first step is to calculate the average of the annual values of the firm-level ratios over the period of 1980–1999, which helps smooth out temporal fluctuations. Next, the median value across the firms within each industry is adopted as a proxy for R&D intensity (i.e., RDI baseline) in that industry.

The first column in Table 1 provides this measure (RDI baseline) for each 2-digit manufacturing industry. Chemicals industry has the highest R&D intensity as share of overall capital expenditures (ISIC 24), which is followed by medical instruments, office and computing machinery, communication equipment, electrical and machinery industries (ISIC 33, 30, 32, 31 and 29, respectively). Wearing apparel industry has the lowest R&D intensity (ISIC 18), followed by coke, wood, basic metal, food and paper product industries (ISIC 23, 20, 27, 15 and 21, respectively). It is also worth noting that there is variation across industries' R&D intensity, with a mean value of 0.97 and a standard deviation of 1.34 (see Table A.1 in the Appendix). The two-digit industries at the 25th and 75th percentiles of technological intensity are paper products (ISIC 21) and machinery (ISIC 29), respectively. Thus, the inherent differences in technological intensity across paper and machinery industries can be explained as the former typically requiring less R&D investment (low-tech), while the latter being highly dependent on R&D investment (high-tech).

In robustness, I use various other proxies for technological intensity. First, I adopt a measure of R&D intensity (i.e., RDI alternative I) from Brown et al. (2017). Similar to the measure above, it is calculated based on the publicly listed firms in the US from the Compustat database. It is defined as the ratio of R&D expenditures to sales for each firm, using the summed values of R&D investment and sales over the 1990s. Then, the median value across firms within each industry is used as a proxy for that industry. The second column in Table 1 illustrates this measure. Next, I use a proxy for technological intensity (i.e., RDI alternative II) based on the data from the OECD instead of the US, as calculated by averaging the ratio of industry R&D expenditure to output ratio over the period of 1990-2009. This is sensible as a benchmark for industry technological intensity, given relatively high levels of economic, financial and institutional development in the OECD countries. Column 3 shows those values, as adopted from Markus et al. (2019).

The next two proxies for industry technological intensity focus on innovative output, namely patenting and quality certificates, adopted from Paunov (2016). Firms invest in R&D for new inventions or quality improvements, as they expect future gains from these investments. Patents and quality certificates are thus the outputs of innovative activities that allow firms to reap associated gains. Data on patenting is from the NBER Patent Database covering the patent applications filed with the US Patent and Trademark Office (USPTO) over the period of 1980-1986. Patent intensity in each industry is calculated by dividing the number of patents by value added in million US dollars, as with Aghion et al. (2015). Data on quality certificates is from the World Bank Enterprise Surveys (WBES) based on more than 100 countries. Average share of firms holding quality certificates in each industry over the period of 2006–2011 is used as a proxy for industry technological intensity. The last two columns in Table 1 report these measures.

Table 1: Industry technological intensity

Industry	ISIC	RDI baseline	RDI alternative I	RDI alternative II	Patent intensity	QC intensity
Food and beverages	**15**	0.180	0.0065	0.002	0.2	23.1
Tobacco products	**16**	0.402	0.0045	0.004	0.0	**41.1**
Textiles	**17**	0.349	**0.0127**	**0.005**	0.4	16.2
Wearing apparel, fur	**18**	0.000	0.0000	0.002	0.4	11.1
Leather, leather products, footwear	**19**	**0.554**	0.0069	0.004	0.4	9.4
Wood products (excl. furniture)	**20**	0.164	0.0048	0.002	0.1	12.6
Paper and paper products	**21**	0.266	0.0097	0.003	0.2	24.1
Printing and publishing	**22**	**0.602**	0.0082	0.001	0.2	13.1
Coke, refined petroleum, nuclear fuel	**23**	0.062	0.0057	0.004		
Chemicals and chemical products	**24**	**5.456**	**0.2748**	**0.035**	**6.4**	**35.1**
Rubber and plastics products	**25**	0.368	**0.0139**	**0.009**	**1.4**	**31.0**
Non-metallic mineral products	**26**	0.337	0.0116	0.005	0.6	20.5
Basic metals	**27**	0.168	0.0069	0.005	0.2	28.6
Fabricated metal products	**28**	0.351	0.0096	0.004	**0.9**	27.4
Machinery and equipment n.e.c.	**29**	**0.926**	**0.0232**	**0.017**	**10.0**	**31.8**
Office, accounting, computing machinery	**30**	**2.845**	**0.1205**	**0.059**	**19.0**	**36.8**
Electrical machinery and apparatus	**31**	**1.245**	**0.0318**	**0.028**	**11.3**	**46.6**
Radio, TV, communication equipment	**32**	**2.353**	**0.1054**	**0.065**	**25.5**	**53.2**
Medical, precision, optical instruments	**33**	**3.168**	**0.1053**	**0.047**	**18.7**	**42.9**
Motor vehicles, trailers, semi-trailers	**34**	**0.441**	**0.0166**	**0.018**	**1.4**	**44.6**
Other transport equipment	**35**	**0.614**	**0.0206**	**0.031**	0.3	**43.2**
Furniture; manufacturing n.e.c.	**36**	**0.511**	**0.0177**	0.004	**2.3**	10.4

Notes: R&D intensity (RDI) baseline is the ratio of R&D expenditure to capital expenditure (Igan et al. 2022). RDI alternative I is the ratio of R&D expenditure to sales (Brown et al. 2017). RDI alternative II is the share of R&D expenditure in output in the OECD (Markus et al. 2019). Patent intensity is the patent counts as share of million USD value added, and quality certificate (QC) intensity is the share of firms holding a certificate (Paunov 2016). The color-coding (in highlighting cells) in the table is based on the quartiles of each measure, ranging from light green to dark orange from the 1st to the 4th quartile. The industries with red/bold text are above the median of the corresponding measure.

It is important to note that these proxies for industry technological intensity are positively correlated, including the proxies from the US (RDI baseline and RDI alternative I), and the ones from the US and the OECD (RDI baseline and RDI alternative II) (see Table A.2 in the Appendix). In addition, (i) the industries that are above the median value of each proxy (as shown by the red/bold text in Table 1), and (ii) the industries in each quartile of technological intensity based on different proxies (as shown by the color coding in Table 1 from green to orange for higher technological intensity) mostly overlap. The positive associations across different proxies are reassuring for the identification strategy in the analysis.

Finally, I employ the analysis by adopting a classification based on the ratio of R&D expenditure to value added using data from the OECD countries, as provided by Galindo-Rueda and Verger (2016). In this categorization, 8 manufacturing industries are identified as high-tech (ISIC 24, 29-35), 5 industries as medium-tech (ISIC 23, 25-28), and the rest as low-tech. I assign a variable indicating the degree of industries' technological intensity, which takes 3 for high-tech industries, 2 for medium-tech industries, and 1 for low-tech industries. It is worth noting that this classification is also very similar to "RDI baseline" measure. For instance, 7 out of 8 high-tech industries according to this classification are among the top 8 industries with the highest R&D intensity as categorized in the baseline (ISIC 24, 29-33, 35, as shown in column 1 in Table 1).

2.4. Other Industry Characteristics

In robustness, I test whether technological intensity may indeed be serving as a proxy for various other industry characteristics. I first account for industry's (i) dependence on external finance, (ii) liquidity needs, (iii) asset tangibility, (iv) physical capital intensity, and (v) product complexity (or input concentration). These variables are from Igan et al. (2022). Dependence on external finance is defined as the share of firm's capital expenditures which are not financed with cash flow from operations, as with Rajan and Zingales (1998). The proxy for liquidity needs is calculated the ratio of a firm's total inventories to annual sales, as introduced by Raddatz (2006). Asset tangibility is the share of net property, plant and equipment in total book-value of firm assets, in line with Braun and Larrain (2005). Similar to the baseline measure for R&D intensity, these variables are first calculated at the firm level by averaging the annual shares over the period of 1980-1999 to smooth out temporal fluctuations. Then, the median value across firms within each industry is used as a proxy for that industry.

Physical capital intensity is calculated as the total real capital stock as share of total value added in each industry from the NBER-CES Manufacturing Industry Database, as with Nunn (2007) and Ciccone and Papaioannou (2009). It is averaged over the period of 1980-1999. Product complexity (or input concentration) is proxied by industry Herfindahl index of intermediate input use (multiplied by minus 1), which is computed based on the US 1992 Input-Output (I-O) Use Table, following Levchenko (2007). This inverse index gauges the degree of concentration of purchases in each industry. Table 3 documents these measures.

Finally, I construct two proxies for industries' exposure to trade. For this purpose, I utilize the OECD's STAN Bilateral Trade Database by Industry and the end-use category (BTDIxE) to compute industries' share of exports or imports in total manufacturing in the OECD countries. I sum the US dollar values of industry-level exports (and imports) over the 1990s, and calculate the industry's share in total manufacturing.[12] The last two columns in Table 3 provides those measures.

Table 3: Other industry characteristics

Industry	ISIC	Physical capital intensity	Product complexity	Dependence on external finance	Liquidity needs	Asset tangibility	Imports	Exports
Food and beverages	**15**	1.466	-0.111	-0.309	0.102	0.363	0.037	0.035
Tobacco products	**16**	1.047	-0.118	-2.897	0.252	0.219	0.037	0.035
Textiles	**17**	1.287	-0.121	-0.157	0.178	0.329	0.030	0.020
Wearing apparel, fur	**18**	0.440	-0.090	-0.298	0.213	0.116	0.030	0.020
Leather, leather products and footwear	**19**	0.630	-0.098	-0.735	0.219	0.128	0.030	0.020
Wood products (excl. furniture)	**20**	1.126	-0.119	-0.250	0.114	0.293	0.016	0.012
Paper and paper products	**21**	1.674	-0.106	-0.385	0.116	0.510	0.019	0.019
Printing and publishing	**22**	0.911	-0.081	-0.752	0.069	0.267	0.019	0.019
Coke, refined petroleum, nuclear fuel	**23**	2.496	-0.157	-0.236	0.076	0.617	0.026	0.019
Chemicals and chemical products	**24**	1.768	-0.069	3.868	0.141	0.206	0.110	0.120
Rubber and plastics products	**25**	1.253	-0.073	-0.273	0.126	0.363	0.029	0.029
Non-metallic mineral products	**26**	1.600	-0.060	-0.350	0.145	0.421	0.016	0.017
Basic metals	**27**	2.272	-0.068	-0.210	0.168	0.397	0.062	0.058
Fabricated metal products	**28**	1.137	-0.056	-0.566	0.178	0.278	0.027	0.027
Machinery and equipment n.e.c.	**29**	0.995	-0.039	-0.431	0.203	0.216	0.098	0.125
Office, accounting, computing machinery	**30**	0.752	-0.086	1.056	0.190	0.133	0.064	0.051
Electrical machinery and apparatus	**31**	0.938	-0.068	-0.025	0.194	0.245	0.043	0.046
Radio, TV, communication equipment	**32**	1.108	-0.088	0.317	0.194	0.179	0.072	0.074
Medical, precision, optical instruments	**33**	0.549	-0.050	1.241	0.235	0.155	0.034	0.038
Motor vehicles, trailers, semi-trailers	**34**	1.365	-0.049	-0.140	0.142	0.270	0.126	0.139
Other transport equipment	**35**	0.914	-0.067	-0.248	0.213	0.250	0.035	0.049
Furniture; manufacturing n.e.c.	**36**	0.764	-0.041	-0.337	0.176	0.204	0.039	0.030

Notes: Columns 1-5 document industry's physical capital intensity, product complexity (i.e., inverse Herfindahl index of purchases), dependence on external finance, liquidity needs, and asset tangibility, respectively, as adopted from Igan et al. (2022). Columns 6-7 report industries' import and export shares in total manufacturing (own calculations), respectively.

[12] The industry classification in the database is broader than 2-digit ISIC classification for a few industries. For those, I equally divide the corresponding measure to get a measure for 2-digit ISIC industries (i.e., for ISIC 15-16, ISIC 17-19, and ISIC 21-22). I normalize industry level exports (or imports) with total exports (or imports) in manufacturing, rather than industries' own output, since country-year pairs with available data and industry classification do not exactly overlap to fully match industry-level trade variables with industry output.

2.5. Country-level Data

In robustness, I account for several macroeconomic, financial and institutional variables to mitigate concerns about whether conflicts are indeed a proxy for those factors. For this purpose, I use real GDP per capita (constant in US dollars) as a proxy for economic development, credit to the private sector (as percent of GDP) as a proxy for financial development, and trade (as percent of GDP) as a proxy for trade openness. They are from the World Bank's World Development Indicators (WDI) database.

I adopt the index from Chinn and Ito (2006) to gauge the level of financial openness. It is a de jure (regulatory) measure of capital account openness, scaled between 0 and 1, higher values indicating more open financial systems. I also test the results by accounting for FDI as a de facto measure of financial globalization (stock of liabilities, as percent of GDP), as adopted from Milesi-Ferretti (2022) which is an update of the original dataset by Lane and Milesi-Ferretti (2018). Finally, as a proxy for institutional quality, I use the index on the constraints on executives from the Polity V dataset from Center for Systemic Peace. The index provides a summary measure for the degree of the institutionalized constraints on the decision-making of chief executives. It ranges between 0 and 7, higher values indicating a stronger institutional environment.

I also use data on exchange rates and inflation to calculate the appreciation in real exchange rate. Data on nominal exchange rates (local currency vis-a-vis USD) is from the WDI database. Consumer price inflation (CPI) and producer price inflation (PPI) come from the World Bank's inflation database (constructed by Ha et al. 2023).

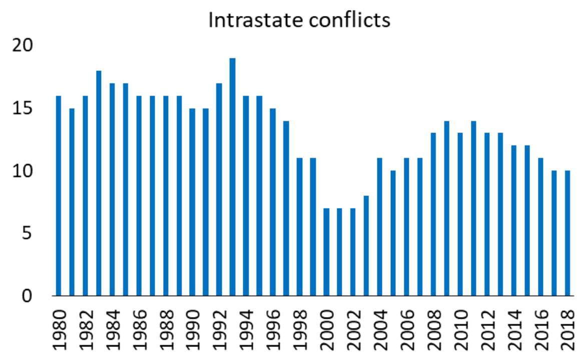
2.6. Sample

I use all available data starting from 1980 with one exception, i.e., by excluding a few country-industry pairs with less than 5 years of available data to maintain within-industry variation over time. However, this step does not affect, or drive, any results throughout the paper. The main sample consists of 2-digit manufacturing industries (ISIC 15-36) over the period of 1980-2018. The sample consists of 114 countries, with 21 of them being advanced economies (see the Appendix).

There are 519 events of violent conflicts in the sample (covering about 19 percent of country-industry-year observations). Figure 1 reports the number of events each year in the sample.[13] It is worth noting that the vast majority of those events (97 percent) took place in emerging markets and developing economies. I employ various tests in robustness to make sure that the countries for which conflicts are less relevant do not drive the findings.

[13] Conflicts are also spread across countries in different continents with 70, 279, 91 and 79 country-year observations with conflicts in Africa, Asia, Americas and Europe, respectively.

Figure 1: Intrastate conflicts over years



Notes: Chart reports the number of countries with intrastate conflicts in each year over the sample period.

3. Methodology

The goal is to examine the heterogeneous effects of conflicts on growth based on the variation in industries' technological intensity. I employ a difference-in-differences approach pioneered by Rajan and Zingales (1998). The Rajan and Zingales (1998) approach is aimed at identifying the causal effects of a country-specific factor by focusing on the differential impact a country-level variable on industries with inherently different characteristics. The original paper by Rajan and Zingales (1998) explores the effect of financial development on industries with different levels of dependence on external finance. In this paper, I examine the differential impact of conflicts on industries with different degrees of technological intensity. The hypothesis is that if conflicts affect innovative activities, the impact of those events on growth should be more pronounced in industries with relatively higher technological intensity.

For the identification to hold, there are two implicit assumptions aligned with the empirical literature pioneered by Rajan and Zingales (1998). First, I assume that some industries inherently and persistently rely more on R&D activities than others, mainly driven by their production processes. Second, these innate differences carry over the countries, such that an industry's technological intensity as calculated using the data from the US serves as a proxy for its technological intensity in other countries.

The specification is as follows:

$$\Delta \log(LP_{c,j,t}) = \alpha \, VA\, share_{c,j,t-1} + \sum_{r=-2}^{2} \beta_r \, Tech\ intensity_j \times Conflict_{c,t-r} + \theta_{c,t} + \theta_{c,j} + \theta_{j,t} + \epsilon_{c,j,t} \qquad (1)$$

where c, j and t stand for countries, 2-digit manufacturing industries and years, respectively. The dependent variable $\Delta \log(LP_{c,j,t})$ is the growth rate of industry labor productivity (in percentage points). The variable $Tech\ intensity_j$ is a proxy for industry's technological intensity, enabling a comparison across 2-digit manufacturing industries, as described above. $Conflict_{c,t-r}$ is a dummy variable indicating the years of conflicts. The main variable of interest is the set of interaction terms between industry's technological intensity and the dummy variables for conflicts. The coefficient estimates of these interactions illustrate whether the pattern of labor productivity growth changes around those events, particularly based on industry's reliance on R&D activities. I document the coefficient estimates for β_r for $r = -2, -1,\ 0,\ 1,\ 2,$ spanning the five-year window around conflicts. The estimates for β_{-2} and β_{-1} assesses whether labor productivity growth exhibits a distinct pattern in the two-year period running up to conflicts, whereas β_0 focuses on the years of conflicts. The estimates for β_1 and β_2 explore the growth dynamics in the aftermath of those events.

The inclusion of the forward values of conflicts ($Conflict_{c,t-r}$ with $r = -1, -2$) improves the identification of the effect of those events on labor productivity growth. For identification, it is important that labor productivity in industries which engage in high-tech activities more intensely does not show a different growth pattern during the pre-conflict years. The specification in (1) explicitly tests this by including the forward values of those episodes. I expect the coefficient estimates β_{-2} and β_{-1} to be statistically insignificant. On the other hand, to the extent that conflicts have an adverse and disproportionate impact on labor productivity growth in high-tech industries, I expect β_0 to be negative and statistically significant. If the effect on growth in high-tech industries is persistent, the coefficient estimates of β_1 and β_2 should be negative as well. If those coefficients turn out to be positive, it would suggest that a growth rebound following conflicts, potentially offsetting the losses during those episodes.

Another important issue for the identification is the inclusion of country-year ($\theta_{c,t}$), country-industry ($\theta_{c,j}$) and industry-year ($\theta_{j,t}$) fixed effects. Country-year fixed effects isolate the underlying variation in labor productivity growth that is common across industries in a country during a year. In particular, this set of fixed effects controls for the impact of all time-variant economic, political and institutional developments, as well as country-specific annual shocks including demand or supply shocks, which are common across industries, on labor productivity growth. Country-industry fixed effects account for any underlying reasons which can lead to a lower, or higher, growth in an industry in a given country, on average. This set of fixed effects accounts for, for instance, if industries with higher technological intensity on average grow less, or more, in some countries due to some unobserved, persistent factors. Finally, industry-year fixed effects controls for the role of industry-specific global developments, trends, growth opportunities, or shocks, at an annual frequency. Thus, the use of industry-level data alleviates potential concerns about omitted variables by allowing me to control for the effects of a large set of factors on industry labor productivity growth.

Country-year and industry-year fixed effects are also important to eliminate the role of inflation dynamics in the results. First, industry-year fixed effects absorb the influence of a common global (US dollar) inflation for each industry in a year. For many cases, assuming a common global inflation is reasonable, since the manufacturing goods are tradable, and therefore manufacturers generally face common, global prices (Rodrik 2013). However, in practice, there may be some reasons why domestic prices may change differently compared to world prices, even in the case of tradables. To the extent this is an issue, country-year fixed effects absorb the role of the component of inflation which is country-specific but common across industries in a year.

It is also important to control for the lagged value of the value added share of the industry in total manufacturing value added in its country ($VA\ share_{c,j,t-1}$), since industries that are initially larger compared to their peers may have less room, or have limited additional resources or new opportunities, to grow faster. Standard errors are clustered at the country-industry level.[14]

Using industry-level data in attempting to identify the effect of conflicts on growth also has the advantage of mitigating reverse causality. In particular, as opposed to macro-data, it is not likely for the changes in the growth pattern of a R&D intensive (2-digit) manufacturing industry to significantly influence the likelihood of conflict in a country.

In the next step, I examine whether industry's technological intensity can indeed be a proxy for various other industry characteristics. For this purpose, I extend the specification in (1) by including the interactions between other industry characteristics and the dummy variables for conflicts. The specification is as follows:

$$\Delta \log\left(LP_{c,j,t}\right) = \alpha\ VA\ share_{c,j,t-1} + \sum_{r=-2}^{2} \beta_r\ Tech\ intensity_j \times Conflict_{c,t-r} + \sum_{r=-2}^{2} \mu_r\ I_j \times Conflict_{c,t-r} + \theta_{c,t} + \theta_{c,j} + \theta_{j,t} + \epsilon_{c,i,t} \quad (2)$$

where I_j represents industry's physical capital intensity, input concentration, dependence on external finance, liquidity needs, asset tangibility, and exposure to imports and exports, as described above.

Finally, I account for the heterogeneous effects of various country-level variables on labor productivity growth based on industry's technological intensity. In particular, although country-year fixed effects absorb the common impact of all country-level variables on industry labor productivity growth at an

[14] The results throughout the paper stay virtually the same, if the standard errors are (i) not clustered at all (but robust to heteroskedasticity), (ii) three-way clustered (at country-industry, country-year and industry-year levels), (iii) two-way clustered with any combinations of those three levels, or (iv) one-way clustered at country, industry or year levels.

annual frequency, it is still important to test whether those country-level variables can have an impact that possibly changes with industry's technological intensity. In this regard, this set of tests also checks whether conflicts may indeed be a proxy for other county-level factors. I include the interactions between industry's technological intensity and country-specific factors, as follows:

$$\Delta \log(LP_{c,j,t}) = \alpha\, VA\, share_{c,j,t-1} + \sum_{r=-2}^{2} \beta_r\, Tech\ intensity_j \times Conflict_{c,t-r} + \sum_{r=-2}^{2} \gamma_r\, Tech\ intensity_j \times X_{c,t-r} + \theta_{c,t} + \theta_{c,j} + \theta_{j,t} + \epsilon_{c,i,t} \quad (3)$$

where $X_{c,t-r}$ represents proxies for economic and financial development, financial openness, trade openness, FDI, or institutional quality, as mentioned above.

To the extent that (i) industry technological intensity is not a proxy for other industry features, and (ii) conflicts do not serve as a proxy for other country-level factors, I expect the results from the specifications (2) and (3) to be similar to the baseline result from the first specification above.

4. Results

4.1. Baseline Results

Table 4 illustrates the baseline results. Column 1 includes only the two-year forward values of the dummy variable for conflicts. Column 2 adds the dummy variable for the years of conflicts. Finally, the last column employs the full specification in (1).[15] Figure 2 provides an illustration of the result from the third column in Table 4. To start with, it shows that labor productivity growth in high-tech industries does not exhibit a distinct pattern in the pre-conflict period, which is important in identifying the effect of conflicts on growth. The negative coefficient and statistically significant (at the 1 percent level) coefficient estimate at year *t* suggests that labor productivity declines in the years of conflicts, particularly in industries with higher technological intensity.

The disproportionate impact of conflicts on labor productivity growth in high-tech industries is large. The two-digit industries at the 25th and 75th percentiles of R&D intensity distribution are paper products (ISIC 21) and machinery (ISIC 29), respectively. The proxy for technological intensity is 0.266 for paper products, and 0.926 for machinery, as shown in Table 1 (RDI baseline). The coefficient estimate of 2.2 in the years of conflicts suggests that labor productivity growth declines by an additional 1.5 percentage points in machinery industry compared to paper products (2.2 times the difference in R&D intensity measures for those two industries). This differential impact is economically important considering that the average annual growth rate of industry labor productivity in the sample is 4.1 percent (see Table

[15] I also employ the Akaike Information Criterion (AIC) for those three models in Table 4. The full model presents the lowest AIC score, thereby producing the best fit.

A.1 in the Appendix). In the context of the Rajan and Zingales (1998) approach, the estimated effect is only the additional decline in growth in the machinery industry relative to the decline in paper products. Thus, it quantifies the differential effect of conflicts on labor productivity growth in industries with relatively higher technological intensity (rather than being the overall impact), while still being economically sizable.

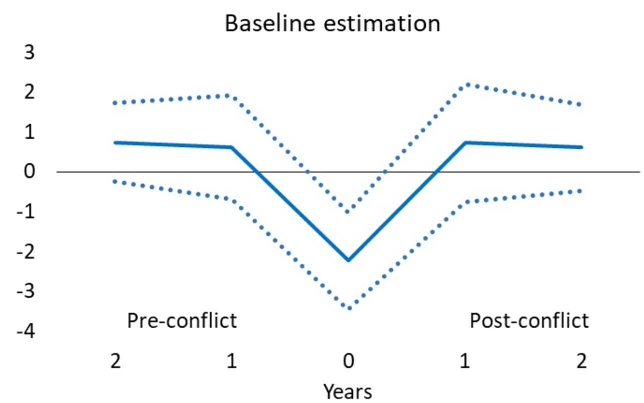
Focusing on the two-year window following conflicts, this additional decline in labor productivity growth in high-tech industries (i.e., the disproportionate effect of conflicts on industries with greater technological intensity) does not appear to persist. However, it is no rebound (i.e., no significantly higher growth following conflicts) neither to make up for the lost labor productivity in high-tech industries the years of conflicts. This suggests that firms do not simply delay R&D projects in the year of conflicts to redeploy them in the short-term following those events. Rather, some productivity enhancing investments in R&D intensive industries seem to be canceled, or at least, shelved for a longer period. The inclusion of the lagged values in the specification is also useful to disentangle the impact of conflicts during each year of those events exclusively, which is particularly important in the case of protracted conflicts. The results suggest that there appears to be a decline in growth in high-tech industries during each year of such episodes, thereby accumulating larger losses during durable conflicts.

Table 4: Labor productivity growth, technological intensity, and conflicts

Variable	(1)	(2)	(3)
$Tech\ intensity_j \times Conflict_{c,t+2}$	0.705	0.732	0.764
	(0.585)	(0.584)	(0.583)
$Tech\ intensity_j \times Conflict_{c,t+1}$	-0.360	0.669	0.609
	(0.592)	(0.793)	(0.802)
$Tech\ intensity_j \times Conflict_{c,t}$		-1.325**	-2.236***
		(0.543)	(0.770)
$Tech\ intensity_j \times Conflict_{c,t-1}$			0.728
			(0.916)
$Tech\ intensity_j \times Conflict_{c,t-2}$			0.590
			(0.661)
$VA\ share_{c,j,t-1}$	-1.498***	-1.497***	-1.498***
	(0.087)	(0.087)	(0.087)
Country-year F.E.	Yes	Yes	Yes
Country-industry F.E.	Yes	Yes	Yes
Industry-year F.E.	Yes	Yes	Yes
Observations	49,518	49,518	49,518
R-squared	0.358	0.358	0.358

Notes: Results are based on equation 1. Standard errors in parentheses are clustered at the country-industry level. *** p<0.01, ** p<0.05, * p<0.1.

Figure 2: An illustration of the baseline result



Notes: Chart reports the coefficient estimates of the interaction terms with the 90 percent confidence intervals as shown in the last column in Table 4.

Finally, the negative and statistically significant coefficient of industry's initial value added share suggests that smaller industries tend to exhibit higher labor productivity growth.

4.2. Accounting for Other Industry Characteristics

In this section, I check whether industry's technological intensity may be serving as a proxy for other industry-level features. Thus, these tests examine alternative explanations whether the effect of conflicts on labor productivity growth materializes through other industry characteristics, rather than industry's technological intensity. Table 5 illustrates the findings. In column 1, I check whether industries with higher R&D intensity may be the ones with higher dependence on physical capital. In particular, it can be the case that conflicts affect industries that rely more on physical capital as a whole, rather than the industries that are specifically more dependent on R&D activities. However, the results show that the previous finding stays similar, and the physical capital channel does not play a significant role in the interplay between conflicts and growth.

In column 2, I include a proxy for product complexity. This test can be important, to the extent that high-tech industries need a wide set of inputs compared to their peers which engage in relatively basic production activities. The findings show that the baseline result remains similar in this test, and conflicts do not seem to have a pronounced effect across industries based on industry's product complexity.

In columns 3 and 4, I test whether R&D intensity may be a proxy for industry's dependence on external finance or liquidity needs, respectively. Accounting for these financing-related measures is important, since industries with greater R&D activities may rely more on external finance, or have higher liquidity needs, due to various reasons. Finally, high intangibility of R&D investment may make it more vulnerable to disruptions in finance (column 5). The baseline result is robust across these tests (i.e., even after accounting for a financial channel), thereby eliminating financing frictions as an alternative explanation. It is interesting to note that conflicts also seem to have a disproportionately negative effect on growth in industries with greater reliance on external finance with one-year delay, while there is evidence for the recovery of losses via this channel in the short-term (column 3).

Finally, I test whether differences in exposure of industries to imports or exports may be driving the results, pointing to a trade-related explanation. The last two columns account for the roles of industries' reliance of imports and exports in the interplay between conflicts and growth. The main result remains similar in those tests, and conflicts do not seem to a significantly different effect on industries based on their exposure to imports or exports.

Table 5: Accounting for other industry characteristics

Variable	Physical capital intensity	Product complexity	Dependence on external finance	Liquidity needs	Asset tangibility	Imports	Exports
$Tech\ intensity_j \times Conflict_{c,t+2}$	0.765	0.903	0.360	0.744	1.142	0.566	0.602
	(0.582)	(0.565)	(1.667)	(0.559)	(0.987)	(0.830)	(0.802)
$Tech\ intensity_j \times Conflict_{c,t+1}$	0.601	0.605	1.801	0.613	0.455	0.663	0.665
	(0.792)	(0.821)	(1.685)	(0.783)	(0.814)	(1.131)	(1.106)
$Tech\ intensity_j \times Conflict_{c,t}$	-2.232***	-2.426***	-3.367**	-2.176***	-2.378***	-2.741***	-2.775***
	(0.764)	(0.811)	(1.616)	(0.744)	(0.786)	(1.043)	(1.048)
$Tech\ intensity_j \times Conflict_{c,t-1}$	0.721	1.043	2.842	0.673	0.810	1.272	1.311
	(0.911)	(0.959)	(1.994)	(0.891)	(0.902)	(1.081)	(1.124)
$Tech\ intensity_j \times Conflict_{c,t-2}$	0.590	0.384	-1.799	0.627	0.505	0.228	0.191
	(0.660)	(0.692)	(1.302)	(0.657)	(0.673)	(0.804)	(0.819)
$I_j \times Conflict_{c,t+2}$	2.755	-22.114	0.530	3.681	10.838	16.182	11.084
	(2.492)	(40.338)	(1.946)	(23.192)	(11.354)	(41.030)	(32.859)
$I_j \times Conflict_{c,t+1}$	-1.038	0.726	-1.562	-0.728	-4.331	-4.153	-3.949
	(2.551)	(45.678)	(1.833)	(25.493)	(11.530)	(56.476)	(45.674)
$I_j \times Conflict_{c,t}$	0.351	29.906	1.478	-12.170	-4.021	40.396	36.660
	(2.552)	(42.868)	(1.660)	(23.851)	(11.581)	(50.189)	(42.388)
$I_j \times Conflict_{c,t-1}$	-0.453	-49.720	-2.762*	11.056	2.346	-44.000	-39.936
	(2.788)	(44.991)	(1.623)	(24.806)	(12.501)	(42.319)	(37.328)
$I_j \times Conflict_{c,t-2}$	-0.410	32.672	3.127**	-7.500	-2.377	29.160	27.279
	(1.766)	(28.977)	(1.406)	(17.121)	(7.712)	(31.734)	(26.887)
$VA\ share_{c,j,t-1}$	-1.500***	-1.498***	-1.497***	-1.498***	-1.499***	-1.497***	-1.497***
	(0.087)	(0.087)	(0.087)	(0.087)	(0.087)	(0.087)	(0.087)
Country-year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	49,518	49,518	49,518	49,518	49,518	49,518	49,518
R-squared	0.358	0.358	0.358	0.358	0.358	0.358	0.358

Notes: Results are based on equation 2. I stands for industry's physical capital intensity (column 1), product complexity (inverse of Herfindahl index of intermediate input use) (column 2), dependence on external finance (column 3), liquidity needs (column 4), asset tangibility (column 5), import share (column 6), and export share (column 7). Standard errors in parentheses are clustered at the country-industry level. *** p<0.01, ** p<0.05, * p<0.1.

Finally, I examine whether the result on the differential effect of conflicts on high-tech industries remains similar, when I account for the industry size in in this relationship. This can be a concern to the extent that relatively smaller industries may have less resources to cushion against such large shocks (and cut their R&D spending more compared to larger peers). To rule out this alternative explanation for the previous results, I include the interactions between the initial value added share of industry and the dummy variables for conflicts. The baseline result remains robust, and the effect of conflicts does not significantly change based on industry size (see Table A.3 in the Appendix).

4.3. Accounting for Other Country-level Factors

Next, I examine whether macroeconomic, financial, or institutional environment, may be driving the previous results (by affecting high-tech industries more than others), rather than the occurrence of conflicts. Table 6 illustrates the findings. In column 1, I include the interactions between the five-year window of GDP per capita (as a proxy for economic development) to account for that violent conflicts generally take place in countries with lower levels of economic development. Based on a similar reasoning, the next two columns focus on financial development (column 2) and openness (column 3). Column 4 accounts for the role of trade openness in labor productivity growth in high-tech industries. Columns 5 and 6 account for the differential role of FDI and institutional quality in industry growth based on technological intensity, to account for that conflicts may take place in countries which typically do not receive much FDI or have weaker institutions. The baseline result remains similar, thereby ruling out alternative explanations whether these country-level factors may drive the results. Moreover, those country-level factors do not have much effect on labor productivity growth in high-tech industries.

Table 6: Accounting for other country-level variables

Variable	Economic development	Financial development	Financial openness	Trade openness	FDI	Institutional quality
$Tech\ intensity_j \times Conflict_{c,t+2}$	0.742	0.965	0.803	0.494	0.773	0.789
	(0.593)	(0.772)	(0.595)	(0.592)	(0.590)	(0.578)
$Tech\ intensity_j \times Conflict_{c,t+1}$	0.621	0.572	0.589	0.751	0.638	0.597
	(0.814)	(1.001)	(0.806)	(0.827)	(0.814)	(0.802)
$Tech\ intensity_j \times Conflict_{c,t}$	-2.252***	-1.835***	-2.283***	-2.274***	-2.222***	-2.255***
	(0.782)	(0.878)	(0.796)	(0.806)	(0.782)	(0.778)
$Tech\ intensity_j \times Conflict_{c,t-1}$	0.746	0.333	0.719	0.458	0.785	0.753
	(0.953)	(1.173)	(0.937)	(0.968)	(0.960)	(0.920)
$Tech\ intensity_j \times Conflict_{c,t-2}$	0.541	0.318	0.372	0.789	0.429	0.592
	(0.682)	(0.900)	(0.688)	(0.692)	(0.682)	(0.653)
$Tech\ intensity_j \times X_{c,t+2}$	-1.518	0.018	2.331*	-0.003	0.002	0.088
	(3.070)	(0.015)	(1.272)	(0.015)	(0.001)	(0.148)
$Tech\ intensity_j \times X_{c,t+1}$	2.810	-0.045*	-2.221	0.024	-0.002	-0.002
	(5.024)	(0.024)	(1.670)	(0.023)	(0.001)	(0.231)
$Tech\ intensity_j \times X_{c,t}$	-1.320	0.021	-0.209	-0.014	-0.001	-0.072
	(4.939)	(0.027)	(1.579)	(0.028)	(0.001)	(0.196)
$Tech\ intensity_j \times X_{c,t-1}$	-1.345	0.016	1.895	-0.022	0.001	0.018
	(4.702)	(0.023)	(1.697)	(0.023)	(0.001)	(0.161)
$Tech\ intensity_j \times X_{c,t-2}$	1.300	-0.001	-1.379	0.020	0.001	-0.060
	(2.823)	(0.013)	(1.131)	(0.014)	(0.001)	(0.151)
$VA\ share_{c,j,t-1}$	-1.528***	-1.611***	-1.487***	-1.523***	-1.512***	-1.498***
	(0.091)	(0.118)	(0.091)	(0.087)	(0.090)	(0.087)
Country-year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Country-industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	47,560	33,260	47,516	46,746	48,976	49,518
R-squared	0.355	0.358	0.359	0.367	0.352	0.358

Notes: Results are based on equation 3. X stands for the real GDP per capita (column 1), credit to the private sector as percent of GDP (column 2), the Chinn-Ito index on capital account openness (column 3), trade as percent of GDP (column 4), FDI (column 5), and the index on the constraints on executives (column 6). Standard errors in parentheses are clustered at the country-industry level. *** p<0.01, ** p<0.05, * p<0.1.

4.4. Other Proxies for Technological Intensity

In this section, I adopt several alternative proxies for industry technological intensity to test the robustness of the results. Table 7 shows the findings. In the first column, I use the measure of R&D intensity as percent of sales (RDI alternative I), instead of industry capital expenditures as in the baseline measure. In the second column, R&D intensity is proxied based on data from the OECD (RDI alternative II), instead of the US. Column 3 and 4 use proxies for technological intensity based on innovative output, i.e., patenting and quality certificate intensity, respectively. Column 5 adopts a classification of industries' technological intensity from the OECD (i.e., high-, medium-, and low-tech, as explained in Section 2). The results remain similar when industry technological intensity is proxied by those different measures.

It is worth noting that the magnitude of the estimated differential effect at year *t* differs across these tests, as reported in Table 7.[16] For instance, the coefficient estimate in the first column (with RDI alternative I) suggests that labor productivity growth of the industry at the 75th percentile of the measure in the second column (ISIC 29) declines about 0.7 percentage points more in the years of conflicts, compared to the industry at the 25th percentile of the same measure (ISIC 27). This proxy yields the lowest estimated effect, among all measures. The estimated differential impact in labor productivity growth (across the industries at the 25th and 75th percentiles of these measures) is largest in the third column (generating a 6.6 percentage points additional decline in industry growth), when industry technological intensity is proxied using R&D expenditure in the OECD. Finally, the coefficient estimate based on the classification using the OECD data (the last column) suggests that violent conflicts have a 3.2 percentage points larger impact on labor productivity growth in high-tech industries relative to medium-tech, or in medium-tech industries relative to low-tech. While the range of the additional decline in labor productivity (from 0.7 to 6.6 percentage points) points to some sensitivity to the specific proxy, for the context of this paper, it is important that the coefficient estimate remains statistically significant, and the magnitude of the estimated differential effect is economically sizable for all those proxies.

[16] It is misleading to simply compare the coefficient estimates as reported in Table 7, since the scales of those proxies for technological intensity are not comparable. Thus, instead of looking at the coefficient estimates, I focus on the additional decline in growth in high-tech industries relative to industries with less technological intensity based on each measure, as reported in Table 7.

Table 7: Other proxies of technological intensity

Variable	RDI alternative I	RDI alternative II	Patent intensity	QC intensity	Tech classification
$Tech\ intensity_j \times Conflict_{c,t+2}$	16.538	99.016	0.197	0.135	1.876
	(10.544)	(73.398)	(0.205)	(0.085)	(1.309)
$Tech\ intensity_j \times Conflict_{c,t+1}$	10.193	66.565	0.089	0.081	0.709
	(15.292)	(83.692)	(0.229)	(0.102)	(1.445)
$Tech\ intensity_j \times Conflict_{c,t}$	-39.786***	-276.509***	-0.587**	-0.214**	-3.175**
	(14.435)	(97.108)	(0.279)	(0.106)	(1.533)
$Tech\ intensity_j \times Conflict_{c,t-1}$	7.702	130.639	0.403	0.108	1.288
	(17.503)	(116.990)	(0.313)	(0.098)	(1.488)
$Tech\ intensity_j \times Conflict_{c,t-2}$	15.474	34.093	-0.049	-0.005	0.526
	(12.990)	(76.886)	(0.204)	(0.073)	(1.071)
$VA\ share_{c,j,t-1}$	-1.498***	-1.498***	-1.567***	-1.568***	-1.498***
	(0.087)	(0.087)	(0.103)	(0.103)	(0.087)
Estimated differential effect	*0.7*	*6.6*	*3.7*	*5.2*	*3.2*
Country-year F.E.	Yes	Yes	Yes	Yes	Yes
Country-industry F.E.	Yes	Yes	Yes	Yes	Yes
Industry-year F.E.	Yes	Yes	Yes	Yes	Yes
Observations	49,518	49,518	47,550	47,550	49,518
R-squared	0.358	0.358	0.373	0.373	0.358

Notes: Results are based on equation 1. Proxies for industry technological intensity are described in Section 2. Standard errors in parentheses are clustered at the country-industry level. *** p<0.01, ** p<0.05, * p<0.1.

4.5. Additional Tests

In this section, I start by testing the results in various relevant subsamples. Table 8 depicts the results. First, I run the test based on the data from the country-industry pairs with at least 10 years of observations to make sure that the industries with lower number of observations in the sample do not drive the results (column 1). Next, I focus on the countries for which conflicts are more relevant during the period of the analysis. For this purpose, first, column 2 excludes the advanced economies from the sample, since those events are rare in this set of countries. Then, I follow a more restrictive approach, and use data only from the countries that had at least one year of conflict during the sample period (column 3).[17] In column 4, I drop the US from the sample to address a possible concern regarding endogeneity of the measure of technological intensity, since it is calculated based on data from the US. In the next test (column 5), I exclude the country-industry pairs with relatively high and low labor productivity growth on average (based on the 5^{th} and 95^{th} percentiles of average labor productivity growth during the sample period) to make sure that some industries that typically outperform, or underperform, their peers do not drive the results. The findings remain similar.

[17] I also run a test by dropping a few countries with more than 20 years of conflict during the period of the analysis from the sample to make sure that those countries are not the ones driving the results. The results are similar.

The next test focuses on reverse causality. Although this phenomenon is not very relevant in the present analysis focusing on the effects of conflicts on industry-level growth as discussed above, I still run a test using the smaller industries in the sample to address any remaining concerns. In particular, two-digit manufacturing industries that are smaller in total manufacturing in their country are atomic for macroeconomic prospects, and therefore, their growth is even less likely to affect a country's likelihood of going into a conflict, compared to their larger peers. Column 6 runs the test by using data from the country-industry pairs which have an average value added share in total manufacturing in their country lower than 10 percent over the sample period. The impact of conflicts on labor productivity growth in high-tech industries remains pronounced, thereby further alleviating any concerns about reverse causality.

In column 7, I account for the "magnitude" of conflicts, instead of using a dummy variable. In particular, whenever there is a conflict, the corresponding variable takes 1 if the event is classified as mild (as described in Section 2), and 2 for more intense episodes. The result remains similar, and points to a larger effect in the case of more intense episodes, relative to milder events.

Finally, I aim to alleviate any concerns about a possible bias in the estimation arising from the changes in real exchange rates. In principle, the changes in domestic costs (including wages) should be offset by depreciation of the local currency, while keeping the value in the US dollars similar. However, this may not apply in some cases, e.g., during the periods of sustained movements in the real exchange rate. To address a potential bias arising from this issue, I explicitly "correct" for the changes in real exchange rates.[18] For this purpose, I deflate the growth in labor productivity with (one plus) the rate of appreciation of the real exchange rate, in line with Rodrik (2013). This reduces the growth rate in labor productivity in countries which saw a real appreciation, while increasing it in countries with a real depreciation. Column 8 shows that the result is similar.

[18] To calculate he changes in real exchange rate, I use bilateral real exchange rates (vis-a-vis USD) and producer price inflation. When the latter is not available, I adopt consumer price inflation.

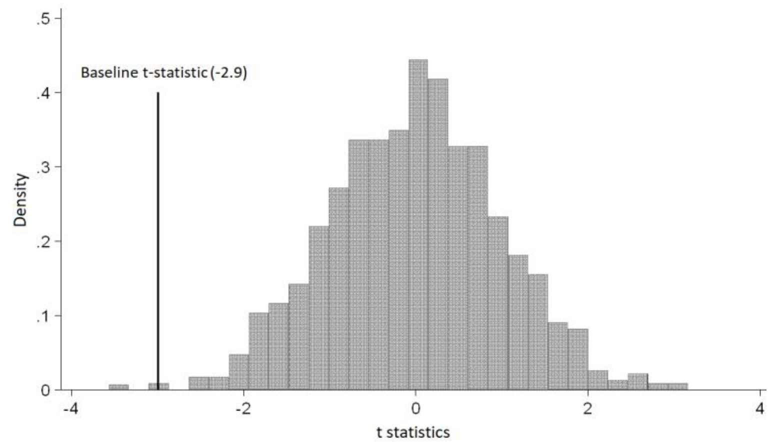
Table 8: Additional tests

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Tech\ intensity_j \times Conflict_{c,t+2}$	0.813	0.730	0.825	0.763	0.781	1.058	0.609	0.579
	(0.604)	(0.609)	(0.598)	(0.583)	(0.584)	(0.828)	(0.522)	(0.781)
$Tech\ intensity_j \times Conflict_{c,t+1}$	0.609	0.689	0.481	0.611	0.322	0.942	0.419	1.070
	(0.835)	(0.827)	(0.787)	(0.802)	(0.762)	(1.081)	(0.738)	(1.031)
$Tech\ intensity_j \times Conflict_{c,t}$	-2.498***	-2.330***	-2.054***	-2.241***	-1.828***	-2.812***	-1.949***	-2.897***
	(0.810)	(0.799)	(0.770)	(0.770)	(0.707)	(1.136)	(0.675)	(1.081)
$Tech\ intensity_j \times Conflict_{c,t-1}$	1.305	0.698	0.510	0.731	0.663	1.298	0.559	0.706
	(0.963)	(0.941)	(0.890)	(0.916)	(0.916)	(1.271)	(0.827)	(1.008)
$Tech\ intensity_j \times Conflict_{c,t-2}$	0.212	0.550	0.637	0.583	0.513	0.776	0.633	0.654
	(0.695)	(0.694)	(0.661)	(0.662)	(0.679)	(0.867)	(0.597)	(0.731)
$VA\ share_{c,j,t-1}$	-1.492***	-1.565***	-1.776***	-1.500***	-1.415***	-2.549***	-1.498***	-1.433***
	(0.087)	(0.099)	(0.153)	(0.088)	(0.087)	(0.165)	(0.087)	(0.094)
Country-year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	47,464	35,747	17,402	48,792	44,963	43,058	49,518	49,252
R-squared	0.360	0.351	0.421	0.358	0.382	0.368	0.358	0.391

Notes: Results are based on equation 1. Column 1 uses data only form country-industry pairs with at least 10 years of data. Column 2 drops the advanced economies from the sample. Column 3 employs the test using data only from the countries that had at least one episode of conflict in the sample period. Column 4 excludes the US from the sample. Column 5 drops country-industry pairs with relatively high and low labor productivity growth over the sample period (based on the 5th and 95th percentiles of the average growth in the sample). Column 6 runs the test using data from country-industry pairs with an average value added share in total manufacturing in their country smaller than 10 percent over the sample period. Column 7 accounts for the size of conflicts, instead of using a dummy variable. Column 8 deflates labor productivity growth with (one plus) the appreciation in real exchange rate. Standard errors in parentheses are clustered at the country-industry level. *** p<0.01, ** p<0.05, * p<0.1.

Another possible issue in identifying the impact of conflicts on industry growth can be that other country-level shocks that somewhat coincide with conflicts may be driving the results. I address this phenomenon empirically by examining how likely it is for random shocks to produce the main finding in this paper. For this purpose, I adopt a randomization test approach. I keep the average annual probability of conflicts same as the data for each country, while assigning a dummy variable randomly as placebo events. I follow this exercise 1000 times, and employ the full specification (1) each time with a randomly assigned placebo dummy variable. Figure 3 shows the distribution of t-statistics for the coefficient estimate at year *t* (i.e., β_0) from this exercise. It shows that only 0.4 percent of 1000 tests based on randomly assigned placebo conflicts generates a t-statistic that is smaller than the one as reported in the baseline result. Thus, unobserved country-level shocks are not likely to drive the main result in this paper, pointing to a systematic relationship between conflicts and R&D activities.

Figure 3: Randomization tests (t-statistics)



Notes: Chart documents the distribution of t-statistics of the interaction term between technological intensity and the placebo dummy (for β_0 in specification 1) for 1000 placebo tests.

5. Conclusion

Conflicts are associated with a long-lasting drag on economic output, whereas establishing causality in this relationship based on macro-data is not straightforward. This paper investigates the effect of conflicts on economic activity, and attempts to establish causality in the conflict-growth nexus by using cross-country panel data at the industry-level, and exploiting within-country variation across industries' technological intensity. It identifies a channel through which those episodes can drag economic output, i.e., by impacting innovative activities. The findings show that conflicts lead to a disproportionate decline in labor productivity growth in industries with greater technological intensity. The differential effect of conflicts on labor productivity growth in high-tech industries is estimated to be large. Moreover, the additional labor productivity loss in high-tech industries in the years of conflicts is not offset in the post-conflict period. Given the link between innovative activities and long-term economic growth, the findings provide insight into the observed patterns of durable income losses in the aftermath of conflicts.

Specific policies to prevent, or contain, violent conflicts may depend on the country-specific context, and are beyond the scope of this paper. However, the findings on the differential impact of conflicts on high-tech industries point to the need for policies supportive of innovative activities during those events. An interesting avenue for future research is to explore which specific policies help reduce economic costs of conflicts through the R&D channel in the conflict-affected states.

References

Aghion, Philippe, and Peter Howitt. “A model of growth through creative destruction.” *Econometrica*, 60(2), 323–351 (1992).

Aghion, Philippe, Peter Howitt, and Susanne Prantl. "Patent rights, product market reforms, and innovation." *Journal of Economic Growth* 20 (2015): 223-262.

Aghion, Philippe, and Xavier Jaravel. "Knowledge spillovers, innovation and growth." *The Economic Journal* 125, no. 583 (2015): 533-573.

Ahn, JaeBin, Romain A. Duval, and Can Sever. *Macroeconomic Policy, Product Market Competition, and Growth: The Intangible Investment Channel*. No. 2020/025. International Monetary Fund, 2020.

Alderman, Harold, John Hoddinott, and Bill Kinsey. "Long term consequences of early childhood malnutrition." *Oxford Economic Papers* 58, no. 3 (2006): 450-474.

Anokhin, Sergey, and William S. Schulze. "Entrepreneurship, innovation, and corruption." *Journal of Business Venturing* 24, no. 5 (2009): 465-476.

Bhattacharya, Utpal, Po-Hsuan Hsu, Xuan Tian, and Yan Xu. "What affects innovation more: policy or policy uncertainty?." *Journal of Financial and Quantitative Analysis* 52, no. 5 (2017): 1869-1901.

Bircan, Çağatay, Tilman Brück, and Marc Vothknecht. "Violent conflict and inequality." *Oxford Development Studies* 45, no. 2 (2017): 125-144.

Blattman, Christopher, and Edward Miguel. "Civil war." *Journal of Economic Literature* 48, no. 1 (2010): 3-57.

Blomberg, S. Brock, and Gregory D. Hess. "The temporal links between conflict and economic activity." *Journal of Conflict Resolution* 46, no. 1 (2002): 74-90.

Blomberg, S. Brock, Gregory D. Hess, and Siddharth Thacker. "On the conflict–poverty nexus." *Economics & Politics* 18, no. 3 (2006): 237-267.

Bloom, Nicholas. "The impact of uncertainty shocks." *Econometrica* 77, no. 3 (2009): 623-685.

Braun, Matias, and Borja Larrain. "Finance and the business cycle: international, inter-industry evidence." *The Journal of Finance* 60, no. 3 (2005): 1097-1128.

Brodeur, Abel. "The effect of terrorism on employment and consumer sentiment: Evidence from successful and failed terror attacks." *American Economic Journal: Applied Economics* 10, no. 4 (2018): 246-282.

Brown, James R., Gustav Martinsson, and Bruce C. Petersen. "What promotes R&D? Comparative evidence from around the world." *Research Policy* 46, no. 2 (2017): 447-462.

Bundervoet, Tom, Philip Verwimp, and Richard Akresh. "Health and civil war in rural Burundi." *Journal of Human Resources* 44, no. 2 (2009): 536-563.

Center for Systemic Peace. Major Episodes of Political Violence 1946-2018 Database.

Center for Systemic Peace. Polity V Database.

Cerra, Valerie, and Sweta Chaman Saxena. "Growth dynamics: the myth of economic recovery." *American Economic Review* 98, no. 1 (2008): 439-457.

Chupilkin, M and Z Kóczán (2022), “The Economic Consequences of War: Estimates Using Synthetic Controls”, EBRD Working Paper.

Chamarbagwala, Rubiana, and Hilcías E. Morán. "The human capital consequences of civil war: Evidence from Guatemala." *Journal of Development Economics* 94, no. 1 (2011): 41-61.

Chen, Min, and Yonghong Tang. "The shock of armed conflict on research and development investment: empirical evidence from cross-country data." *Technology Analysis & Strategic Management* (2023): 1-14.

Chinn, Menzie D., and Hiro Ito. "What matters for financial development? Capital controls, institutions, and interactions." *Journal of Development Economics* 81, no. 1 (2006): 163-192.

Ciccone, Antonio, and Elias Papaioannou. "Human capital, the structure of production, and growth." *The Review of Economics and Statistics* 91, no. 1 (2009): 66-82.

Collier, Paul, and Anke Hoeffler. "On economic causes of civil war." *Oxford Economic Papers* 50, no. 4 (1998): 563-573.

Collier, Paul. "On the economic consequences of civil war." *Oxford Economic Papers* 51, no. 1 (1999): 168-183.

Collier, Paul, V. L. Elliott, Håvard Hegre, Anke Hoeffler, Marta Reynal-Querol, and Nicholas Sambanis. "Breaking the Conflict Trap: Civil War and Development Policy." *World Bank Publications-Books* (2003).

Collier, Paul, and Marguerite Duponchel. "The economic legacy of civil war: firm-level evidence from Sierra Leone." *Journal of Conflict Resolution* 57, no. 1 (2013): 65-88.

Corral, Paul, Alexander Irwin, Nandini Krishnan, and Daniel Gerszon Mahler. *Fragility and conflict: On the front lines of the fight against poverty*. *World Bank Publications*, 2020.

Crost, Benjamin, Joseph Felter, and Patrick Johnston. "Aid under fire: Development projects and civil conflict." *American Economic Review* 104, no. 6 (2014): 1833-1856.

Davis, Donald R., and David E. Weinstein. "Bones, bombs, and break points: the geography of economic activity." *American Economic Review* 92, no. 5 (2002): 1269-1289.

De Groot, Olaf J., Carlos Bozzoli, Anousheh Alamir, and Tilman Brück. "The global economic burden of violent conflict." *Journal of Peace Research* 59, no. 2 (2022): 259-276.

Dixit, Avinash K., and Robert S. Pindyck. *Investment under uncertainty*. Princeton University Press, 1994.

Fang, Xiangming, Siddharth Kothari, Cameron McLoughlin, and Mustafa Yenice. "The Economic Consequences of Conflict in Sub-Saharan Africa." *IMF Working Papers* 2020, no. 221 (2020).

Fearon, James D., and David D. Laitin. "Ethnicity, insurgency, and civil war." *American Political Science review* 97, no. 1 (2003): 75-90.

Fich, Eliezer M., Tung Nguyen, and Dimitris Petmezas. "Uncertainty and corporate innovation: evidence from terrorist attacks." *Available at SSRN 3394564* (2020).

Galindo-Rueda, Fernando, and Fabien Verger. "OECD taxonomy of economic activities based on R&D intensity." OECD Working Papers (2016).

Gates, Scott, Håvard Hegre, Håvard Mokleiv Nygård, and Håvard Strand. "Development consequences of armed conflict." *World Development* 40, no. 9 (2012): 1713-1722.

Ghobarah, Hazem Adam, Paul Huth, and Bruce Russett. "Civil wars kill and maim people—long after the shooting stops." *American Political Science Review* 97, no. 2 (2003): 189-202.

Gross, Daniel P., and Bhaven N. Sampat. "America, jump-started: World War II R&D and the takeoff of the US innovation system." *American Economic Review* 113, no. 12 (2023): 3323-3356.

Grossman, Gene M., and Elhanan Helpman. *Innovation and growth in the global economy*. MIT Press, 1993.

Ha, Jongrim, M. Ayhan Kose, and Franziska Ohnsorge. "One-stop source: A global database of inflation." *Journal of International Money and Finance* (2023): 102896.

Hall, Bronwyn H., and Josh Lerner. "The financing of R&D and innovation." In *Handbook of the Economics of Innovation*, vol. 1, pp. 609-639. North-Holland, 2010.

Hardy, Bryan, and Can Sever. "Financial crises and innovation." *European Economic Review* 138 (2021): 103856.

Hoeffler, Anke, and Marta Reynal-Querol. "Measuring the costs of conflict." *Washington, DC: World Bank* (2003).

Humphreys, Macartan. "Economics and violent conflict." *Cambridge, MA* 31 (2003).

Igan, Deniz, Alexandre R. Lauwers, and Damien Puy. *Capital flows and institutions*. Bank for International Settlements, Monetary and Economic Department, 2022.

Ilyina, Anna, and Roberto Samaniego. "Technology and financial development." *Journal of Money, Credit and Banking* 43, no. 5 (2011): 899-921.

Imai, Kosuke, and Jeremy M. Weinstein. "Measuring the economic impact of civil war." *CID Working Paper Series* (2000).

Institute for Economics & Peace. Global Peace Index 2023: Measuring Peace in a Complex World, Sydney, June 2023. Available from: http://visionofhumanity.org/resources.

Iqbal, Zaryab, and Christopher Zorn. "Violent conflict and the spread of HIV/AIDS in Africa." *The Journal of Politics* 72, no. 1 (2010): 149-162.

Jordà, Òscar. "Estimation and inference of impulse responses by local projections." *American Economic Review* 95, no. 1 (2005): 161-182.

Kim, Hyunseob, and Howard Kung. "The asset redeployability channel: How uncertainty affects corporate investment." *The Review of Financial Studies* 30, no. 1 (2017): 245-280.

Knight, Malcolm, Norman Loayza, and Delano Villanueva. "The peace dividend: military spending cuts and economic growth." *IMF Staff Papers* 43, no. 1 (1996): 1-37.

Kogan, Leonid, Dimitris Papanikolaou, Amit Seru, and Noah Stoffman. "Technological innovation, resource allocation, and growth." *The Quarterly Journal of Economics* 132, no. 2 (2017): 665-712.

Lai, Brian, and Clayton Thyne. "The effect of civil war on education, 1980—97." *Journal of Peace Research* 44, no. 3 (2007): 277-292.

Levchenko, Andrei A. "Institutional quality and international trade." *The Review of Economic Studies* 74, no. 3 (2007): 791-819.

Li, Daitian, Tony W. Tong, Yangao Xiao, and Feida Zhang. "Terrorism-induced uncertainty and firm R&D investment: A real options view." *Journal of International Business Studies* (2022): 1-13.

Lindberg, Jonas, and Camilla Orjuela. "Corruption in the aftermath of war: an introduction." In *Corruption in the Aftermath of War*, pp. 1-14. Routledge, 2017.

Markus, Keith E., Sahar Milani, and Rebecca Neumann. "The impact of patent protection and financial development on industrial R&D." *Research Policy* 48, no. 1 (2019): 355-370.

Miguel, Edward, and Gerard Roland. "The long-run impact of bombing Vietnam." *Journal of Development Economics* 96, no. 1 (2011): 1-15.

Milesi-Ferretti, Gian Maria, 2022, "The External Wealth of Nations Database," The Brookings Institution.

Lane, Philip R., and Gian Maria Milesi-Ferretti. "The external wealth of nations revisited: international financial integration in the aftermath of the global financial crisis." *IMF Economic Review* 66 (2018): 189-222.

Novta, Natalija, and Evgenia Pugacheva. "The macroeconomic costs of conflict." *Journal of Macroeconomics* 68 (2021): 103286.

Nunn, Nathan. "Relationship-specificity, incomplete contracts, and the pattern of trade." *The Quarterly Journal of Economics* 122, no. 2 (2007): 569-600.

OECD. STAN Bilateral Trade Database.

Paunov, Caroline. "Corruption's asymmetric impacts on firm innovation." *Journal of Development Economics* 118 (2016): 216-231.

Plümper, Thomas, and Eric Neumayer. "The unequal burden of war: The effect of armed conflict on the gender gap in life expectancy." *International Organization* 60, no. 3 (2006): 723-754.

Raddatz, Claudio. "Liquidity needs and vulnerability to financial underdevelopment." *Journal of Financial Economics* 80, no. 3 (2006): 677-722.

Rajan, Raghuram G., and Luigi Zingales. "Financial dependence and growth." *The American Economic Review* 88, no. 3 (1998): 559.

Rodrik, Dani. "Where did all the growth go? External shocks, social conflict, and growth collapses." *Journal of Economic Growth* 4 (1999): 385-412.

Rodrik, Dani. "Unconditional convergence in manufacturing." *The Quarterly Journal of Economics* 128, no. 1 (2013): 165-204.

Romer, Paul M. "Endogenous technological change." *Journal of Political Economy* 98, no. 5, Part 2 (1990): 71-102.

Sever, Can. "The myth of economic recovery: The case of crises in neighboring countries." *Economics Letters* 164 (2018): 65-69.

Serneels, Pieter, and Marijke Verpoorten. "The impact of armed conflict on economic performance: Evidence from Rwanda." *Journal of Conflict Resolution* 59, no. 4 (2015): 555-592.

Shemyakina, Olga. "The effect of armed conflict on accumulation of schooling: Results from Tajikistan." *Journal of Development Economics* 95, no. 2 (2011): 186-200.

Teulings, Coen N., and Nikolay Zubanov. "Is economic recovery a myth? Robust estimation of impulse responses." *Journal of Applied Econometrics* 29, no. 3 (2014): 497-514.

United Nations Industrial Development Organization (UNIDO) Database. Vienna.

World Bank . World Bank Enterprise Surveys Database. Washington DC.

World Bank. World Development indicators Database. Washington DC.

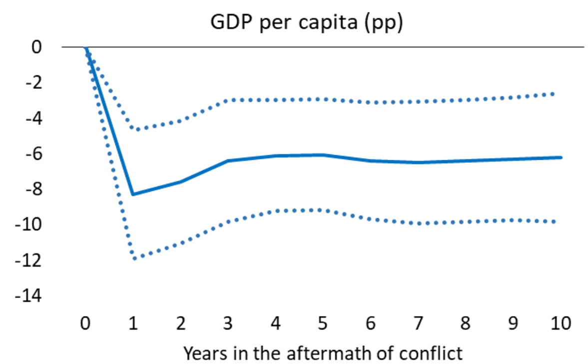
World Bank. World Development Report 2011. “Conflict, Security, and Development”. Washington DC.

Xu, Gang, and Go Yano. "How does anti-corruption affect corporate innovation? Evidence from recent anti-corruption efforts in China." *Journal of Comparative Economics* 45, no. 3 (2017): 498-519.

Appendix

Macroeconomic Relevance of Conflicts

Figure A.1: GDP per capita following conflicts



Notes: The results are based on a global sample over the period of 1980-2018. Real GDP per capita is from the World Bank's World Development Indicators database. The dummy variable indicating the years of domestic conflicts is from the Major Episodes of Political Violence (MEPV) database from the Center for Systemic Peace. It is explained in Section 2. Chart reports the coefficient estimates (reflecting the change in GDP per capita in percentage points) for 10 years with the 90 percent confidence intervals from local projections, as shown below.

The results in Figure A.1 are from local projections (Jorda 2005), as follows:

$$log(GDP\ per\ capita_{c,t+p-1}) = \beta_0^p\ Conflict_{t-1} + \sum_{r=1}^{p} \beta_r^p\ Conflict_{t+r-1} + \theta_c^p + \theta_t^p + \epsilon_{c,t}^p$$

where c and t stand for country and year, respectively. Country (θ_c^p) and year (θ_t^p) fixed effects are included. Standard errors are clustered at the country-level. I run this regression for 10 years, i.e., $p = 1, \ldots, 10$, controlling for the forward values of conflicts to eliminate a potential bias (as proposed by Teulings and Zubanov 2014). Figure A.1 reports the coefficient estimates of β_0^p for the 10-year period in the aftermath of conflicts (i.e., $p = 1, \ldots, 10$).

Summary Statistics

Table A.1: Summary statistics

Variable	Mean	Median	25th ptile	75th ptile	Std. dev.
Industry characteristics					
R&D intensity baseline	0.971	0.422	0.266	0.926	1.335
R&D intensity alternative I	0.0371	0.0122	0.0069	0.0232	0.0638
R&D intensity alternative II	0.016	0.005	0.004	0.028	0.020
Patent intensity	4.8	0.6	0.2	6.4	7.6
Quality certificate intensity	28.7	28.6	16.2	41.1	13.5
Physical capital intensity	1.204	1.117	0.911	1.466	0.520
Product complexity (inverse Herfindahl)	-0.083	-0.077	-0.106	-0.060	0.030
Dependence on external finance	-0.096	-0.262	-0.385	-0.140	1.164
Liquidity needs	0.166	0.177	0.126	0.203	0.050
Asset tangibility	0.280	0.259	0.204	0.363	0.126
Import share	0.045	0.035	0.027	0.062	0.031
Export share	0.046	0.033	0.020	0.051	0.037
Industry-level variables					
Labor productivity growth (%)	4.10	4.50	-7.09	15.79	27.72
Value added share (%)	5.48	3.43	1.47	6.63	7.10

Notes: The variables are explained in detail in Section 2.

Table A.2: Correlations between the measures of technological intensity

	RDI baseline	RDI alternative I	RDI alternative II	Patent intensity	QC intensity
RDI baseline	1				
RDI alternative I	0.98***	1			
RDI alternative II	0.75***	0.69***	1		
Patent intensity	0.65***	0.56***	0.91***	1	
QC intensity	0.45**	0.40*	0.74***	0.62***	1

Notes: The variables are explained in detail in Section 2. *** p<0.01, ** p<0.05, * p<0.1.

Countries in the Sample

The list of countries is as follows (restricted by the availability of data): Albania, Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burundi, Cameroon, Canada, Central African Republic, Chile, China, Colombia, Costa Rica, Croatia, Cuba, Cyprus, Czechia, Denmark, Ecuador, Egypt, El Salvador, Eritrea, Estonia, Eswatini, Ethiopia, Fiji, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Honduras, Hungary, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Kyrgyzstan, Lao, Latvia, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Netherlands, New Zealand, Niger, North Macedonia, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Saudi Arabia, Senegal, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Syria, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Türkiye, UK, Uruguay, USA, Venezuela, Vietnam, Yemen, Zambia.

Accounting for Industry Size

Table A.3: Accounting for industry size

Variable	(1)
$Tech\ intensity_j \times Conflict_{c,t+2}$	0.755
	(0.585)
$Tech\ intensity_j \times Conflict_{c,t+1}$	0.600
	(0.808)
$Tech\ intensity_j \times Conflict_{c,t}$	-2.238***
	(0.777)
$Tech\ intensity_j \times Conflict_{c,t-1}$	0.748
	(0.918)
$Tech\ intensity_j \times Conflict_{c,t-2}$	0.611
	(0.661)
$VA\ share_{c,j,t-1} \times Conflict_{c,t+2}$	0.001
	(0.130)
$VA\ share_{c,j,t-1} \times Conflict_{c,t+1}$	0.111
	(0.130)
$VA\ share_{c,j,t-1} \times Conflict_{c,t}$	-0.079
	(0.144)
$VA\ share_{c,j,t-1} \times Conflict_{c,t-1}$	0.056
	(0.105)
$VA\ share_{c,j,t-1} \times Conflict_{c,t-2}$	-0.162
	(0.120)
$VA\ share_{c,j,t-1}$	-1.487***
	(0.089)
Country-year F.E.	Yes
Country-industry F.E.	Yes
Industry-year F.E.	Yes
Observations	49,518
R-squared	0.358

Notes: Results are based on equation 2. Standard errors in parentheses are clustered at the country-industry level. *** p<0.01, ** p<0.05, * p<0.1.

PUBLICATIONS