Does the R&D Public Procurement Matter for High-Tech Exports? Evidence from the USA

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Abstract

Recently, demand-side innovation policies have succeeded in stimulating technology upgrading in many countries around the world. Especially, public procurement has become a major and important industrial policy for achieving technological development and competitiveness. This paper examines empirically the impact of R&D public procurement (innovative public procurement) on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The econometric analysis relies on panel fixed-effects estimations and an instrumental variable approach to investigate the causal effect of the R&D public procurement on high-tech exports. Based on a unique panel dataset of federal procurement in the USA, the empirical results show that there is a positive and statistically significant effect of R&D federal procurement on high-tech exports. The results of this paper confirm the importance and effectiveness of R&D public procurement as a policy to enhance technological competitiveness. The results are robust using various robustness checks. Moreover, this paper also shows three potential mechanisms through which R&D public procurement may affect high-tech exports.

Keywords: Government Purchases, R&D, High-tech industries, The USA
JEL: F10, F14, H57, O30, O31, O38

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1 Introduction

In developed economies, government procurement has become increasingly important. In 2015, government procurement accounted for an average of 12% of GDP in OECD countries and 30% of their government expenditure (Crespi & Guarascio, 2019; OECD, 2015). The US government, in particular, is the world's largest public purchaser, spending around half a trillion dollars on the purchases of products and services each year (Vonortas, 2015). In the United States, public procurement accounted for roughly 19 percent of the GDP in 2017 (Hafsa et al., 2021; OECD,2015). The R&D public procurement by the US is 20 times more than the EU equivalents (Hommen & Rolfstam, 2008; Lember et al., 2014). Government procurement has a long history of supporting the US technological progress by improving the growth of high-tech industries such as electronics, telecommunications, and aviation (Mowery, 2011).

The high-tech sectors are characterized by a high intensity of R&D. As a result, R&D is the most important factor of high-tech exports (Sandu & Ciocanel, 2014). Therefore, high-tech sectors benefit the most from public procurement that supports R&D. Moreover, high-tech sectors require high economies of scale, have high sunk costs, and have high levels of threats and ambiguities (Mahmood, 1992; Malerba, 2007; Porter, 1990). Therefore, innovative public procurement can play an important role in enhancing the performance of high-tech sectors in many ways. Selling high-tech products to the government can improve firms' acceptance and competitive advantage in international markets (Uyarra & Flanagan, 2010). Moreover, selling in big amounts can reduce the cost of production and achieve a high level of economies of scale (Edler & Georghiou, 2007). Moreover, guaranteeing a set level of demand can reduce the market risk and uncertainties of high-tech industries (Aschhoff & Sofka, 2009). Public procurement can enhance the performance of firms by boosting the quality standards and the domestic market competition (Caldwell et al., 2005). Thus, firms can develop their capabilities and compete efficiently in the foreign market.

Moreover, public procurement reduces market failures which occur due to the low interaction between producers and consumers. The consumers lack knowledge about the new technologies, while the producers lack knowledge of the needs of customers(market failure). The market failure is exacerbated by inadequate consumer-producer contact. Thus, public procurement has an important role in reducing this market failure by signaling the market technology needs of customers and modern technological advancements by producers (Edler & Georghiou, 2007). Far from supporting technological development in the market, government purchases can be associated with satisfying some social needs that are unprofitable for the private sector, such as environment, energy efficiency, and health care (Ghisetti, 2017; Edler & Georghiou, 2007).

The academic evidence has begun to pay attention to the function of public procurement in promoting firm performance. Slavtchev and Wiederhold (2016) contribute to the literature on the role of public purchases. They show that the technological composition of non-innovative public procurement has a positive impact on the private sector's investment in innovation in the U.S. states. The authors contribute to the theory by developing a theoretical model, built by Cozzi and Impullitti (2010), in which they take into consideration the different technological intensities across sectors. Using data on 24 OECD countries, Crespi and Guarascio (2019) find that public purchases have positive effects on the patenting activities of domestic firms. However, these positive effects on domestic innovation are offset when the market of public procurement is exposed to high competition by foreign firms. They argue that opening the public tenders to foreign firms may hinder public efforts to stimulate local innovation.

Using firm-level data on Sub-Sharan African countries, Hoekman and Sanfilippo (2018) find that selling goods and services to the government has a positive effect on total factor productivity, value-added per worker, wages, and innovation. The effect is bigger for local companies, small manufacturing businesses, and businesses in the country's capital. Using data on Korean firms, Lee (2021) finds that public procurement has a positive effect on firm growth(growth rate of employment and value added and revenues). The author also finds that small, youthful, and financially constrained businesses benefit the most. The author looks into a variety of mechanisms that explain why public procurement has a positive effect on Korean businesses. The author demonstrates that public procurement positively affects a business' reputation, intellectual capital, business investments, and access to finance.

On the other hand, Chang (2017) uses Korean SMEs in Mining and Manufacturing sectors to study the impact of government purchases on firms' productivity and survival capability. The author finds that public procurement increases the firm productivity only in the year of obtaining the contract. However, they find that public procurement increases the firm survival abilities in the short and long term.

The objective of this paper is to study the effect of R&D federal procurement on high-tech exports of 50 U.S. states and the District of Columbia. To my knowledge, no previous paper discusses the effect of R&D public procurement on high-tech exports. This is the first paper in economic research to discuss this relationship. Discussing a new channel of procurement (R&D public procurement) is an original contribution of this paper. Using Slavtchev and Wiederhold's (2016)'s unique dataset, I could disentangle the effect of R&D public procurement(innovative) away from the non-R&D public procurement(non-innovative). Previous research only focuses on the effect of total federal procurement or non-R&D federal procurement but ignores the effect of R&D public procurement. Moreover, this paper contributes to the literature on international economics by discussing a new determinant of high-tech exports (Braunerhjelm & Thulin, 2008; Sandu & Ciocanel,2014; Cao et al., 2020). Furthermore, many studies have focused on R&D

expenditure as the main input factor in innovation but ignore high-tech exports as an innovation output (Falk, 2009). Studying high-tech exports is essential to benchmark the country's innovation performance. This study is motivated by two factors. First, many developed economies have experienced the failure of supply-side innovation policies since they crowded out the private R&D instead of enhancing it (Guerzoni & Raiteri,2015). Therefore, attention by policymakers toward demand-side innovation policies has grown. Second, since the 2000s, military purposes and the US wars have led to an increase in the US federal expenditure on R&D, especially the expenditure on R&D purchases. These two reasons drive the motivation to study the effect of US R&D federal procurement.

This empirical analysis builds on a unique dataset constructed by Slavtchev and Wiederhold(2016) who disentangle between R&D and non-R&D public procurement. I use the R&D federal procurement as a main explanatory variable, while I use the non-R&D federal procurement as an additional control variable. The main dependent variable is high-tech exports of 50 U.S. states and the District of Columbia. To alleviate any omitted variable bias, I control for a wide set of state-level covariates as well as state and year fixed effects. Using panel fixed-effects estimations, I show a positive and statistically significant effect of R&D public procurement on high-tech exports. One percent increase in R&D public procurement(log) leads to an increase in high-tech exports(log) by 0.091 percent. To tackle the endogeneity issues, I estimate a Two-Stage Least Squares (2SLS) regression. I instrument the R&D federal procurement using the number of senators in the senate appropriation committee. The IV results confirm the presence of a positive and statistically significant impact of R&D federal procurement on high-tech exports. One percent increase in R&D public procurement(log) leads to an increase in high-tech exports(log) by 0.267 percent.

The results are robust to (i) using two alternative proxies of high-tech exports(the share of high-tech exports in the GDP and total exports); (ii) using an alternative proxy of R&D public procurement (the share of R&D public procurement in the GDP); (iii) using additional control variables such as population, GDP, R&D user costs, and graduates of science and engineering, total federal R&D expenditure, private R&D expenditure, and high-tech non R&D public procurement; (iv) using Prais-Winsten Estimator, and GLS random-effects model; (v) dropping top 10 high-tech states; and (vi) dropping outliers. Moreover, I show three potential mechanisms which explain the positive effect of R&D public procurement on high-tech exports. I show that the R&D public procurement has positive effects on the share of science and engineering employment in total employment, industrial output, and private R&D investments. The remainder of the paper is outlined as follows. Section 2 presents a review of the literature. Section 3 presents the Hypothesis. Section 4 presents Background Information. Section 5 presents Data. Section 6 presents Empirical Strategy. Section 7 introduces Results. Section 8 Mechanisms. Section 9 concludes.

2 Literature Review

2.1 The effect of public procurement on innovation

There is a strand of literature that discusses the effect of public procurement on innovation. Using firm-level data in USA, Draca(2013) finds a positive effect of defense procurement on innovation(patenting and R&D investment). Using the Community Innovation Survey of 10 European countries, Douglas et al. (2017) find a positive effect of government procurement on technological and non-technological innovation. The authors also reveal that the countries which are technologically laggard benefit just as much as those that are technologically better. Using data on Finnish SMEs, Saastamoinen et al. (2018) confirm that government purchases have a significant impact on the innovation revenues. Using Brazilian firm-level data, Rocha (2019) shows there is a positive impact of government procurement on innovative expenditure by firms. The author shows that the majority of firms that benefit from public procurement are small businesses and those that operate in industries with low technological intensity.

Using data on German firms, Czarnitzki et al. (2020) emphasize that government procurement has an important role in the development of incremental rather than radical innovation. Castelnuovo et al. (2021) show a positive effect of procurement by Italian Space Agency (ASI) on its suppliers'patents, especially for Firms belonging to high-tech sectors rather than those belonging to low or medium-technological sectors.

Green public procurement also received part of the attention. Using firm-level data in Germany and difference-in-differences approach, Krieger and Zipperer (2022) find a positive effect of green public procurement on green product innovation. Similar results are confirmed by Ghisetti(2017) using firm-level data in the 28 Member States of the European Union,Switzerland and the USA.

Many studies have found that public procurement is the most effective policy relative to other policies. Using data on German firms, Aschhoff and Sofka (2009) examined the impact of four different types of state interventions on innovation. The four analyzed policies are regulations, public support to educational establishments, state R&D grants, and public procurement. They find that public support for educational establishments and public procurement equally and positively affect the share of turnover with market novelties. By contrast, both R&D grants and regulation have an insignificant effect on innovation. They claim that the positive effects of public procurement are higher for small firms, especially in economically and technologically disadvantaged areas.

Using firm-level data in 27 member states of the EU, Norway, and Switzerland, Guerzoni and Raiteri (2015) find that public procurement is the best policy to stimulate the technology upgrading relative to other policies such as R&D tax cuts and R&D grants. Using firm-level data in the USA and European countries, Radicic (2019) shows that public procurement, as a demand-side innovation policy, is more effective than supply-side innovation policies in stimulating process and product innovation.

2.2 The effect of public procurement on other outcomes of firm performance

This paper is also related to a strand of literature discussing the effect of public procurement on other outcomes of firm performance. Using data on formal Brazilian firms, Ferraz et al. (2015) show the positive association between public procurement and employment growth in the short and long term. Using US firm-level data,Hebous et al. (2016) show that public procurement has positive effects on the capital investment of financially limited firms. Using firm-level data in 109 economies, Ghossein et al. (2018) find a positive effect of the public procurement system on firm performance (innovation, international certification, foreign technology adoption, and online connectivity).

Using data on small Ecuadorian firms, Fadic (2018) find a positive impact of public procurement on wages and capital investments only in the year of obtaining the contract. However, in the long term, these favorable effects disappear. Also, Bessonova (2019) find that government procurement harms efficient businesses using data on Russian firms. Public procurement supports inefficient firms, increase their chances of survival in the market, and protects them from competing with other efficient firms. Thus, the efficiency in the market deteriorates. The selection procedure may result in the exit of the most efficient enterprises from the market, leading to low efficiency and low competition in the market.

Studying the effect of public procurement on trade is scarce in the literature. Using data from European countries, Crozet and Trionfetti (2002) show that discriminatory public procurement reduces trade flows between countries using the gravity model. Similarly, Kono and Rickard (2014) find a negative effect of discriminatory public procurement on imports in democratic countries only.

3 Hypothesis

High-tech sectors are characterized by high intensity of R&D, so these sectors are the most needing to public procurement that supports R&D and innovation (Mahmood, 1992; Malerba, 2007).

The R&D public procurement can promote the performance of high-tech sectors in international markets in many ways. The government uses the R&D public procurement to reduce the technological uncertainty of firms by acting as an early user of technologies in the market, offering guidance for firms, and proposing technological solutions (Uyarra et al., 2017). The government can use the R&D public procurement to test the ground of products and provide feedback about the newly invented or improved technologies (Edler & Georghiou, 2007). Furthermore, innovative public procurement has the potential to improve market interactions and eliminate knowledge gaps between producers and consumers, as well as identifying market needs for new technologies (Edler & Georghiou, 2007).

Selling to the government, especially innovative products, enhances the reputation, recognition, and credibility of firms and increases customers' trust domestically and internationally. Moreover, R&D public procurement can improve the firm's quality of standards that enhance the firm's ability to compete in worldwide marketplaces (Edler & Georghiou, 2007). The public sector can be demanding and sophisticated and reflect the international needs in its purchases (Uyarra et al., 2017). Public procurement stimulates domestic competition, which induces firms to adopt more efficient production techniques, and adopt cost-cutting operations, facilitating entry and competitiveness into foreign markets (Edler & Georghiou, 2007). Considerable amounts of public purchases may help firms to guarantee a minimum level of market size which enable firms to grow, increase their local production, operate at lower costs, and enable firms to gain a competitive advantage in domestic and foreign markets (Geroski, 1990; Uyarra & Flanagan, 2010). Moreover, the government selects firms for procurement based on requirements and competence. Therefore, being chosen by the government might increase the financial institution's trust and support in a firm that deals with the government. As a result, businesses can overcome their financial constraints, which significantly hinder technological advancement(Dai et al., 2021). Based on these arguments, I hypothesize that public procurement of innovation positively affects high-tech exports. For the empirical investigation, I explore whether innovative federal procurement promotes states' technological exports to the world.

Hypothesis 1. *The public procurement of innovation has a positive effect on the high-tech exports*

4 Background information on the US federal procurement

Studying the United States is relevant due to many reasons. Since 1945, the US federal procurement has played an essential role in enhancing the performance of high-tech sectors such as aeroplanes and semiconductors (Lember et al., 2014; Weiss & Thurbon, 2006). Moreover, the procurement has been used by the US federal government to enhance the performance of domestic manufacturers against overseas competitors (Weiss & Thurbon, 2006). Boeing, IBM, and Lockheed are clear proof of the important role of government procurement in enhancing enterprises' technological growth, as government purchases have contributed to the acceleration of the expansion of these large firms locally and internationally (Weiss & Thurbon, 2006). Compared to the 1980s and 1990s, government procurement in the United States grew by more than 100%, from $250 billion to $530 billion in 2009, and $700 billion in 2011 (OECD, 2015).

According to The Federal Acquisition Regulation ("FAR"), federal R&D procurement is defined as the federal purchases of (newly created or improved existing) of final products or service, including R&D. According to the main data source of procurement (FPDS), most of the federal R&D procurement is oriented to high-tech sectors. To explain the process of public procurement, First of all, firms use SAM.gov to find R&D contracts. Then, contracting officers award firms for doing procurement based on some criteria. After awarding the contract, the contracting officers write a work statement specifying what they want in detail. The work statement should be flexible to give businesses greater room for creativity. Regarding the evaluation, firms should send scientific and technical reports to the contracting officers. Reports show the work completed in accordance with the agreement and show to what extent goals are achieved. Reports are essential for monitoring technical compliance, providing feedback, and approving contract adjustments like extending performance periods (Acquisition.GOV, n.d.).

5 Data

5.1 Dataset and measurement of variables

5.1.1 The dependent variable: High tech exports

The main dependent variable is high-tech exports of 50 U.S. states and the District of Colombia. I obtain data from the Foreign Trade Division, U.S. Census Bureau, which is the official source of reporting the U.S. export and import statistics. The value of exports is expressed in current U.S. dollars. I convert the amount of exports to constant USD using an aggregate GDP deflator(the base year 2000) since no available information on the state-specific GDP deflator (Slavtchev & Wiederhold, 2016). I assign exports to high-tech industries, using the NAICS classification 4-digits on the high-tech industry from the Bureau of Labor Statistics (BLS) (Hecker, 2005). Then, I aggregate the high-tech exports of seven products, not service industries since there is no available data for the service sector. The high-tech industries included are Pharmaceutical, Computer equipment, Communications, Semiconductor, Navigational, Aerospace, and Software publishers. These industries are classified as high-tech, depending on the share of science &

engineering employment relative to all employment(Hecker, 2005). Table 24 shows the NAIC classification used in the analysis.

5.1.2 The independent variable: R&D public procurement

One of the main originalities of this paper is the use of a unique dataset of federal procurement made by the US federal government. The dataset is constructed by (Slavtchev & Wiederhold, 2016). They collect data on US public procurement from the Federal Procurement Data System—Next Generation (FPDS-NG), provided by the General Services Administration (GSA). Slavtchev and Wiederhold (2016) use data on more than 20 million procurement reported to the FPDS-NG. The data of the FPDS-NG also include the amount, location, start and end date of procurement, and the type of procurement in terms of being oriented to innovation or not. Slavtchev and Wiederhold (2016) match the procurement value to the state and year, and then they aggregate the value of procurement across industries, states, and years. They disentangle two types of public procurement which are R&D public procurement and non R&D public procurement.

5.1.3 Control Variables

I use a set of control variables which include FDI, university R&D expenditure, non-R&D public procurement, R&D user costs, graduates in science & engineering, federal aid to state, private R&D expenditure, federal R&D expenditure, state GDP, and population. I obtain data on FDI from the U.S. Bureau of Economic Analysis (BEA). Following Mullen and Williams (2005), Wang et al. (2019), and McMillan (2009), I proxy FDI value by using data on the gross book value of foreign affiliates' property, plant, and equipment at the state level. I deflate FDI using the aggregate GDP deflator due to the unavailability of a state-specific GDP deflator (Slavtchev & Wiederhold, 2016). I obtain data on population from the U.S. Census Bureau, and I use data on state GDP from the U.S. Bureau of Economic Analysis (BEA).

I obtain data on university R&D expenditure at the state level from the Higher Education R&D Survey(HERD) constructed by the National Science Foundation (NSF). The Higher Education R&D Survey(HERD) is the main source of data on R&D spending by all American higher education establishments. NSF is a separate federal institution that monitors technological development in the United States through collecting data and conducting analysis based on statistics and surveys. All expenditures data are converted into constant USD using an aggregate GDP deflator (the base year 2000). I use the survey of graduate students in science and engineering that provides data on S&E graduates in all academic establishments in the USA. The data is obtained from the national science foundation (NSF). I control for Federal aid to the state using data from Slavtchev and Wiederhold's dataset. Federal aid to the state includes all types of federal assistance to state governments.

I obtain data on R&D user costs from Slavtchev & Wiederhold's dataset. They rely on Moretti and Wilson (2014) to collect the data. I use data on the number of senators in the senate appropriation committee (instrumental variable) from the U.S. Senate website. I obtain data on non-R&D federal procurement from Slavtchev and Wiederhold's dataset. As a further control variable, I obtain data for the high-tech non R&D procurement from Slavtchev and Wiederhold's (2016) dataset. I obtain data on the total federal R&D expenditure from Slavtchev and Wiederhold(2016) 's dataset. The total federal R&D expenditure is the expenditure performed by federal entities conducting R&D investment. To test the mechanism, I use data on the industrial output, defined as the share of GDP produced by the private sector. Data for private-industry output is from the Bureau of Economic Analysis. I also test the mechanism using the share of employees of science, engineering, and technology in the total employment per state. The data on this variable is obtained from the National Science Foundation (NSF). I use data on R&D spending of private firms at the state level from the US Survey of Industrial R&D (SIRD), constructed by the National Science Foundation (NSF). The US Survey of Industrial R&D (SIRD) covers all firms that spend on R&D and either belong to the manufacturing or non-manufacturing sectors.

5.2 Descriptive analysis on the estimation sample

Table 1 shows summary statistics of the data. I report the minimum, maximum values, mean, standard deviation, and number of observations. The main outcome variable is high-tech exports reported in billion dollars. The mean of high-tech exports is 4.95. The standard deviation is 9.37. The minimum value is 0.008 billion dollars, while the maximum value is 66.93 billion dollars. Regarding the main explanatory variable(R&D public procurement), The mean is 0.606. The standard deviation is 1.182. The minimum value is 0.000104 billion dollars, while the maximum value is 8.6253 billion dollars. I report the same summary statistics for other control variables and the instrumental variable. I support the empirical analysis with a visual show of the pattern between the R&D public procurement and high-tech exports. Figure 1 shows a positive pattern between the R&D public procurement and the high-tech exports in 50 U.S. states and the district of Columbia. This fact is also confirmed by the Figure 2 shows the positive relationship between the logged values of the R&D public procurement and the high-tech exports, using a scatter plot.

6 Empirical Methodology

6.1 An OLS approach

Using data on the federal procurement from a unique panel dataset constructed by Slavtchev and Wiederhold(2016), I investigate the effect of the R&D public procurement on high-tech exports in 50 U.S. states and the District of Colombia during the period 2000-2008. Equation (1) illustrates the econometric specification of the impact of the R&D public procurement on high-tech exports. All variables are used in natural log transformation. I use OLS to estimate equation(1), which is known as panel fixed-effects (FE) estimation.

$$Ln(high-tech\ exports)_{it} = \alpha + \beta_1 Ln(\ R\&D\ public\ procurement)_{it-1} +$$

$$\beta_2 Ln(X)_{it-1} + \omega_i + \nu_t + u_{it}$$

(1)

In equation(1), $high-tech\ exports_{it}$ denotes the amount of high - tech exports in state i and year t. $R\&D\ public\ procurement_{it-1}$ denotes the total amount of R&D public procurement in state i and year t-1 . To alleviate any confounding factors which may drive the results, I control for X_{it-1} that denotes a set of state-level covariates which include FDI, University R&D Expenditure, Non-R&D Public Procurement, R&D user costs, Graduates in Science & engineering, Federal Aid to State,private R&D expenditure, federal R&D expenditure, State GDP, and Population. All explanatory variables are lagged by one year to mitigate the reverse causality bias. Equation (1) contains a state fixed effects, ω_i, which controls for unobserved state characteristics that are time constant. I use year fixed effect to ensure that the relationship between high-tech exports and R&D public procurement is not driven by unobservable and time-varying factors such as special policies, global shocks, or technological revolution. The error term is denoted by u_{it}. I cluster standard errors by state and year to account for the correlations in the error structure across states and years.

6.2 An Instrumental Variable approach

Using OLS can be biased. There might be an endogeneity problem due to two reasons. First, there might be unobserved factors that are correlated with both the R&D public procurement and the high-tech exports. There might be unobserved state-specific characteristics that vary over time and cannot be controlled by state or year-fixed effect or control variables. Second, the reverse causality issue may lead to biased results. The better technological performance of some states may attract the government to conduct federal procurement. However, using the lagged values of R&D federal procurement reduces the reverse causality bias. To mitigate the endogeneity issue, I apply an instrumental-variable (2sls) approach to examine the causal effect of R&D public procurement on high-tech exports. I use the number of senators in the senate appropriation committee to identify the exogenous variation in public procurement and support the causal effect of R&D public procurement on high-tech exports. Besides using the IV approach, I use a set of control variables and state and year-fixed effects to mitigate omitted variable bias.

6.2.1 The correlation between R&D public procurement and the number of senators in senate appropriation committee

In line with Aghion et al. (2009), and Slavtchev and Wiederhold (2016), I instrument the public procurement using the number of state senators on the Senate Appropriations Committee. This Committee is responsible for the expenditure of any money from the Treasury. The senators control all types of money, including the money spent on procurement. The senators seek to use this public money and direct it to their states so that voters get satisfied and re-elect senators again (Levitt & Snyder, 1997). States with representatives in the senate appropriation committee are expected to have more federal procurement and appropriations compared to states with no representative senators in the Committee (Slavtchev & Wiederhold, 2016).

Politicians cannot provide a direct cash return to their states, but they can direct specific contracts to their states (Aghion et al., 2009). Decisions to allocate federal procurement to the states receive special attention from the media because of their importance in supporting the states (Wheeler, 2004). The media interest in federal procurement, in particular, encourages politicians to direct government procurement to their states to obtain greater electoral support. Many reasons explain why senators prefer this type of R&D procurement rather than other types of procurement. The senators choose to conduct R&D public procurement to stimulate the technological capabilities of the states directly. Stimulating the technological progress of the state is essential to enhance the state's economic growth and technological competitiveness. Also, the R&D federal procurement is a promising policy to create jobs and improve the economic performance of state businesses. Moreover, the military wars that the USA started in the 2000s have led to an increase in the interest in the innovative public procurement side by side with defense-oriented procurement.

6.2.2 The instrument's orthogonality to omitted variables

To argue that the instrument is exogenous, it is necessary to know how senators are chosen inside the appropriation committee and the criteria of appointment inside the committee. Each party determines a list of members as potential members of the committee. Then, the senate's full body chooses the members of each committee according to the Senate's rules. The appointment and retirement process or any change in the senators does not rely on the state characteristics but relies on the senator's personal characteristics(Aghion et al. 2009; Slavtchev & Wiederhold, 2016). Moreover, the age and years of experience of the senator in the public service determine his eligibility to be on the senate appropriation committee. The longer years of experience of the senators make them eligible to be on the committee regardless of the economic performance or population size of their states (Slavtchev & Wiederhold, 2016). Moreover, there is no direct effect of the number of senators in the committee on the high-tech exports of the states. However, I use a set of control variables that include other types of R&D public expenditures to ensure that the impact of the number of senators in the senate appropriation committee on high-tech exports is only through R&D public procurement. In the next sections, tables show that IV estimates are robust to include such control variables.

7 Empirical Findings

7.1 Benchmark Results: Estimating the effect of R&D public procurement on high-tech exports

Table 2 presents the baseline results, using the OLS approach. In column 1, I show the effect of R&D public procurement on high-tech exports using only the year and state fixed effect without adding any control variables. The coefficients estimates show a positive and statistically significant impact of R&D federal procurement on high-tech exports. The estimated coefficients of the key variable of interest have a statistical significance at 1%. These results are consistent with many previous studies confirming the positive effects of public procurement on innovation measured by patenting or R&D private expenditure (Crespi & Guarascio, 2019; Slavtchev & Wiederhold,2016; Aschhoff & Sofka ,2009). Because both the dependent and the main independent variables are in logarithmic form, Beta (B) indicates the elasticity of high-tech exports to public procurement. One percent increase in R&D public procurement(log) leads to an increase in high-tech exports(log) by 0.091 percent. This estimated coefficient of R&D public procurement is close to those found by (Slavtchev & Wiederhold, 2016).

In column 2, I control for foreign direct investment (FDI) and use state and year fixed effects. FDI is an important determinant of high-tech exports. Not controlling for FDI may lead to omitted variable bias. FDI provides domestic businesses with technical expertise and increases their production (Moran et al., 2016). FDI supports domestic firms through upgrading technology and managerial practices (Moran et al., 2016; Lovely & Huang, 2018). Estimates in column (2) show that the estimated coefficient of R&D federal procurement is still positive and statistically different from zero(significant at 1%). The coefficient estimate is very close in terms of magnitude to those of Column (1). One percent increase in R&D public procurement(log) leads to an increase in high-tech exports(log) by 0.093 percent. However, the estimated coefficient of FDI is statistically insignificant. In column 3 of Table 2, I use three additional control variables. I control for university R&D expenditure, federal aid to the state, and non R&D public procurement to alleviate any concerns about confounding factors driving results. First, controlling for university R&D expenditure is important since the university R&D expenditure may play an important role in enhancing the technological competitiveness of the state through improving the human capital accumulation and upgrading the skilled labour. Furthermore, the academic innovation stimulated by university R&D expenditure can also improve the technological development of the state (Zhou & Luo, 2018). Second, I control for federal aid to the state which refers to the federal financial support to the state governments. According to Slavtchev and Wiederhold(2016), federal aid to the state may have an important role in enhancing and supporting the technological development of the states. Third, I control for non-R&D federal procurement. Slavtchev and Wiederhold (2016) argue that the non-R&D federal procurement is essential to support the innovation and the technological progress at the state level by increasing the market demand and production. After using these controls variables, the estimated coefficients of R&D public procurement in column (3) become little lower than those in columns (1) & (2), providing reassurance that it is important to consider confounders jointly. Moreover, the estimated coefficients of R&D federal procurement in column (3) are positive and statistically significant at 5%. Concerning the control variables, the estimated coefficients of non-R&D federal procurement and university R&D expenditure are the only significant controls at 10 and 5%, respectively. To address the endogeneity issue, I use the instrumental variable approach. I use as an instrument the number of senators in the senate appropriations committee. The second-stage results in Table 3 show that the estimated coefficients of R&D federal procurement are positive and statistically significant at 5%. One percent increase in R&D public procurement(log) leads to an increase in high-tech exports(log) by 0.267 percent(Column 1) and 0.287 percent(Column 2), respectively. The estimated coefficients of R&D public procurement are higher than those of OLS, showing better results than those in Table 2. For all first-stage results, the estimated coefficients of the first-stage are positive and statistically significant at 1%, suggesting a strong relationship between the number of senators in the senate appropriations committee and the R&D federal procurement. The Kleibergen-Paap F statistics is above 10 which rules out the idea of weak instruments. For all second stage tables, Durbin-Wu-Hausman tests show that the FE and IV estimators are not different.

7.2 Robustness checks

In Table 4, I check the robustness using the share of high-tech exports in the GDP(logarithm form). It is a measure of the importance of technology sectors global demand in the national economy (Seyoum et al., 2014; Xing & Pradhananga, 2013). In Table 4, I consider a similar specification to the baseline estimation of Table 2 using the OLS approach. The estimated coefficients of R&D public procurement in Table 4 are positive and statistically significant at 1-5%, and are close to those of Table 2 (Baseline Results), confirming the stability and robustness of the results. Moreover, I check the robustness In Table 5 using the instrumental variable approach and the same previous alternative measure of the dependent variable (the share of high-tech exports in the GDP). The second stage results show that the estimated coefficients of R&D federal procurement are still positive and statistically different from zero. The estimated coefficients of R&D federal procurement in the second stage results are close to those in Table 2. The first-stage results confirm the satisfaction of the relevance condition(significant at 1%).

As an additional robustness check in Table 6, I use the share of high tech export in total exports as an alternative measure of the dependent variable. This measure captures the technological intensity of exports. The results show a positive and statistically significant relationship between R&D public procurement and high-tech exports share, confirming the robustness of the findings. Similarly in Table 7, I use the same previous alternative measure of the dependent variable and apply an instrumental variable approach. The second stage results show that the estimated coefficients of R&D federal procurement remain positive and statistically significant at 1%. In Table 8, I use the share of R&D public procurement in the GDP(logarithm form) as an alternative proxy for R&D public procurement. The findings confirm the positive effects of federal procurement on high-tech exports. The results confirm the economic and statistical significance in all columns. The estimated coefficients of R&D federal procurement remain stable and close to those in Table 2. In Table 9, I use the same previous alternative proxy of R&D federal procurement and the instrumental variable approach. The second-stage results remain robust and stable.

In Table 10, I conduct a further robustness check using an additional control variable called the R&D user costs. The rationale for this check is to rule out any possibility of omitted variable bias. R&D user costs refer to the cost of RD after tax credits in the state (Moretti & Wilson 2014). In Table 10(Columns 1 & 2), the estimated coefficient of R&D federal procurement is positive ad statistically different from zero, using the OLS approach. The findings are stable in terms of magnitude and statistical significance. However, the estimated coefficients of R&D user costs are statistically insignificant. In Table 10(Column 4), I employ the instrumental variable approach and control for the R&D user costs. The findings confirm the stability and robustness.

In Table 11, I control for the number of graduates in science and engineering(in logarithm form). S&E graduates have advanced skills and talents that have positive effects on the technological progress, competitiveness, and economic growth of U.S. states (Winters, 2014; Atkinson & Mayo, 2010). Rodríguez-Pose and Lee (2020) find that scientists and engineers are an important element of the technological development of U.S. cities. Winters (2014) find that the graduate students of science and engineering have a positive influence on innovation activities in comparison to other graduates. Thus, I additionally do a robustness check by controlling for the graduates in science and engineering. Results reported in Table 11 (Columns 1 & 2) using the OLS approach show that the estimated coefficients of R&D federal procurement remain robust and statistically significant at 1 and 5%. However, the estimated coefficient of S&E graduate students tends to be statistically insignificant. In Table 11(Column 4), I employ the instrumental variable approach and control for the S&E graduate students. The second stage findings remain robust. The key variable of interest (R&D federal procurement) is positive and statistically significant at 1%.

The size of the home market is considered an important determinant of high-tech exports. According to Weder (2003), larger home market sizes provide enterprises with more profits and boost firms' economies of scale and output, which in turn improves export performance, particularly in high-tech industries with high fixed costs (Weder, 2003; Helpman & Krugman, 1985; Corsetti et al.,2007). In Table 12, I check the robustness by controlling for State population as a proxy of the home market size. Not controlling for it might lead to falsely attributing its effects to R&D public procurement and bias the results. Results in Table 12 show that the estimated coefficients of R&D public procurement remain stable and unchanged in terms of magnitude and economic significance. Using the OLS approach, the estimated coefficient of the population is highly significant in Column (1) but it loses its statistical significance in Column(2). In Table 12(column 4), I control for state population with the usage of the instrumental variable approach. Results remain the same as the benchmark results (Table 3). In Table 13, I use another proxy of the home market size effect using the GDP of the state, following Slavtchev and Wiederhold (2016). The estimated coefficients of R&D public procurement, using the OLS approach remain stable and are the same as those in Table 2. Similarly, in Table 13(column4), the second stage results remain unchanged when I control for state GDP and also use the instrumental variable approach. In Table 14, I check the robustness by controlling for R&D federal expenditure. Federal R&D expenditure includes all other types of R&D federal spending. Using similar specifications to the benchmark results in Table 2, Results in Table 14 confirm the positive and statistically significant impact of R&D federal procurement on high-tech exports. One percent increase in R&D public procurement(log) leads to an increase in high-tech exports(log) by 0.089 percent(column 1) and 0.076(column 2). The estimated coefficients of R&D federal procurement are significant at 1-5%. The estimated coefficients of federal R&D expenditure is statistically significant at 5%(in Column 1 & 2). Similarly, the second-stage findings in Table 14(column 4) confirm the positive and statistically significant effect of R&D federal procurement using the instrumental variable approach and controlling for the federal R&D expenditure. The second stage results show that a one percent increase in R&D public procurement(log) leads to an increase in high-tech exports(log) by 0.320 percent(column 4).

Innovation and R&D are key elements of high-tech exports, according to many previous studies (Sandu & Ciocanel, 2014; Braunerhjelm & Thulin,2008). Therefore, I control for innovation using the amount of private R&D expenditure(in logarithm form). Using the OLS ad IV approach, the results in Table 15 confirm that the estimated coefficients of R&D federal procurement are still positive and statistically different from zero. Results in Table 15 confirm the robustness and stability. However, the estimated coefficient of R&D private expenditure tends to be statistically insignificant. Additionally, Table 16 controls for the non-R&D public procurement in high-tech sectors instead of controlling for the total non-R&D procurement. The OLS and IV results in Table 16 confirm the positive and statistically significant effect of R&D federal procurement on high-tech exports. The estimated coefficients of R&D federal procurement remains stable and close to those in the baseline results in Table 2. However, the estimated coefficients of the non-R&D procurement in high-tech sectors are statistically insignificant. In Table 17, I apply the OLS and IV approach using all the control variables in the analysis jointly to ensure that results are not driven by any confounding factors that may bias results. Results confirm the stability and robustness in terms of economic and statistical significance.

Instead of clustering the standard errors, I use another alternative way to correct for autocorrelation and heteroskedasticity in the data. I use a time-series cross-sectional Prais–Winsten (PW) regression model with panel-corrected standard errors (PCSE). This method provides disturbances which are robust to heteroskedasticity and autocorrelation. I use the "xtpcse" Stata command to implement it where I determine AR1 autocorrelation. Using Prais–Winsten (PW) regression, the estimated coefficients of federal procurement in Table 18 are still positive and statistically significant. Similarly, I use the GLS estimates panel data models as a correction for heteroskedasticity and autocorrelation. It is implemented using XTGLS STATA command (Mittal & Nault, 2009). The results reported in Table 19 show the positive and statistically significant effect of federal procurement on high-tech exports. The results are robust at 1%.

In Table 20 and Table 21, Using the OLS and IV approach, I check the robustness by dropping the top 10 high-tech states. I obtain the state ranking from The state The technology and Science Index (STSI) that evaluates the 50 U.S. states in terms of scientific research and technological advancement. The index is published by Milken Institute. I drop Massachusetts, Colorado, California, Maryland, Washington, Utah, New Hampshire, Virginia, Delaware, and Oregon. The rationale for this check is to ensure that the top 10 high-tech states do not drive results. Using the OLS and IV approach, results are still positive and statistically significant, in Table 20 and Table 21.

As a further robustness check, I detect outliers by plotting the leverage and residuals. This check is important since it rules out the possibility that the results are driven by specific states. The high leverage is the extreme points above the horizontal line, while the high residuals are the extreme points on the right of the vertical line. The high leverage is the point that has a high effect on the estimation line. Figure 3 shows that the states of New Hampshire, Kansas, Georgia, and Rhode Island have high leverage while the states of Arkansas, Hawaii, Wyoming, Mississippi, and West Virginia have high residuals. In Table 22, I check the robustness of the results by running the same benchmark specification with the exclusion of these states(outliers). The estimated coefficients of R&D federal procurement are still positive and statistically significant at 1-5%, respectively.

8 Mechanisms

In this section, I explore three possible mechanisms which explain the positive effects of R&D federal procurement on high-tech exports.

8.1 S&E employment

The first channel is related to S&E employment. The federal R&D procurement can enhance high-tech exports through increasing S&E employment. This will be explained in two steps. The first step is related to how the federal R&D procurement increases the S&E employment. The second step is related to how the increase in the S&E employment, resulting from federal R&D procurement, helps firms to export high-tech products. First, federal R&D procurement motivates high-tech firms to employ scientists and engineers to achieve technological goals specified in government procurement. In other words, federal R&D procurement provides new marketplaces and huge job opportunities, particularly for highly skilled workers like scientists and engineers (Wolff & Reinthaler, 2008). Doing R&D and introducing new products needs highly sophisticated and solid knowledge, and innovative solutions that can only be offered by scientists and engineers. Employing scientists and engineers is paramount since they are the most qualified and capable of completing this sort of complex operations needed for federal R&D procurement (Shapiro et al., 2015). Overall, an increase in the demand for R&D and new technologies leads to an increase in the demand for employing qualified personnel such as scientists and engineers.

Second, the increase in S&E employment is essential for enhancing high-tech exports. Employing scientists and engineers can improve firms' technological capabilities and intellectual assets, accelerate firms' innovative ideas, and upgrade the quality level and sophistication of high-tech products(Shapiro et al., 2015). Scientists and engineers can provide firms with a bigger pool of new discoveries and patenting activity which enhances the firms' technological competitiveness in local and international markets. High-tech exports have high intensity of R&D, which needs S&E employees who are highly skilled (Leiponen, 2005). High-tech exports need S&E employees to deal effectively with technical complexities and introduce new and effective technical solutions related to high-tech products (Mosbah et al., 2018; Shapiro et al., 2015). All of these positive effects resulting from employing scientists and engineers contribute to enhancing high-tech exports and technological competitiveness in international markets. Previous research confirms the positive impact of learning-by-hiring on businesses' technological capabilities. These studies support the idea that scientists and engineers are valuable sources of knowledge for improving a firm's international competitiveness (Almeida & Kogut, 1999; Kaiser et al., 2015; Tzabbar ,2009; Kaiser et al., 2018). Based on these two arguments, I can conclude that federal R&D procurement can enhance high-tech exports by increasing the employment of scientists and engineers. Results In Table 23(column 1) confirm a positive and statistically significant effect of R&D public procurement on the share of science and engineering employment in total employment.

8.2 Industrial output

The second channel is related to industrial output. The federal R&D procurement can enhance high-tech exports by increasing the industrial output. This will be explained in two steps. The first step is related to how the federal R&D procurement increases the industrial output. The second step is related to how the increase in the industrial output, resulting from federal R&D procurement, helps firms to export high-tech products.

First, federal R&D procurement can increase the industrial output of high-tech products in many ways. Guaranteeing a certain level of public demand enhances the firms' economies of scale and production levels. The large-scale or bundling of public purchases reduces market risks and ambiguities and allows businesses to expand their production capacity and industrial output(Geroski, 1990; Uyarra & Flanagan, 2010). Federal R&D procurement improves the firms' market trustworthiness and credibility, widening the firm's local and international production base. Federal R&D procurement can enhance industrial output by enhancing radical technological breakthroughs and launching a customer base for innovative products. The increase in predicted revenues and market prospects due to public procurement encourages firms to increase their industrial output (Crespi & Guarascio, 2019).

Second, the increase in the industrial output resulting from procurement enhances high-tech exports in many ways. Having a wide local base of industrial production guarantees extra output for exports and achieves larger profits which enable firms to cover trade expenses(Saeed & Ullah, 2021). The large industrial output helps firms to easily afford sunk startup expenses in foreign markets(Kiendrebeogo, 2014). The large local industrial output signals a good reputation which enhances and expands the foreign consumer base. There are several previous studies that confirm the causal effect of output growth on export growth (Sharma et al., 1991; Yousefvand et al., 2017; Yeaple, 2009). Based on these two arguments, I can conclude that federal R&D procurement can enhance high-tech exports by increasing industrial output. In Table 23(column 2), results show the positive and statistically significant effect of R&D public procurement on industrial output.

8.3 Private R&D

The third channel is related to private R&D. The federal R&D procurement can enhance high-tech exports by increasing private R&D. This will be explained in two steps. The first step is related to how the federal R&D procurement increases the private R&D. The second step is related to how the increase in the private R&D, resulting from federal R&D procurement, helps firms to export high-tech products.

Firms that have federal R&D procurement with the government tend to increase their private R&D expenditure in order to keep pace with government demand, achieve technological purposes required in federal procurement, and improve the knowledge that is necessary to succeed in meeting government demand (Ekananda & Parlinggoman, 2017). Moreover, firms increase their private expenditure on R&D to attract more federal procurement and expand their market size(Guerzoni & Raiteri, 2015). Federal R&D procurement stimulates the market's demand for innovative technologies and raises expectations for the market's expansion. This, in turn, encourages many firms to increase their expenditure on private R&D (Geroski, 1990). There is a legal responsibility that necessitates firms to succeed in the innovation process and R&D (Ekananda & Parlinggoman, 2017). As a result, the firm increases its expenditure on private R&D to avoid failure. Moreover, federal R&D procurement leads to the creation of new ideas and projects, which increase the firms' expenditure on R&D (Ali-Yrkkö, 2004). In some fields, without public procurement, no private R&D would be allocated to new technologies or fields. As a result of public procurement, firms adjust and launch a new portfolio of private R&D (Wallsten, 2000).

In this paper, the role of private R&D is complementary, not crowding out. Both private R&D and federal R&D procurement complement each other to enhance high-tech exports. In other words, federal R&D procurement leads to an increase in private R&D, which is essential for the improvement of high-tech exports. The high-tech sectors are characterized by a high intensity of R&D. Therefore, private R&D expenditure can play an important role in enhancing the high-tech exports of these sectors. In other words, these sectors are the most needing for R&D and innovation (Mahmood, 1992; Malerba, 2007; Porter, 1990).

The role of private R&D is complementary and important to the role of federal R&D procurement. Private R&D expenditure boosts the businesses' capacity to create new technologies to be exported abroad. It promotes the development of intellectual capital and broadens the scientific scope of the firm(Coad & Rao, 2010). In other words, private R&D is important to accelerate the acquisition of important tacit knowledge, raising the probability of key discoveries' emergence and new high-tech fields' emergence, which has a positive impact on the development of high-tech exports. Private R&D can create successful local technologies that have a better likelihood of being adopted internationally (Uyarra & Flanagan, 2010). Private R&D expenditure enhances the technological diversity and complexity of high-tech products and technological know-how, leading to enhancing diffusion and commercialization of high-tech products(Lome et al., 2016). It increases the company's worth and makes the product more competitive and of high quality(Kim et al., 2018). It increases businesses' economic worth and expedites their integration into global value networks (Tung & Binh, 2022; Shen et al., 2017; Shin et al., 2009). Additionally, it speeds up the expansion of high-tech startups(Stam & Wennberg, 2009). Based on these ideas, I argue that the R&D public procurement is expected to have a positive effect on Private R&D. In Table 23(column 3), results show the positive and statistically significant effect of R&D public procurement on private R&D investments.

9 Conclusion

At the beginning of the 2000s, many developed countries started to adopt demand-side innovation policies instead of supply-side innovation policies. Public procurement, as a demand-side policy, has proven to be a central and key tool in creating job opportunities, and enhancing economic growth and competitiveness (Aigheyisi & Edore, 2015). This paper aims to discuss the effect of R&D public procurement on high-tech exports using data on 50 U.S. states and the District of Colombia during the period 2000-2008. Based on a unique panel dataset constructed by Slavtchev and Wiederhold(2016), this paper contributes to the literature by exploring an original research question that has not been considered before in the literature. Studying the U.S. context is relevant since the U.S. federal government is the world's largest purchaser in the world.

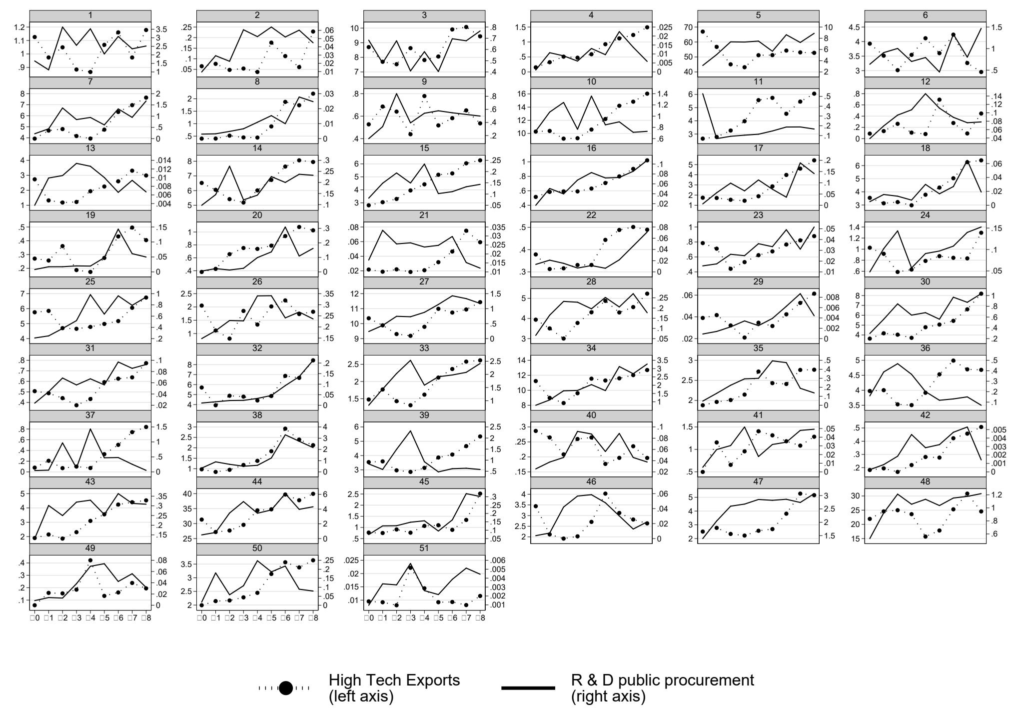
Using panel fixed effect estimations and an instrumental variable approach, this paper shows the causal and positive effect of R&D public procurement on high-tech exports. One percent increase in R&D public procurement(log) leads to an increase in high-tech exports(log) by 0.091 percent. The IV results confirm a positive and statistically significant impact of R&D federal procurement on high-tech exports. According to the IV findings, a one percent increase in R&D public procurement(log) leads to an increase in high-tech exports(log) by 0.267 percent.

These findings are robust to using alternative proxies of the dependent and main explanatory variables, using a wide range of control variables, and detecting outliers. Furthermore, I investigate three possible channels that can explain the positive impact of R&D public procurement on high-tech exports. I show that R&D federal procurement can play a pivotal role in supporting industrial production, the R&D investments, and increasing the employment of S&E workers. Through these channels, I argue that R&D federal procurement can improve the performance of high-tech sectors and enhance their competitiveness in global markets.

Based on these results, this paper provides some policy implications by confirming the importance of R&D federal procurement in supporting the technological intensity of exports and fostering technological competitiveness in foreign markets. The government should support innovation-oriented public procurement relative to the other type. This study confirms that the R&D public procurement can be used as an effective tool to reduce market failure and effectively signal the technological products. Furthermore, further efforts should be considered to increase the effectiveness of public procurement schemes, such as adopting an evaluation scheme that selects the best firm with high technological competitiveness. The government should ensure the effectiveness of auctions and overcome obstacles such as complicated and time-consuming procedures. Moreover, the government should upgrade the quality of institutions organizing the process of government procurement and reduce bureaucracy and related corruption. Moreover, future studies can ask the same research question using a different regional framework, such as European countries or developing countries.

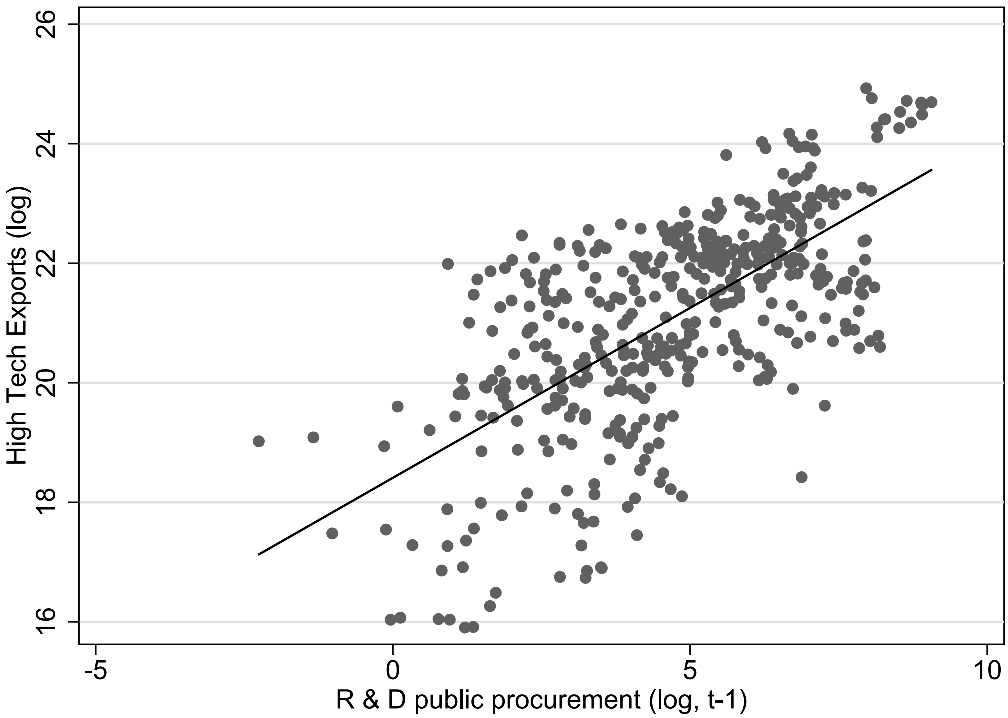
10 Figures and Tables

Figure 1: High-tech exports and R&D public procurement of 50 U.S. states and DC



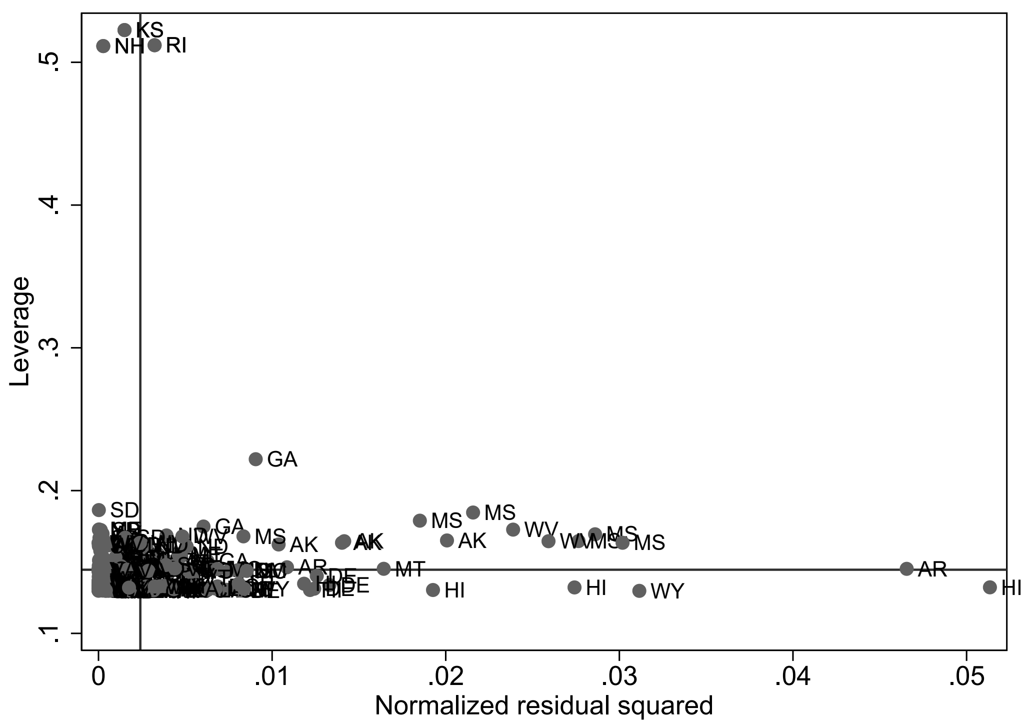
Notes: The figure represents high-tech exports and R&D public procurement across the 50 U.S. states and DC over the period 2000–2008. High-tech exports are state amount in (billions of constant USD, the base year 2000). R&D public procurement is state amount in (billions of constant USD, the base year 2000).
Source: Author's Contribution based on data from Slavtchev and Wiederhold(2016), U.S. Census Bureau

Figure 2: Scatter plot of high-tech exports and R&D public procurement



Notes: The fitted line shows a log-linear relationship between the lagged R&D public procurement and High-tech exports in 50 US states and DC in the period 2000–2008. High-tech exports are state amount in (billions of constant USD, the base year 2000). R&D public procurement is state amount in (billions of constant USD, the base year 2000).
Source: Author's Contribution based on data from Slavtchev and Wiederhold(2016), U.S. Census Bureau

Figure 3: Outlier Detection



Notes: The lines on the figure show the average values of leverage and the (normalized) residuals squared. The high leverage are the extreme points above the horizontal line while the high residuals are the extreme points on the right of the vertical line.

Table 1: Descriptive statistics on outcome variables, key variable of interest, and other controls

	(1)				
	mean	sd	min	max	count
High-tech exports(billion)	4.956148	9.375334	0.0080793	66.93824	415
R&D public procurement(billion)	0.6069608	1.182019	0.0001047	8.625367	415
FDI(billion)	20.63328	21.86762	0.685	128.424	415
University R&D expenditure(billion)	0.5096363	0.6120506	0.018026	3.761313	415
Graduates in Science & Engineering(thousand)	9.545	11.394	0.572	68.039	415
Federal Aid to State(billion)	6.952595	7.826173	0.7780952	43.52548	415
GDP of state (Billion)	220.1327	256.6319	16.714	1593.577	415
Population(million)	6.057442	6.532685	0.49178	36.22612	415
Non R&D Public Procurement(billion)	4.063035	5.231285	0.0455557	30.69369	415
R&D user costs	1.164018	0.0379802	1.023474	1.225699	415
Industrial Output (Billion)	209.7683	258.6249	13.116	1713.469	415
Number of Senators	0.5493976	0.5077595	0	2	415
S&E Employment(Share)	10.76277	2.641165	5.422702	17.51013	273
Private R&D Expenditure(Billion)	3.721777	6.635035	0.0192215	49.61558	415
Federal R&D Expenditure (billion)	2.330847	29.42324	0.0008897	519.9681	415

Notes: the table shows descriptive statistics that are calculated using the sample data.

Table 2: Baseline Results: OLS Approach

Dependent Variable: High-Tech Exports			
	(1)	(2)	(3)
R&D Public Procurement	0.0912***	0.0935***	0.0782**
	(0.0327)	*(0.0331)*	*(0.0327)*
FDI		0.0871	0.0905
		(0.0757)	*(0.0713)*
University R&D Expenditure			0.4203**
			(0.2069)
Federal Aid to State			0.3178
			(0.2887)
Non-R&D Public Procurement			0.1191*
			(0.0644)
State Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	415	415	415

Notes: This table reports the baseline estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using panel fixed-effects estimates. The dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Baseline Results: Two-stage least squares estimation

Dependent Variable:				
	(1st Stage) (R&D PP)	(2nd Stage) (high-tech exports)	(1st Stage) (R&D PP)	(2nd Stage) (high-tech exports)
Seats in Appropriations Committee(IV)	0.4457***		0.4448***	
	(0.1356)		*(0.1360)*	
R&D Public Procurement		0.2678**		0.2871**
		(0.1232)		*(0.1318)*
FDI	-0.0603	0.1157*	-0.0599	0.1145*
	(0.1278)	*(0.0690)*	*(0.1289)*	*(0.0680)*
University R&D Expenditure	1.1010***	0.2288	1.1027***	0.1895
	(0.3450)	*(0.2595)*	*(0.3565)*	*(0.2727)*
Federal Aid to State			-0.0397	0.3352
			(0.2217)	*(0.2772)*
Non-R&D Procurement			-0.0121	0.1229*
			(0.1367)	*(0.0643)*
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value		0.1951		0.1913
Kleibergen-Paap rk Wald F statistic	10.803		10.692	
Observations	415	415	415	415

Notes: This table reports the baseline estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using a Two-stage least squares estimation. The dependent variable in the first stage is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). The dependent variable in the second stage is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Robustness Check: Using Alternative proxy of the Dependent Variable(high-tech exports/GDP), OLS Approach

Dependent Variable: High-Tech Export As a Share of GDP			
	(1)	(2)	(3)
R&D Public Procurement	0.0950***	0.0978***	0.0826**
	(0.0337)	*(0.0344)*	*(0.0338)*
FDI		0.1087	0.1133*
		(0.0723)	*(0.0685)*
University R&D Expenditure			0.4129*
			(0.2251)
Federal Aid to State			0.2534
			(0.3148)
Non-R&D Public Procurement			0.1228*
			(0.0644)
State Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using panel fixed-effects estimates. This table checks the robustness using the share of high-tech exports in the GDP in a state (in logs) as a dependent variable. High-tech exports are defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Robustness Check: Using Alternative proxy of the Dependent Variable(high-tech exports/GDP), Two-stage least squares estimation

Dependent Variable:				
	(1st Stage) (R&D PP)	(2nd Stage) (high-tech exports/GDP)	(1st Stage) (R&D PP)	(2nd Stage) (high-tech exports/GDP)
Seats in Appropriations Committee(IV)	0.4457***		0.4448***	
	(0.1356)		*(0.1360)*	
R&D Public Procurement		0.2942**		0.3110**
		(0.1201)		*(0.1264)*
FDI	-0.0603	0.1397**	-0.0599	0.1396**
	(0.1278)	*(0.0642)*	*(0.1289)*	*(0.0632)*
University R&D Expenditure	1.1010***	0.1984	1.1027***	0.1606
	(0.3450)	*(0.2661)*	*(0.3565)*	*(0.2782)*
Federal Aid to State			-0.0397	0.2724
			(0.2217)	*(0.2976)*
Non-R&D Public Procurement			-0.0121	0.1270**
			(0.1367)	*(0.0641)*
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value		0.1658		0.1647
Kleibergen-Paap rk Wald F statistic	10.803		10.692	
Observations	415	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using a Two-stage least squares estimation. This table checks the robustness using the share of high-tech exports in the GDP in a state (in logs) as a dependent variable in the second stage. High-tech exports are defined as the aggregated value of exports in high-tech industries at the state level. The dependent variable in the first stage is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 6: Robustness Check: Using a different proxy of the Dependent Variable(high-tech exports/total exports), OLS Approach

Dependent Variable: High Tech Exports As a Share of Total Exports			
	(1)	(2)	(3)
R&D Public Procurement	0.0172**	0.0170**	0.0148**
	(0.0079)	*(0.0076)*	*(0.0075)*
FDI		-0.0085	-0.0071
		(0.0154)	*(0.0157)*
University R&D Expenditure			0.0548**
			(0.0268)
Federal Aid to State			-0.0031
			(0.0513)
Non-R&D Public Procurement			0.0178
			(0.0133)
State Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using panel fixed-effects estimates. This table checks the robustness using the share of high-tech exports in total exports in a state as a dependent variable. High-tech exports are defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Robustness Check: Using a different proxy of the Dependent Variable(high-tech exports/total exports), Two-stage least squares estimation

Dependent Variable:				
	(1st Stage) (R&D PP)	(2nd Stage) (high-tech exports/total exports)	(1st Stage) (R&D PP)	(2nd Stage) (high-tech exports/total exports)
Seats in Appropriations Committee(IV)	0.4457***		0.4448***	
	(0.1356)		*(0.1360)*	
R&D Public Procurement		0.0658***		0.0667***
		(0.0249)		*(0.0234)*
FDI	-0.0603	-0.0017	-0.0599	-0.0012
	(0.1278)	*(0.0129)*	*(0.1289)*	*(0.0136)*
University R&D Expenditure	1.1010***	0.0017	1.1027***	-0.0025
	(0.3450)	*(0.0367)*	*(0.3565)*	*(0.0372)*
Federal Aid to State			-0.0397	0.0012
			(0.2217)	*(0.0515)*
Non-R&D Public Procurement			-0.0121	0.0188
			(0.1367)	*(0.0143)*
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value		0.1856		0.1769
Kleibergen-Paap rk Wald F statistic	10.803		10.692	
Observations	415	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using a Two-stage least squares estimation. This table checks the robustness using the share of high-tech exports in total exports in a state (in logs) as a dependent variable in the second stage. High-tech exports are defined as the aggregated value of exports in high-tech industries at the state level. The dependent variable in the first stage is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 8: Robustness Check: Using a different proxy of the key variable of interest(R&D public procurement/ GDP), OLS Approach

Dependent Variable: High-Tech Exports	(1)	(2)	(3)
The Share of R&D Public Procurement In GDP	0.0916***	0.0935***	0.0786**
	(0.0321)	*(0.0326)*	*(0.0322)*
FDI		0.0852	0.0888
		(0.0763)	*(0.0718)*
University R&D Expenditure			0.4195**
			(0.2053)
Federal Aid to State			0.3212
			(0.2877)
Non-R&D Public Procurement			0.1184*
			(0.0645)
State Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using panel fixed-effects estimates. This table checks the robustness using the share of R&D public procurement in the GDP(in logs and lagged by one year) as an alternative proxy for the key variable of interest. R&D public procurement is defined as the innovative purchases by the federal US government at the state level. The dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 9: Robustness Check: Using a different proxy of the key variable of interest(R&D public procurement/ GDP), Two-stage least squares estimation

Dependent Variable:	(1st Stage) (R&D PP/GDP)	(2nd Stage) (high-tech exports)	(1st Stage) (R&D PP/GDP)	(2nd Stage) (high-tech exports)
Seats in Appropriations Committee(IV)	0.4616***		0.4600***	
	(0.1403)		*(0.1409)*	
The Share of R&D Public Procurement In GDP		0.2587**		0.2775**
		(0.1228)		*(0.1319)*
FDI	-0.0382	0.1094	-0.0369	0.1075
	(0.1272)	*(0.0691)*	*(0.1287)*	*(0.0678)*
University R&D Expenditure	1.1083***	0.2370	1.1081***	0.1985
	(0.3608)	*(0.2566)*	*(0.3728)*	*(0.2694)*
Federal Aid to State			-0.0811	0.3463
			(0.2467)	*(0.2743)*
Non-R&D Public Procurement			-0.0027	0.1202*
			(0.1384)	*(0.0640)*
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value		0.1989		0.1941
Kleibergen-Paap rk Wald F statistic	10.828		10.657	
Observations	415	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using a Two-stage least squares estimation. This table checks the robustness using the share of R&D public procurement in the GDP (in logs and lagged by one year) as a dependent variable in the first stage. R&D public procurement is defined as the innovative purchases by the federal US government at the state level. The dependent variable in the second stage is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 10: Robustness Check: Controlling For R&D user costs

Dependent Variable:	(OLS Approach) (high-tech exports)	(OLS Approach) (high-tech exports)	(IV Approach: 1st Stage) (R&D PP)	(IV Approach: 2nd Stage) (high-tech exports)
Seats in Appropriations Committee(IV)			0.4288***	
			(0.1377)	
R&D Public Procurement	0.0905***	0.0780**		0.2963**
	(0.0326)	*(0.0327)*		*(0.1381)*
R&D user costs	-0.3145	-0.1213	-1.4538	0.3727
	(0.8737)	*(0.8701)*	*(2.1854)*	*(1.2755)*
FDI		0.0907	-0.0586	0.1147*
		(0.0712)	*(0.1292)*	*(0.0686)*
University R&D Expenditure		0.4192**	1.0863***	0.1836
		(0.2056)	*(0.3804)*	*(0.2777)*
Federal Aid to State		0.3189	-0.0284	0.3327
		(0.2876)	*(0.2192)*	*(0.2770)*
Non-R&D Public Procurement		0.1184*	-0.0209	0.1253**
		(0.0625)	*(0.1364)*	*(0.0606)*
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value				0.1833
Kleibergen-Paap rk Wald F statistic			9.702	
Observations	415	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. This Table checks the robustness by controlling for R&D user costs. The coefficients are estimated using panel fixed-effects estimates in Columns (1) and (2) while The coefficients are estimated using Two-stage least squares estimation in Columns (3) and (4). In Columns (1) and (2), the dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). In Columns (3), the dependent variable in the first stage is R&D public procurement. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). In Columns (4), the dependent variable in the second stage is high-tech exports in a state. The key variable of interest is the fitted values of R&D public procurement from the first stage. Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 11: Robustness Check: Controlling For Graduates in Science and Engineering

Dependent Variable:	(OLS Approach) (high-tech exports)	(OLS Approach) (high-tech exports)	(IV Approach: 1st Stage) (R&D PP)	(IV Approach: 2nd Stage) (high-tech exports)
R&D Public Procurement	0.0968***	0.0847**		0.3093***
	(0.0342)	*(0.0353)*		*(0.1143)*
Seats in Appropriations Committee(IV)			0.4234***	
			(0.1277)	
Graduates in S&E	0.3484*	0.3364	-1.4849**	0.6861***
	(0.1988)	*(0.2084)*	*(0.6128)*	*(0.2477)*
FDI		0.0922	-0.0671	0.1191*
		(0.0731)	*(0.1187)*	*(0.0704)*
University R&D Expenditure		0.3933*	1.1904***	0.1245
		(0.2239)	*(0.3205)*	*(0.2901)*
Federal Aid to State		0.3413	-0.1429	0.3838
		(0.2983)	*(0.1912)*	*(0.2873)*
Non-R&D Public Procurement		0.1214*	-0.0219	0.1277*
		(0.0658)	*(0.1340)*	*(0.0668)*
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value				0.1639
Kleibergen-Paap rk Wald F statistic			10.992	
Observations	415	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. This Table checks the robustness by controlling for graduates in science and engineering at the state level(in logs and lagged by one year). The coefficients are estimated using panel fixed-effects estimates in Columns (1) and (2) while The coefficients are estimated using Two-stage least squares estimation in Columns (3) and (4). In Columns (1) and (2), the dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). In Columns (3), the dependent variable in the first stage is R&D public procurement. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). In Columns (4), the dependent variable in the second stage is high-tech exports in a state. The key variable of interest is the fitted values of R&D public procurement from the first stage. Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 12: Robustness Check: Controlling For state population

Dependent Variable:	(OLS Approach) (high-tech exports)	(OLS Approach) (high-tech exports)	(IV Approach: 1st Stage) (R&D PP)	(IV Approach: 2nd Stage) (high-tech exports)
R&D Public Procurement	0.0912***	0.0782**		0.2871**
	(0.0327)	*(0.0327)*		*(0.1318)*
State Population	6.0272***	0.5463	10.7966***	-1.7611
	(0.7998)	*(1.5347)*	*(2.4926)*	*(2.0056)*
FDI		0.0905	-0.0599	0.1145*
		(0.0713)	*(0.1289)*	*(0.0680)*
University R&D Expenditure		0.4203**	1.1027***	0.1895
		(0.2069)	*(0.3565)*	*(0.2727)*
Federal Aid to State		0.3178	-0.0397	0.3352
		(0.2887)	*(0.2217)*	*(0.2772)*
Non-R&D Public Procurement		0.1191*	-0.0121	0.1229*
		(0.0644)	*(0.1367)*	*(0.0643)*
Seats in Appropriations Committee(IV)			0.4448***	
			(0.1360)	
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value				0.1913
Kleibergen-Paap rk Wald F statistic			10.692	
Observations	415	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. This Table checks the robustness by controlling for population size at the state level(in logs and lagged by one year). The coefficients are estimated using panel fixed-effects estimates in Columns (1) and (2) while The coefficients are estimated using Two-stage least squares estimation in Columns (3) and (4). In Columns (1) and (2), the dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). In Columns (3), the dependent variable in the first stage is R&D public procurement. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). In Columns (4), the dependent variable in the second stage is high-tech exports in a state. The key variable of interest is the fitted values of R&D public procurement from the first stage. Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 13: Robustness Check: Controlling For state GDP

Dependent Variable:	(OLS Approach) (high-tech exports)	(OLS Approach) (high-tech exports)	(IV Approach: 1st Stage) (R&D PP)	(IV Approach: 2nd Stage) (high-tech exports)
R&D Public Procurement	0.0912***	0.0782**		0.2871**
	(0.0327)	*(0.0327)*		*(0.1318)*
State GDP	2.3329***	0.2115	4.1790***	-0.6817
	(0.3096)	*(0.5940)*	*(0.9648)*	*(0.7763)*
FDI		0.0905	-0.0599	0.1145*
		(0.0713)	*(0.1289)*	*(0.0680)*
University R&D Expenditure		0.4203**	1.1027***	0.1895
		(0.2069)	*(0.3565)*	*(0.2727)*
Federal Aid to State		0.3178	-0.0397	0.3352
		(0.2887)	*(0.2217)*	*(0.2772)*
Non-R&D Public Procurement		0.1191*	-0.0121	0.1229*
		(0.0644)	*(0.1367)*	*(0.0643)*
Seats in Appropriations Committee(IV)			0.4448***	
			(0.1360)	
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value				0.1913
Kleibergen-Paap rk Wald F statistic			10.692	
Observations	415	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. This Table checks the robustness by controlling for GDP at the state level(in logs and lagged by one year). The coefficients are estimated using panel fixed-effects estimates in Columns (1) and (2) while The coefficients are estimated using Two-stage least squares estimation in Columns (3) and (4). In Columns (1) and (2), the dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). In Columns (3), the dependent variable in the first stage is R&D public procurement. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). In Columns (4), the dependent variable in the second stage is high-tech exports in a state. The key variable of interest is the fitted values of R&D public procurement from the first stage. Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 14: Robustness Check: Controlling For Federal R&D Expenditure

Dependent Variable:	(OLS Approach) (high-tech exports)	(OLS Approach) (high-tech exports)	(IV Approach: 1st Stage) (R&D PP)	(IV Approach: 2nd Stage) (high-tech exports)
R&D Public Procurement	0.0890***	0.0766**		0.3203***
	(0.0336)	*(0.0341)*		*(0.1169)*
Federal R&D Expenditure	0.0542**	0.0511**	0.0224	0.0478**
	(0.0215)	*(0.0228)*	*(0.0430)*	*(0.0186)*
FDI		0.0990	-0.0552	0.1265**
		(0.0676)	*(0.1266)*	*(0.0633)*
University R&D Expenditure		0.4192**	1.1015***	0.1501
		(0.2097)	*(0.3569)*	*(0.2588)*
Federal Aid to State		0.3374	-0.0303	0.3564
		(0.2918)	*(0.2163)*	*(0.2812)*
Non-R&D Public Procurement		0.0767	-0.0306	0.0839
		(0.0679)	*(0.1374)*	*(0.0671)*
Seats in Appropriations Committee(IV)			0.4517***	
			(0.1337)	
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value				0.1207
Kleibergen-Paap rk Wald F statistic			11.409	
Observations	415	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. This Table checks the robustness by controlling for federal R&D Expenditure at the state level(in logs and lagged by one year). Federal R&D Expenditure refers to the expenditure performed by federal entities that conduct R&D investment. The coefficients are estimated using panel fixed-effects estimates in Columns (1) and (2) while The coefficients are estimated using Two-stage least squares estimation in Columns (3) and (4). In Columns (1) and (2), the dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). In Columns (3), the dependent variable in the first stage is R&D public procurement. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). In Columns (4), the dependent variable in the second stage is high-tech exports in a state. The key variable of interest is the fitted values of R&D public procurement from the first stage. Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 15: Robustness Check: Controlling For Private R&D Expenditure

Dependent Variable:	(OLS Approach) (high-tech exports)	(OLS Approach) (high-tech exports)	(IV Approach: 1st Stage) (R&D PP)	(IV Approach: 2nd Stage) (high-tech exports)
R&D Public Procurement	0.0850***	0.0740**		0.2811**
	(0.0326)	*(0.0332)*		*(0.1268)*
Private R&D Expenditure	-0.1279*	-0.0869	-0.1899	-0.0347
	(0.0749)	*(0.0747)*	*(0.1338)*	*(0.0566)*
FDI		0.0962	-0.0624	0.1203*
		(0.0668)	*(0.1239)*	*(0.0637)*
University R&D Expenditure		0.4031*	1.0663***	0.1841
		(0.2094)	*(0.3521)*	*(0.2648)*
Federal Aid to State		0.2939	-0.0797	0.3210
		(0.2819)	*(0.2304)*	*(0.2688)*
Non-R&D Public Procurement		0.1240**	-0.0119	0.1284**
		(0.0600)	*(0.1403)*	*(0.0617)*
Seats in Appropriations Committee(IV)			0.4222***	
			(0.1400)	
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value				0.1718
Kleibergen-Paap rk Wald F statistic			9.088	
Observations	415	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. This Table checks the robustness by controlling for private R&D Expenditure at the state level(in logs and lagged by one year). Private R&D Expenditure refers to the amount of firm-funded R&D. The coefficients are estimated using panel fixed-effects estimates in Columns (1) and (2) while The coefficients are estimated using Two-stage least squares estimation in Columns (3) and (4). In Columns (1) and (2), the dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). In Columns (3), the dependent variable in the first stage is R&D public procurement. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). In Columns (4), the dependent variable in the second stage is high-tech exports in a state. The key variable of interest is the fitted values of R&D public procurement from the first stage. Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 16: Robustness Check: Controlling For Non-R&D public procurement in high-tech industries

Dependent Variable:	(OLS Approach) (high-tech exports)	(OLS Approach) (high-tech exports)	(IV Approach: 1st Stage) (R&D PP)	(IV Approach: 2nd Stage) (high-tech exports)
R&D Public Procurement	0.0922***	0.0784**		0.3067**
	(0.0329)	*(0.0328)*		*(0.1288)*
Technological Intensity of Non-R&D Public Procurement	0.0485	0.0426	0.0009	0.0488
	(0.0362)	*(0.0355)*	*(0.1025)*	*(0.0456)*
FDI		0.0843	-0.0596	0.1100*
		(0.0682)	*(0.1275)*	*(0.0643)*
University R&D Expenditure		0.4438**	1.1007***	0.1927
		(0.1988)	*(0.3435)*	*(0.2572)*
Federal Aid to State		0.3213	-0.0418	0.3388
		(0.2932)	*(0.2199)*	*(0.2779)*
Seats in Appropriations Committee(IV)			0.4452***	
			(0.1350)	
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value				0.1772
Kleibergen-Paap rk Wald F statistic			10.871	
Observations	415	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. This Table checks the robustness by controlling for the amount of non-R&D public procurement in high-tech industries at the state level(in logs and lagged by one year). federal non-R&D procurement refers to the purchases of already existent products or services in high-tech industries. The coefficients are estimated using panel fixed-effects estimates in Columns (1) and (2) while The coefficients are estimated using Two-stage least squares estimation in Columns (3) and (4). In Columns (1) and (2), the dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). In Columns (3), the dependent variable in the first stage is R&D public procurement. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). In Columns (4), the dependent variable in the second stage is high-tech exports in a state. The key variable of interest is the fitted values of R&D public procurement from the first stage. Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 17: Using all Controls

Dependent Variable:	(OLS Approach) (high-tech exports)	(IV Approach: 1st Stage) (R&D PP)	(IV Approach: 2nd Stage) (high-tech exports)
R&D Public Procurement	0.0752**		0.3601***
	(0.0380)		*(0.0880)*
R&D user costs	-0.2258	-1.3263	0.3753
	(0.7612)	*(1.8776)*	*(1.2911)*
Graduates in S&E	0.3215	-1.4290**	0.7296***
	(0.2030)	*(0.6385)*	*(0.2269)*
State Population	2.1164	16.7695***	-2.9644
	(1.9631)	*(3.6445)*	*(2.3624)*
GDP of State	-0.4852	-0.6086	-0.2495
	(0.5931)	*(1.4620)*	*(0.5858)*
Federal R&D Expenditure	0.0737***	0.0458	0.0636**
	(0.0277)	*(0.0619)*	*(0.0270)*
Private R&D Expenditure	-0.0730	-0.1200	-0.0239
	(0.0725)	*(0.1279)*	*(0.0646)*
FDI	0.0888	-0.0718	0.1241**
	(0.0602)	*(0.0989)*	*(0.0617)*
University R&D Expenditure	0.4100*	1.1481***	0.0894
	(0.2170)	*(0.3229)*	*(0.2624)*
Federal Aid to State	0.3801	-0.1104	0.4197
	(0.3055)	*(0.2119)*	*(0.2924)*
Technological Intensity of Non-R&D Public Procurement	0.0129	-0.0306	0.0286
	(0.0434)	*(0.1135)*	*(0.0454)*
Seats in Appropriations Committee(IV)		0.3942***	
		(0.1212)	
State Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value			0.0734
Kleibergen-Paap rk Wald F statistic		10.571	
Observations	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. This Table checks the robustness by using a wide set of controls including R&D user costs, Graduates in S&E, State Population, GDP of State, Federal R&D Expenditure, Private R&D Expenditure, FDI, University R&D Expenditure, Federal Aid to State, and Technological Intensity of Non-R&D Public Procurement (in logs and lagged by one year). The coefficients are estimated using panel fixed-effects estimates in Columns (1) while The coefficients are estimated using Two-stage least squares estimation in Columns (2) and (3). In Columns (1), the dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). In Columns (2) the dependent variable in the first stage is R&D public procurement. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). In Columns (3), the dependent variable in the second stage is high-tech exports in a state. The key variable of interest is the fitted values of R&D public procurement from the first stage. The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 18: Robustness Check: Using Prais–Winsten estimator

Dependent Variable: High-Tech Exports			
	(1)	(2)	(3)
R&D Public Procurement	0.3837***	0.3225***	0.0794*
	(0.0365)	*(0.0411)*	*(0.0421)*
FDI		0.4562***	0.0048
		(0.0786)	*(0.1009)*
University R&D Expenditure			0.7081***
			(0.1559)
Federal Aid to State			0.2999
			(0.1956)
Non-R&D Public Procurement			0.1811**
			(0.0807)
Year Dummies	Yes	Yes	Yes
Observations	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using Prais–Winsten (PW) regression as a further robustness check. "xtpcse" Stata command is used to run the estimation. The dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). All regressions control for year dummies. *** p<0.01, ** p<0.05, * p<0.1

Table 19: Robustness check: GLS estimates panel data models

Dependent Variable: High-Tech Exports			
	(1)	(2)	(3)
R&D Public Procurement	0.5938***	0.3911***	0.0772***
	(0.0153)	*(0.0204)*	*(0.0252)*
FDI		0.5271***	-0.0320
		(0.0359)	*(0.0504)*
University R&D Expenditure			0.7063***
			(0.0624)
Federal Aid to State			0.3750***
			(0.0713)
Non-R&D Public Procurement			0.1497***
			(0.0413)
Year Dummies	Yes	Yes	Yes
Observations	415	415	415

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using GLS estimates panel data models as a further robustness check. "xtgls" Stata command is used to run the estimation. The dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). All regressions control for year dummies. *** p<0.01, ** p<0.05, * p<0.1

Table 20: Robustness Check:Dropping Top High-Tech States, OLS Approach

Dependent Variable: High-Tech Exports			
	(1)	(2)	(3)
R&D Public Procurement	0.0732**	0.0752**	0.0610*
	(0.0308)	*(0.0322)*	*(0.0324)*
FDI		0.1612***	0.1678***
		(0.0555)	*(0.0509)*
University R&D Expenditure			0.3920*
			(0.2078)
Federal Aid to State			0.2544
			(0.2977)
Non-R&D Public Procurement			0.1203
			(0.0735)
State Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	334	334	334

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports over the period 2000–2008. This Table checks the robustness by dropping the top 10 high-tech states: Massachusetts, Colorado, California, Maryland, Washington, Utah, New Hampshire, Virginia, Delaware, and Oregon. The coefficients are estimated using panel fixed-effects estimates. The dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 21: Robustness Check:Dropping Top High-Tech States, Two-stage least squares estimation

Dependent Variable:	(1st Stage) (R&D PP)	(2nd Stage) (high-tech exports)	(1st Stage) (R&D PP)	(2nd Stage) (high-tech exports)
Seats in Appropriations Committee(IV)	0.5140***		0.5155***	
	(0.1584)		*(0.1607)*	
R&D Public Procurement		0.2296**		0.2533**
		(0.1014)		*(0.1111)*
FDI	0.0350	0.1774***	0.0358	0.1758***
	(0.1072)	*(0.0554)*	*(0.1092)*	*(0.0504)*
University R&D Expenditure	1.1060***	0.2132	1.1044***	0.1824
	(0.4059)	*(0.2560)*	*(0.4139)*	*(0.2706)*
Federal Aid to State			0.0047	0.2636
			(0.2276)	*(0.2830)*
Non-R&D Public Procurement			0.0253	0.1196*
			(0.1546)	*(0.0714)*
State Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman test p-value		0.1630		0.1580
Kleibergen-Paap rk Wald F statistic	10.529		10.287	
Observations	334	334	334	334

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports over the period 2000–2008. This Table checks the robustness by dropping the top 10 high-tech states: Massachusetts, Colorado, California, Maryland, Washington, Utah, New Hampshire, Virginia, Delaware, and Oregon. The coefficients are estimated using a Two-stage least squares estimation. The dependent variable in the first stage is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). The dependent variable in the second stage is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The instrumental variable is the Seat appropriations committee, defined as the number of senators a state has on the US Senate Appropriations Committee(lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). The Kleibergen-Paap F statistics is a test of the relevance of instruments. Durbin-Wu-Hausman is a test of whether the FE and IV estimators are different or not. All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 22: Robustness Check: Dropping Outliers

Dependent Variable: High-Tech Exports			
	(1)	(2)	(3)
R&D Public Procurement	0.0808***	0.0855***	0.0717**
	(0.0300)	*(0.0301)*	*(0.0287)*
FDI		0.0935	0.0938
		(0.0902)	*(0.0864)*
University R&D Expenditure			0.3387*
			(0.1907)
Federal Aid to State			0.1358
			(0.1057)
Non-R&D Public Procurement			0.0040
			(0.0450)
State Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	361	361	361

Notes: This table reports the estimates for the impact of R&D public procurement on high-tech exports over the period 2000–2008. This Table checks the robustness by dropping the outliers(New Hampshire, Kansas, Georgia, Rhode Island, Arkansas, Hawaii, Wyoming, Mississippi, and West Virginia). The coefficients are estimated using panel fixed-effects estimates. The dependent variable is high-tech exports in a state (in logs), defined as the aggregated value of exports in high-tech industries at the state level. The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). Further controls include FDI, University R&D Expenditure, Federal Aid to State, and Non-R&D Procurement (in logs and lagged by one year). All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

Table 23: Mechanisms

Dependent Variable:	(1) (Employees in S&E)	(2) (Industrial Output)	(3) (Private R&D Spending)
R&D Public Procurement	0.1543*	0.0134**	0.0250*
	(0.0880)	*(0.0064)*	*(0.0135)*
R&D Private Expenditure	-0.1609		
	(0.1440)		
University R&D Expenditure		-0.0396	
		(0.0645)	
FDI		-0.0179	
		(0.0134)	
State Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	268	415	415

Notes: This table reports the mechanisms through which R&D public procurement may affect high-tech exports of 50 U.S. states and the District of Columbia over the period 2000–2008. The coefficients are estimated using panel fixed-effects estimates. The dependent variable in column (1) is the share of employees of science, engineering, and technology in the total employment in a state. The dependent variable in column (2) is the industrial output of the private sector in a state (in logs). The dependent variable in column (3) is private R&D spending in a state (in logs). The key variable of interest is R&D public procurement, defined as the innovative purchases by the federal US government at the state level(in logs and lagged by one year). All regressions control for state and year fixed effects. Robust Standard errors (reported in parentheses) are clustered at the state and year levels. *** p<0.01, ** p<0.05, * p<0.1

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Table 24: high-tech industries

4 digit NAIC code	Description
3254	Pharmaceutical and medicine manufacturing
3341	Computer and peripheral equipment manufacturing
3342	Communications equipment manufacturing
3344	Semiconductor and other electronic component manufacturing
3345	Navigational, electro-medical, and instruments manufacturing
3364	Aerospace product and parts manufacturing
5112	Software publishers

Notes: High-tech industries follow the classification of the US Bureau of Labor Statistics (Hecker, 2005)

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