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Crowding-out Innovation

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Abstract

We hypothesize that increases in federal spending financed by government borrowing crowd out innovative firms from financial markets. We find that unexpected defense spending shocks are followed by lower R&D investment and subsequent declines in scale, novelty, and economic value of corporate innovation. Consistent with a financing channel in which government borrowing displaces corporate financing, the decline is stronger for firms that are more financially constrained, more dependent on external finance, have higher short-term debt, and lower credit ratings. Unexpected defense spending is followed by higher short-term government borrowing, which in turn is associated with lower corporate innovation.

Keywords: Government Spending, Defense spending, Taxes, Patents, Citations, Government Borrowing, Corporate Borrowing, Crowding out, Innovation, R&D, Productivity, External Financial Dependence, Financial Constraints, Credit Ratings

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I Introduction

Economists, at least since Keynes (1936), have debated government's role in influencing the real economy. Keynesians typically call for large and sudden fiscal interventions in the economy to boost aggregate demand and enhance economic activity. On the other hand, neoclassical economists tend to oppose government intervention, arguing that such spending displaces private sector activity. Extant studies suggest that an increase in government expenditures is associated with a small increase in GDP and a decrease in private consumption and investment, for an overall negative wealth effect (Barro and Redlick (2011)). The negative wealth effect is plausibly the result of government expenditures crowding out private consumption and investment. While the short-term effects of government spending on aggregate income, growth and employment have been studied extensively (e.g., Ramey (2011), Ramey and Zubairy (2018)), less well researched and understood is its relation to long-term productivity and the mechanisms through which this relation propagates.

In this paper, we revisit the debate by examining the relation between federal government spending and corporate innovation. The existing literature on innovation provides substantial evidence and theory on the importance of innovation as a driver of long-term economic growth (e.g., Solow (1957), Romer (1987, 1992), Griliches (1998), Aghion et al. (2005), and Kogan et al. (2017)). Existing empirical studies also indicate that the availability and nature of financing is strongly related to innovative activity

(e.g., Atanassov (2013, 2016), Hall et al. (2005), Brown, Martinsson, and Petersen (2012)). Expanding on this line of research, we hypothesize that increases in federal spending could significantly increase government borrowing, thereby crowding-out some innovative firms from financial markets. If access to financial markets is essential for financing R&D projects, this displacement of private financing by government debt, is expected to result in lower R&D investment and corporate innovation, especially for firms that have weaker balance sheets and cannot easily access alternative sources of financing. As shown in Greenwood, Hanson, and Stein (2010), the maturity of government borrowing can affect the nature of corporate borrowing. Hence, firms with weaker balance sheets, that predominantly borrow short-term, are dependent on external financing and financially constrained, might find themselves crowded-out by government borrowing. Reducing access to an important source of financing for these firms could curtail their financial flexibility. Such flexibility may be essential for high tolerance to experimentation which, according to Manso (2011), can be an important contributor to innovation.

To test our hypotheses, we combine data on unexpected government spending and tax changes, R&D expenditures, patents and patent citations, government borrowing, and corporate credit ratings. Studying the relation between government spending and real economic outcomes like innovation raises potential endogeneity concerns. We employ several distinct approaches to address these concerns. Endogeneity could arise due to simultaneity, omitted variables, or a measurement error (Wooldridge (2010)). A significant concern in our context is that economic agents might anticipate changes in government

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policy and change their innovation behavior before the change in government spending and/or taxes occurs. In this case, the estimated effects of government actions would be biased. Ideally, we would, therefore, want the changes in government spending and taxes to be unanticipated and not directly related to corporate innovation and R&D.

A further concern is that it might be changes in R&D and innovation that drive government spending and not the other way around (reverse causality). For example, if government authorities observe a decline in innovation, they might decide to stimulate it by increasing government spending or reducing taxes. In that case, we might observe a negative relation between government spending and innovation, and a positive relation between taxes and innovation, but it would be driven by innovation changes causing government responses and not the other way around. Yet another concern is that a third factor could be driving both fiscal policy changes and innovation. For example, greater political uncertainty and/or economic recessions could cause lower innovation, while at the same time lead to an increase in government spending and lower taxes to combat the recession or decrease the uncertainty.

To address these concerns, we rely on several approaches developed in the extant literature.[1] Our first approach is based on recent work in macroeconomics, which uses exogenous and unexpected variation in government spending that is unrelated to cyclical fluctuations in the economy. In particular, we follow the narrative approach developed in

[1]We admit that, even though each of these approaches may help mitigate endogeneity, in the case of our macro variables, none of these approaches is perfect and as a result, we are cautious in interpreting our results in a causal manner.

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Ramey (2011) and Ramey and Shapiro (1998) that uses a narrative approach to track unanticipated changes in government expenditures due to military buildups or drawdowns. Ramey (2011) calculates the present discounted value of unexpected changes in government defense spending by using estimates from Business Week and other major news sources. As an alternative specification, we utilize the indicator variable, created by Ramey and Shapiro (1998), and Ramey (2011), for periods with unanticipated substantial jumps in defense-related government expenditures. There are four such episodes in our sample period: the beginning of the Korean war (1950), the unexpected escalation of the Vietnam war (1965), the Carter-Reagan military buildup after the Soviet invasion of Afghanistan (1980), and 9/11/2001.

Investigating the relationship between unexpected military conflicts and defense spending on innovation is also interesting in its own right because it sheds light on a long-standing debate about whether wars are beneficial or detrimental to innovation. On the one hand, there is ample anecdotal evidence that some of the most important technological discoveries such as the radar and the Turing machine were made during World War II, while the internet and GPS technologies were developed during the Cold War (Ruttan (2006)). On the other hand, defense expenditures and the associated government borrowing could have an overall negative association with private innovation through misallocation of investment and crowding out.

We use several different measures to capture the relation between unanticipated military buildups and drawdowns. First, we use a continuous measure that calculates the

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future present discounted value of unanticipated government military spending resulting from the above events (Ramey (2011, 2017)). We find that higher unanticipated defense expenditures driven by unexpected military conflicts are followed by a significant decline in the propensity, quantity, and quality of corporate innovation. The results are economically significant: An increase in exogenous defense spending by one standard deviation from its median is followed by a 3.92% (3.59%) decrease in the number of patents, a 0.97% (1.08%) decrease in the propensity to patent, and a 2.26% (3.42%) decrease in the number of citations per patent after 3 (4) years. The findings are consistent with the view that defense expenditures may crowd-out innovation by pulling both financial and physical resources away from inventive activity (Griliches (1990)).

Beyond these formal panel regressions, we complement our analysis with cross-sectional binscatter plots and aggregate time-series plots that visually document the relationship between defense spending shocks and innovation. We also conduct formal pre-trend tests for all three innovation measures and complementary pre-versus-post contrast tests. These visual and statistical diagnostics help address concerns about declining pre-trends and are consistent with the observed decline in innovation emerging after the government spending shock. We show that our main results are robust to different econometric specifications (Poisson and log-linear) and to controlling for numerous firm-specific, industry-specific, and macroeconomic time-varying factors that could influence our results. Following Petersen (2009), for most of our analysis we cluster our standard errors by firm and year to control for serial correlation at the firm and year

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levels. While we use the universe of Compustat firms in most of our tests to avoid sample selection issues, we confirm that our results remain strongly significant if we use a subsample consisting only of innovative firms.[2]

While we interpret our findings as supportive of crowding out, a potential criticism is that the years of the military conflicts coincide with increased political uncertainty that might have a negative effect on innovation (Baker et al. (2014)). There are two important reasons why political uncertainty is unlikely to explain our main findings. First, as Atanassov et al. (2024) demonstrate, political uncertainty can be positively related to R&D and innovation, since it serves as a growth option that provides a potential upside for innovation. Second, as Ramey (2011) argues and convincingly demonstrates, these military conflicts were unexpected exogenous events that were not the result of political or economic uncertainty or driven by other events that could also affect innovation. In other words, the comparison is between innovation activity in the years with unexpected military conflicts to innovation activity in the years without unexpected military conflicts. This narrative approach, therefore, helps mitigate endogeneity concerns, but cannot fully rule out confounding factors. To further mitigate the concerns about economic conditions, we explicitly control for various measures of uncertainty in our analysis at the economy level (Bloom et al. (2014, 2015)) and at the firm level. Including these controls does not affect our main results.

In the second set of specifications, we follow Ramey (2011) and Ramey and Shapiro

[2]Firms that have at least one patent or firms that have above the median number of citations per patent.

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(1998) and use their indicator variable, instead of a continuous variable, for periods with substantial increases in defense expenditures. We find a significant negative relation between these events and the number of subsequent patents, the propensity to patent and patent citations. Most of the significant relations are evident two or more years after the event, which mitigates the concern of reverse causality (simultaneity). This is consistent with the notion that innovative projects take time to come to fruition and that firms smooth their R&D spending over time, possibly to avoid having to lay off knowledge workers (Hall and Lerner (2010)).

Our next step is to investigate whether the financing channel plays an important role in the relation between government expenditures and corporate innovation. While we focus on this channel, we acknowledge that there could be other complementary channels (e.g., the labor channel), which are beyond the scope of this paper. We employ several distinct strategies. First, we conduct a cross-sectional analysis that compares a treatment group of firms that are arguably more sensitive to the crowding out of financial markets to a control group. We follow Almeida, Campello, and Weisbach (2004), Whited and Wu (2006), and Duchin et al. (2010) and use four measures of sensitivity: short-term debt exposure, external financial dependence, financial constraints and credit ratings. The results are consistent with our predictions.

For firms more sensitive to crowding out, we find that the negative association between government spending and subsequent quantity of innovation is greater for firms in the top quintile of short-term debt to total assets in a given year. Since we also document

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that the government borrowing increases significantly, especially at the short-term end of the borrowing spectrum after unexpected military shocks, these firms are expected to be the most susceptible to crowding out. Next, we show that the negative association between unexpected defense expenditures and innovation is larger for firms with greater dependence on external financing. We use the definition in Rajan and Zingales (1997) of industry level external financial dependence. We also document that the negative association between unexpected military spending and innovation is stronger for financially constrained firms, which suggests that government borrowing can potentially crowd-out not only in short-term debt markets, but could also have a cascading effect in other financial markets. Finally, we demonstrate that the negative relation between unexpected defense spending and the quality of innovation is mitigated for firms with better credit ratings, that are arguably better able to obtain external financing. The results are economically significant and support the hypothesis that the financing channel plays an important role in explaining our main findings.

We next provide more direct evidence for the crowding-out hypothesis and the financing channel by conducting a dynamic analysis. Specifically, we investigate the relation between unexpected military spending and the maturity of government borrowing, and through that, its possible association with innovation. Our tests draw on the gap-filling theory of corporate borrowing proposed in Greenwood, Hanson, and Stein (2010), which contends that the maturity-structure of government borrowing can be expected to affect the maturity of corporate borrowing. We employ a two-stage estimation procedure for our

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analysis. In the first stage, we demonstrate that unexpected shocks to government spending significantly increase the amount of abnormal short-term government borrowing. In the second stage, we find that greater abnormal government borrowing, driven by the exogenous shocks, has a strong negative association with subsequent innovation. We use both simple predictive two-stage models and a more rigorous two-stage-least-squares instrumental variable framework. Our results are statistically and economically significant.

We further explore the financing channel by documenting an intermediate step in innovation. If shocks to government spending are driving the change in innovation, we should find that they are related to the inputs in the innovation process as well. The most easily observable input is R&D spending. To that end, we study how unexpected military spending is related to R&D expenditures. Consistent with our hypotheses, we find that unexpected military spending is negatively related to R&D expenditures in the same year. Further, we investigate whether unexpected government spending is related to the economic value of patents. Kogan et al. (2017) estimate the economic value of each patent by calculating the stock market reaction around the announcement of the patent. We use their data and, consistent with our hypotheses, find that the economic value of patents is lower after an increase government military expenditures.

Next, we investigate the importance of the military channel to rule out potential spurious correlation. We examine whether innovation in firms that operate in military-related industries is differentially related to an increase in unexpected government military spending. Consistent with expectations, we find that firms operating in industries

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related to the military experience higher innovative activity following an unexpected increase in government spending, compared to the negative relation for firms that do not operate in these industries.

Finally, we turn our attention to exogenous changes in federal tax revenues. The idea is that if there is an exogenous increase in tax revenues, the federal government's need to borrow would be lower and there would be less crowding out of private borrowing. For this part of our analysis, we rely on the exogenous variations in tax laws constructed by Romer and Romer (2010) who use a narrative approach of Congressional legislation to construct measures of tax changes that are unrelated to current economic fluctuations. These exogenous changes in tax revenues result from dealing with inherited budget deficits, or for those intended to achieve some longer-run goal such as social fairness, or a smaller role for the government. Romer and Romer (2010) argue that these changes in government revenue are exogenous because they do not directly target GDP and are not used to smooth short-term economic fluctuations. Consistent with our main hypothesis, we find that an exogenous increase in tax revenues is followed by greater propensity to patent and more citations per patent four years in the future. In our regressions, we control for either contemporaneous or lagged GDP growth and aggregate investment growth. The results are both statistically and economically significant. The tax findings provide additional support for the financing channel we propose.

Our paper contributes to the macroeconomic debate between the New Keynesians and the neoclassical economists on the role of government in stimulating the real economy.

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Our focus is twofold. First, by looking at innovative output, we show that there is a potential long-term negative relation between government spending and economic growth. Second, the government may crowd out corporate innovation through reduced availability of financing necessary for innovation, especially for the most vulnerable firms. The financing channel is also related to a long-standing academic debate about the role of finance in spurring innovation and economic growth. Several studies have documented a positive relation between the availability of finance and economic growth. Less certain, however, is the direction of causality. One school of thought (e.g., Schumpeter (1947)) argues that greater availability of finance leads to more innovation. Other scholars (Robinson (1965)) argue that where the real economy leads, finance follows. Our approach in the paper is to use unexpected shocks to government borrowing and show that the crowding out of private borrowing is associated with lower corporate innovation.

Next, we contribute to the literature on external economic or political shocks to firm performance and the moderating relation of external financial dependence and financial constraints (Rajan and Zingales (1997), Almeida, Campello, and Weisbach (2004), Whited and Wu (2006), and Duchin et al. (2010)). Another contribution of our paper is to the debate on the type of financing used by firms to finance innovation. Brown et al. (2009) demonstrate that equity and internal funds are the most important source of financing of R&D. Subsequent work, however, has shown that debt and bank financing are also very important. Atanassov (2016) documents that firms prefer equity and arm's length debt to relationship bank financing. Chava et al. (2013), Amore et al. (2013), and

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Cornaggia et al. (2015) find that bank deregulation and the supply of credit are significantly related to innovation. Other papers that examine the role of debt financing and innovation in various contexts include Nanda and Nicholas (2014), Atanassov (2016), Gu et al. (2017), Acharya and Subramanian (2009) and Croce et al. (2018). Our findings complement the existing literature by using an exogenous shock to government spending and debt and by showing that the credit channel is strongly related to innovation.

The paper also relates to recent research on the role of government in innovative activity. For instance, Atanassov and Liu (2020) document that state corporate income taxes stifle corporate innovation by reducing firms' pledgeable income and their incentives to innovate. Atanassov, Julio, and Leng (2024) demonstrate that political uncertainty is positively related to R&D investment. An exogenous enhancement in the value of borrowers' patents, either through greater patent protection or creditor rights over collateral, is shown to be associated with cheaper loans that provide capital for innovative activities (e.g., Chava et al. (2016)). Our paper is closely related to the paper by Greenwood, Hanson, and Stein (2010) on the crowding out of corporate bonds at maturities at which there is greater government borrowing.

The paper also sheds light on the question of whether wars or other military conflicts can stimulate innovation. We find that for firms operating in industries related to the military, the relation of government spending to innovation is positive, the opposite of the relation for firms in non-defense related industries. Overall, we find that wars are associated with lower innovation, consistent with the government borrowing and spending

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more, and potentially crowding out innovation in the private sector.

Our paper is organized as follows. Section II describes the data and the empirical methodology. Section III analyzes the relation between exogenous federal spending and innovative output. Section IV explores the financing channel. Section V documents the relation between exogenous changes in federal taxes and innovation. Section VI concludes.

II Data and Variable Construction

The initial sample of companies examined in the paper includes 189,088 firm-years based on 20,245 unique firms that have publicly traded stock over the period 1950-2014. We combine the innovation data from Kogan et al. (2017) with financial data from Compustat. Data on military expenditures are obtained from Ramey (2011, 2017), while federal narrative tax revenue data are from Romer and Romer (2010). Government borrowing data are obtained from CRSP U.S. monthly treasury dataset. Data on credit ratings come from S&P Issuer (Entity) Credit Ratings database. The Poisson maximum-likelihood estimation with firm-fixed effects omits observations that do not change during the sample period.[3] Therefore, our final sample in the main specification consists of 92,835 observations with 6,746 unique firms. For some regressions we require that credit ratings data be available. This reduces the sample size to 42,256 observations, while due to the Poisson specification, that number further drops to 26,629 observations.

[3]This may include observations that have zero patents and citations per patent over the sample period.

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II.A Main Explanatory Variables: Exogenous Military Expenditures and Exogenous Changes in Tax Revenues

Our main variable to measure unexpected shocks to government military spending throughout most of the paper is *EDS* (Exogenous Defense Spending). It is created by Ramey (2011), and improved upon by Ramey and Zubairy (2018) to measure the exogenous variation in government defense expenditures. This variable, as we show, is closely and positively related to the need for short-term government borrowing. Ramey (2011) uses news articles to estimate the (discounted) present value of unexpected exogenous future military expenditures for each year from 1939 to 2010. She uses a narrative approach by tracking Business Week articles that give detailed predictions of changes in government spending based on unexpected military events. For data after 2001, Ramey relies more on newspaper sources, because she considers Business Week to be less reliable in subsequent years. The variable *EDS* represents an approximation to the changes in expectations at the time of the news, and involves many judgment calls. In calculating present values, Ramey uses the 3-year Treasury bond rate prevailing at the time.

In Table III, Panels A -C, we use a second variable to capture shocks to defense spending. It is an indicator variable: *ExogWar*, created by Ramey and Shapiro (1998) and Ramey (2011), which is equal to 1, if there is an unexpected substantial increase in government defense expenditures due to an unanticipated military conflict, and zero otherwise. There are four such unexpected episodes that Ramey (2011) discusses - the Korean War in 1950, the Vietnam war (1965), the Carter-Reagan military buildup after

the Soviet invasion of Afghanistan (1980), and 9/11/2001. Because data from Compustat starts in 1950, there is only a limited use of the Korean War shock in our analysis. The results are robust to not including it.

For our measure of abnormal short-term government borrowing, *AbnSTGovBor*, we obtain data on US monthly Treasuries from CRSP. We follow Greenwood, Hanson, and Stein (2010) to calculate the total amount of debt outstanding at each maturity. For each outstanding issue we measure the principal and coupon repayments, adjusting the series each month for variation in the face value outstanding. For every month, we calculate the sum of payments due in the subsequent n periods, across all issues that are still outstanding. The government short-term debt is calculated as the sum of all payments due in one year or less, divided by total payments in all future periods. The abnormal level of government debt, *AbnSTGovBor*, is then calculated by subtracting the predicted value from a regression of the amount of government short-term borrowing on a time trend from the actual value of short-term government borrowing. This regression is provided in the Internet Appendix, Table IA-V. The monthly measures are averaged for each year to convert them to annual frequencies.

For additional analysis of the government's need to borrow we use another variable provided by Romer and Romer (2010). They use sources such as Congressional reports to estimate significant tax changes based on federal legislation during the 1945-2007 period. As we document in our empirical section, higher exogenous tax revenues reduce government borrowing, while lower exogenous tax revenues increase government borrowing,

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especially in the short-term. Romer and Romer (2010) classify the motivation for each tax change into one of four categories: offsetting a change in government spending; offsetting some factor other than spending likely to affect output in the near future; dealing with an inherited budget deficit; and achieving some long-run goal, such as higher normal growth, increased fairness, or a smaller role of government. Romer and Romer (2010) argue the first two motivations are endogenous to GDP, investment and other outcome variables, which could include innovation. The third and the fourth categories are potentially exogenous to innovation because they do not directly target current firm incentives to innovate. In Table IX we use the variable *RomerExogTax* which is defined to be the sum of the present discounted value of the last two categories of tax changes divided by GDP.

II.B Construction of the Dependent Variable

We use three main metrics to measure a firm's innovative output. Patents, the propensity to patent and patent citations measure the output of the innovative process, which is the result of several inputs including physical capital, human capital, research and development, and the effort and creativity of managers and employees. The number of patents provide a measure of the quantity of innovation, while the number of citations received by a patent provides a measure of the quality and long-term importance innovation (Hall et al. (2005), Kogan et al. (2017)). Patent propensity measures the extensive margin. While R&D expenditures may not be a reliable indicator of innovative activity, they represent an intermediate step in the innovation process and we study how

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shocks to military spending and exogenous taxes affect R&D expenditures. It should be noted that patents as a measure of innovative output have the limitation that not all firms and industries patent their innovations. This is because some inventions do not meet the patentability criteria or because the inventor might choose to rely on secrecy or other means to protect her innovation.[4]

The first innovation metric, *Patent*, is equal to the number of patents for each firm in a given year. As is typical in the literature, the relevant year for the innovation is taken to be the patent application year, which is closer to the actual innovation than the grant year (Hall, Jaffe, and Trajtenberg (2001, 2005)). The second metric is the propensity to patent. It measures the likelihood that a firm will create a patent. It is an indicator variable equal to one, if a firm has filed at least 1 patent in a given year, and zero, otherwise. The third metric, citations per patent, assesses the significance of a firm's innovative output. It is motivated by the recognition that a simple count of patents does not distinguish very important innovations from those that are only incremental. Pakes and Shankerman (1984), for instance, show that the distribution of the value of patents is extremely skewed, i.e., most of the value is concentrated in a small number of very important and highly cited patents. Since patents are required to cite prior patents that are technologically relevant, the citations garnered by a patent can provide a measure of its technological and economic significance. Hall et al. (2005) and Kogan et al. (2017), among others, demonstrate that patent citations are a reliable indicator of the value of innovations.

[4]In Table IID, we examine a sub-sample of firms operating in industries in which patenting is important (patents greater than zero or citations per patent above the median), and obtain similar results.

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Patent citations suffer from a truncation bias because citations are received for many years after the patent application is filed and the patent is granted. For instance, a patent granted in 1989 will have far more time to receive citations than a patent granted in 2006 because the latter is closer to the end of our sample period. Another potential concern is that different industries might have different propensities to cite patents. We correct for these biases by using the fixed effects method suggested by Hall, Jaffe and Trajtenberg (2001, 2005). The fixed effects method corrects for these biases by dividing the number of patent citations by the average amount of patent citations in the cohort year to which the patent belongs. We construct the variable *Citations/Patent* that corrects for year fixed-effects. As an additional precaution to deal with the truncation bias and outliers, we right-winsorize this variable at the 99^{th} percentile.

Finally, in additional analysis, we use two alternative measures that capture additional facets of the innovative process. The first is R&D expenditures, one of the inputs to the innovation process and part of the channel through which government spending and borrowing can influence firm innovation. We scale R&D expenditures by total assets as an additional size control. We assign a value of zero for firms that do not report R&D expenditures. The second is the economic value of patents, first proposed by Kogan et al. (2017). The intuition behind this variable is that it assesses the shareholder value created by a given patent. While the significance of patents can usually be captured by citations, as discussed above, this may not always be the case. For that reason, Kogan et al. (2017) estimate the stock market reaction around a patent grant date and use that as

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a proxy of the anticipated economic value of that patent. We use the real values in our main analysis and in unreported regressions document that our results are robust to using the nominal values instead. We assign a value of zero for firms that do not have patents. To control for outliers, we also right-winsorize R&D expenditures and the economic value of patents at the 99^{th} percentile.

We also augment the sample of firms with patents by including all the other firms in Compustat that do not have patents. We take the number of patents and citations per patent, the propensity to patent to be zero for these firms. Including these firms alleviates sample selection concerns, since the sampling procedure is independent of whether the firms patent or not. As we demonstrate in our robustness tests, the results are robust (and sometimes stronger) when we exclude zero patent firms. We include firm-fixed effects in all regression models to address (time-invariant) heterogeneity between firms and/or industries in terms of their ability to generate patents and citations. Finally, our analysis is robust to excluding industries such as financial services and utilities that operate under different regulatory rules from manufacturing firms.

II.C Other Explanatory Variables

The data on total assets, sales, R&D expenditures, debt, net property plant and equipment, EBITDA, come from CRSP/Compustat merged database. We control for firm-specific, time variant characteristics by including the following variables. Profitability is equal to EBITDA divided by total assets. Tangibility is equal to net property plant and

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equipment (NPPE) divided by total assets. The Cash variable is calculated by dividing the cash component of a firm's balance sheet by total assets and Leverage is equal to short-term debt plus long-term debt, divided by total assets. We follow Hall and Ziedonis (2001) and Aghion et al. (2005) among others and include *LnSales* to control for firm size. We calculate the Herfindahl index (HI) at the 4-digit SIC level to measure industry concentration in our regression specifications. We also include the squared Herfindahl index to control for non-linear effects of industry concentration. For some of our cross-sectional analysis that study the financing channel, we create an indicator variable *IGrade* equal to 1, if the firm has a credit rating of BBB or above, and 0 if the firm has a credit rating lower than BBB. To control for economy wide, time varying economic changes we include the variable *LnRGDP* that measures the natural logarithm of real GDP, and *LnRInv* that measures the log of real aggregate investment. The variables BudgSurpl, LnRDef and Tax control for the size of the budget surplus (deficit), the total value of real defense expenditures and the federal tax receipts, respectively. They are scaled by GDP. The data comes from Ramey (2011) and the Bureau of Economic Analysis. The variables LnTotCap and VWR control for the total stock market capitalization and total stock market value weighted return. The data come from CRSP/Compustat database. We also follow Fisher and Peters (2010) and use the variable Top3Xret to measure the stock return of the top three defense contractors. This variable can control for the effect of the military shocks that are anticipated by the stock market. Variable definitions are provided in Appendix A.

Table I presents summary statistics for the main variables.

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II.D Model Specification

Our main model specification is the following:

$$y_{i(t+n)} = \alpha_i + \beta GOV_t + \gamma X_{it} + \epsilon_{it}, \tag{1}$$

where i indexes firms, t indexes time, $y_{i(t+n)}$ is the dependent variable, which is Patent, PatentDum (Propensity to patent) or Citations/Patent for the Poisson (count) specifications, and *RD/TA* ($R\&D$ scaled by total assets) or *EconValPat* (from Kogan et al. (2017)) in the OLS specifications. Here, n is the number of years after the current time period t. GOV_t is a variable that proxies for exogenous shocks to government spending. We control for time invariant unobserved firm characteristics by using firm-fixed effects α_i.[5]

We investigate the channel through which government spending may be related to corporate innovation by modifying the above model. Specifically, we test for the indirect crowding out channel by using a difference-in-difference methodology. We estimate the following model:

$$y_{i(t+n)} = \alpha_i + \beta_1 GOV_t + \beta_2 FinSens_{it} + \beta_3 GOV_t \times FinSens_{it} + \gamma X_{it} + \epsilon_{it}, \tag{2}$$

where i indexes firms, t indexes time, $y_{i(t+n)}$ is the dependent variable, which is Patent or Citations/Patent for the Poisson specifications, and *Log(1+Patent)* or *Log(1+*$\frac{Citations}{Patent}$*)*, for

[5]Because our main explanatory variable is at the year level, we can not directly include time-fixed effects in our main regressions. Therefore, using the fixed effect methods for robustness by Hall, Jaffe and Trajtenberg, when constructing the dependent variables is one way, albeit not perfect, to address these effects.

the log-linear specifications that we use in our robustness checks. As above, n is the number of years after the current time period t. GOV_t is a variable that measures shocks to government spending or taxes. $FinSens_{it}$ is a variable that measures the degree of sensitivity to external financial markets, while α_i indicates firm-fixed effects. The coefficient on the interaction term $GOV_t \times FinSens_{it}$ represents the difference-in-difference estimate.

Before turning to the formal regression analysis, we provide a complementary visual preview of the relationship between exogenous defense spending and corporate innovation. We rely on a cross-sectional binscatter analysis that exploits firm-level variation to examine the association between defense spending shocks and subsequent innovation outcomes. Binscatter plots are a widely used nonparametric tool for visualizing relationships in large datasets (Cattaneo, Crump, Farrell, and Feng (2024)). The methodology proceeds as follows. The procedure residualizes both the dependent variable (a measure of future innovation) and the main explanatory variable (*EDS*) on the full set of firm-level controls and firm fixed effects described above, using the linear fixed-effects estimator of Correia (2016). It then sorts the residualized *EDS* values into 20 equal-sized bins based on their quantile rank, computes the mean of the residualized dependent variable within each bin, and plots these conditional means against the bin-level mean of the residualized *EDS*. The resulting scatter provides a transparent, model-free depiction of the partial correlation between defense spending shocks and subsequent innovation, after absorbing firm heterogeneity and observable covariates. We overlay a linear fit on the binned means and report the slope coefficient and its p-value from an OLS regression on the bin-level data.

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Because patent counts and citations per patent are highly right-skewed, and because we cannot use a Poisson specification with the binscatter methodology, we follow the extant innovation literature and use $\ln(1+y)$ transformations for these two measures, which compresses the right tail and makes the conditional means more informative. The propensity to patent (an indicator variable) is left in levels. Figure 1 presents the plots at horizon $t+4$. All three panels exhibit a clear negative relationship: firms exposed to larger defense spending shocks subsequently produce fewer patents, are less likely to patent at all, and generate less impactful innovations. The negative pattern persists across all three panels, with the propensity to patent and citations per patent highly significant, and the patent count marginally significant.[6] Taken together, the cross-sectional graphs provide preliminary support for our hypothesis that defense spending shocks are followed by declines in corporate innovation.

To complement this firm-level evidence, we also construct aggregate time-series plots that examine the historical co-movement between defense spending shocks and the economy-wide innovation trajectory over the full sample period. As shown in the Internet Appendix, the time-series evidence at horizon $t+4$ exhibits a strong negative correlation. The smoothed correlations between the residualized series are -0.48 for patent counts, -0.45 for the propensity to patent, and -0.29 for citations per patent, suggesting that periods of elevated defense spending are followed by macroeconomic declines in innovation growth. This aggregate relationship provides additional descriptive evidence consistent

[6] As reported in the Internet Appendix, the analogous binscatter at horizon $t+3$ exhibits a similar negative relationship, where the estimated effects are highly significant across all three innovation measures.

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with the crowding-out interpretation, although it does not by itself establish causality or eliminate all alternative macroeconomic explanations. While these visual patterns are suggestive, we now turn to the formal econometric analysis to estimate the magnitude and statistical significance of the crowding-out relation.

III The Relation between Exogenous Defense Government Spending and Technological Innovation

III.A Main Results

The first step of our analysis is to directly test if exogenous shocks to government spending are related to corporate innovation. We use two main proxies of the shocks to government spending to test our hypotheses. First, in Tables IIA - IIE, we use a continuous measure, developed by Ramey (2011) that estimates the present discounted value of government spending that resulted from the unexpected military events. This is our main explanatory variable for the majority of our analysis. Second, in Tables IIIA - IIIC, we use an indicator variable for the significant unexpected military events that, as noted earlier, were followed by a dramatic increase in government spending (Ramey (2011)).

The advantage of using the indicator variables is that we can pinpoint the timing of the event. The advantage of using the continuous variables, however, is that they provide us with a dollar estimate of the military spending resulting from the shock, which is useful in assessing the relative magnitude of each event.

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More specifically, we estimate the following Poisson model:

$$y_{i(t+n)} = \alpha_i + \beta MilitarySpendingShock_t + \gamma X_{it} + \epsilon_{it}, \quad (3)$$

where i indexes firms, t indexes time, $y_{i(t+n)}$ is the dependent variable, which is the number of patents (Patent) in Table II Panel A, the propensity to patent (PatDum) in Table II, Panel B, or the number of citations per patent (Citations/Patent) in Table II Panel C, and n is the number of years before or after the current time period t (from t-3 to t+5). *MilitarySpendingShock* is proxied by *EDS* in Tables IIA - IIE. *EDS* is a measure of the exogenous government defense spending described in Ramey (2011). It is equal to the present discounted value of military expenditures in each year divided by real GDP. *MilitarySpendingShock* is proxied by *ExogWar* in Tables IIIA - IIIC. It is equal to 1, if there is a significant unexpected military event in year t, and zero otherwise. Firm-fixed effects are denoted by α_i, while the vector X_{it} is a vector of control variables described in the previous section. By estimating this specification across multiple horizons n, we trace out an impulse response function (IRF) of corporate innovation to defense spending shocks in the spirit of the local projection approach of Jordà (2005). Figures 2–4 plot these IRFs visually. The coefficients on *EDS* at each horizon, along with confidence intervals, allow us to examine both the dynamic path of the response and the behavior of pre-shock coefficients as a test for pre-existing trends (see also Ramey and Zubairy (2018)).

In Panel A we find that *EDS* is negatively related to the quantity of corporate

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innovation as measured by the number of patents 2, 3 and 4 years after the conflict begins, but we find no significant relation in years t-3, t-2, t-1, t or t+1. We also find no significant relation in year 5 or beyond, suggesting that the estimation becomes too noisy, that the possible relation between military spending shocks and innovation subsides after year 5, or both. The timing suggests that it is more likely that the unexpected government spending precedes the decline in innovation, rather than the other way around. The results are economically significant. A one standard deviation increase from the median of unexpected military spending is followed by a 3.92% and 3.59% decrease in the number of patents, 3 and 4 years after the change (columns 7 and 8, respectively). Figure 2 plots the coefficients on the *EDS* variable on the vertical axis and the lags and leads of the unexpected military shocks on the horizontal axis. It illustrates visually the results from Table II Panel A, showing that the significant relation is evident 2 years after the shock. In Table II Panel B, we examine the relation between *EDS* and the propensity to patent. Reducing the propensity to patent is arguably a more drastic decision than reducing the numbers of patents. We find similar results, though the extensive-margin evidence is weaker than the patent-count evidence. Firms are less likely to have a single patent 4 years after the military shock. There is no significance in years t-3, t-2, t, or t+1. We also do not find a significant result in years t+5 or beyond. Most of the statistical significance comes in years t+2, t+3 and t+4, which is consistent with, but does not by itself establish, a delayed relation from exogenous defense spending to innovation.[7] The results are also economically

[7]While, the coefficient on t-1 is significant, there is no significance in the coefficients in the years around it, mitigating the concern of a pre-existing trend.

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significant. A one standard deviation increase from the median of unexpected military spending is followed by a 0.97% and 1.08% decrease in the propensity to patent, 3 and 4 years after the change (columns 7 and 8, respectively). Figure 3 plots the coefficients on the *EDS* variable on the vertical axis and the lags and leads of the unexpected military shocks on the horizontal axis.

In Table II Panel C, we examine the relation between *EDS* and the number of citations per patent. This is a measure that proxies for the quality and importance of innovation (Griliches (1990), Hall et al. (2001), Hall et al. (2005), and Kogan et al. (2017)). It is possible that while companies reduce the level of patenting, they focus on more significant innovations, implying an increase in the number of citations per patent. Such a finding would significantly weaken evidence for our crowding-out hypothesis. We observe, however, a significant decline in the quality of innovation 3 and 4 years after the unexpected military spending increase. There is no significant relation in the prior years (t-3 to t+2), or in year t+5 and beyond. Since we expect high quality innovations to have a significant lag between when they are initiated and when they are completed, this timing is consistent with a delayed relation between unexpected government spending and innovation. The results are also economically significant. A one standard deviation increase from the median of unexpected military spending is followed by a 2.26% and 3.42% decrease in the number of citations per patent, 3 and 4 years after the change (columns 7 and 8, respectively). Figure 4 plots the coefficients on the EDS variable on the vertical axis and the lags and leads of the unexpected military shocks on the horizontal axis.

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Examining the pre-shock coefficients (at horizons $t-3$, $t-2$, and $t-1$) in Tables IIA–IIC provides a useful diagnostic for the validity of our identification. Because the military spending shocks are plausibly exogenous, we should not observe a systematic decline in innovation *before* the shock occurs. In Table IIA (patents), the pre-shock coefficients are positive and statistically insignificant, consistent with the absence of a pre-existing downward trend. In Table IIC (citations per patent), the pre-shock coefficients are similarly small and insignificant. In Table IIB (propensity to patent), the coefficient at $t-1$ is negative and significant, though the surrounding pre-period coefficients ($t-3$ and $t-2$) are not, mitigating the concern of a systematic pre-trend. The coefficient plots in Figures 2–4 show some variation in the pre-period point estimates, particularly in Figures 2 and 3 where the coefficients at $t-3$ are positive but statistically indistinguishable from zero. The declining pattern from the positive $t-3$ coefficient to the negative post-shock coefficients could, in principle, raise concerns about a pre-existing downward trend that predates the military spending shock. While the statistical tests do not reject the null hypothesis of zero pre-trend effects, we conduct several additional robustness exercises to address this concern more rigorously.

Following Wolfers (2006), we re-estimate the Poisson specification augmented with firm-specific linear time trends. This approach adds an interaction between firm fixed effects and a linear time variable, $\alpha_i \times t$, which absorbs any heterogeneous linear trajectories in innovation across firms. By controlling for each firm's idiosyncratic trend, this specification ensures that the estimated effect of military spending shocks reflects

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deviations from the firm's own trend rather than from a common trajectory. If the results in Tables IIA–IIC were driven by differential pre-existing trends in innovation across firms, the inclusion of firm-specific trends would substantially attenuate the estimates. The results from this exercise are reported in Internet Appendix Tables IA-VIIIA through IA-VIIIC and Figures IA-F4 through IA-F6. For patent counts (IA Table IA-VIIIA), the firm-specific trend specification yields point estimates that are very similar in magnitude to those in Table IIA. Importantly, the pre-shock coefficients become even closer to zero, alleviating the concern that the main results are an artifact of heterogeneous firm-level trends. For citations per patent (IA Table IA-VIIIC), the results show a monotonic decline from $t = 0$ through $t + 4$ and pre-shock coefficients very close to zero. The extensive margin results (IA Table IA-VIIIB) are qualitatively similar, though with somewhat wider confidence intervals.

To further explore the validity of our identification strategy, we report two related diagnostics in Table IA-IXA. First, we perform Bonferroni-adjusted joint tests of whether the pre-period coefficients at $t - 3$, $t - 2$, and $t - 1$ are statistically different from zero. Using the reported pre-period p-values, we fail to reject the null of no pre-trend for all three innovation measures: patent counts ($p = 0.476$), citations per patent ($p = 0.519$), and propensity to patent ($p = 0.171$). These tests indicate that the pre-period point estimates are statistically indistinguishable from zero. Second, as a separate diagnostic, we perform a Wald test comparing the sum of pre-period coefficients ($t - 3$ through $t - 1$) against the sum of post-period coefficients ($t + 2$ through $t + 4$). Because each horizon is estimated in a

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separate regression, we use a cluster bootstrap (500 replications, resampling firms) to recover the joint covariance matrix across horizons. The Wald test rejects the null that the pre- and post-period sums are equal ($\chi^2(1) = 45.15$, $p < 0.001$). This comparison suggests that the post-period decline in innovation differs meaningfully from the pre-period pattern, and is not a simple continuation of it. Analogous Wald tests for the other two innovation measures yield similar conclusions: for the propensity to patent, $\chi^2(1) = 9.98$, $p = 0.002$; for citations per patent, $\chi^2(1) = 29.89$, $p < 0.001$ (Table IA-IXA, Panel B).

Finally, we report sensitivity analysis following the approach developed by Rambachan and Roth (2023), which provides inference that is robust to potential violations of the parallel trends assumption. This methodology computes confidence intervals that remain valid even if the post-treatment violations of parallel trends are up to $\bar{M}$ times as large as the maximum violation observed in the pre-treatment period. We focus on the average coefficient across horizons $t + 3$ and $t + 4$, where the estimated negative relation is largest and most significant. For consistency with the rest of the paper, Table IA-IXB in the Internet Appendix and Figures 5–7 report 90% confidence intervals[8]. The results show that the original 90% confidence intervals exclude zero for all three innovation measures, but they also make clear that the pre-trend diagnostics are not equally strong across outcomes. For patent counts, the "breakdown value" (the largest $\bar{M}$ for which the robust confidence interval still excludes zero) is between 1.0 and 1.5 (Figure 5). This indicates that the patent-count results remain statistically significant

[8]The corresponding 95% intervals yield very similar qualitative conclusions.

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within this sensitivity framework even after allowing for post-period violations of parallel trends equal to the maximum pre-period deviation. The evidence is weaker for the other two outcomes. For the propensity to patent, the robust confidence interval includes zero once $\bar{M}$ reaches 0.5 (Figure 6), while for citations per patent, the breakdown value is approximately 0.75 to 1.0 (Figure 7). Thus, the parallel trends assumption appears to hold well for patent counts but is more tenuous for the propensity to patent and citations per patent. We therefore interpret the patent-count results as the strongest evidence and view the extensive-margin and citation-per-patent results as supportive, but more sensitive to possible pre-trend violations.

The associations between the control variables and innovation in Table II, Panels A - C are worth noting even though they lack a causal interpretation. Interestingly, the estimated relation between real GDP growth and innovation and between real aggregate investment growth[9] and innovation is negative. A possible explanation might be, as argued by Schumpeter (1947), that companies use recessions (when demand is weak) to invest in R&D, leading to high quality innovative output. Firms with more tangible assets (measured by net property, plant and equipment divided by total assets) are associated with fewer citations per patent. Firms with more cash appear to have higher propensity to patent and more citations per patent. While this is consistent with the "deep pockets" theory, it can also mean that more innovative firms generate more cash. Further, firms tend to innovate less when total real defense expenditures are higher. Larger tax receipts are

[9]For patents and the propensity to patent.

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positively related to future innovation. This result is consistent with the financing channel that will be analyzed in the next section. When tax receipts are higher, the government's borrowing need is reduced and arguably, so is the crowding out of private borrowers. Total stock market capitalization is positively related to future innovation. The return to the top three defense contractors, which captures the military shocks that are anticipated by the stock market, is insignificant for patents, and negative and significant in years t+2 and t+3 for the propensity to patent and the citations per patent. This sign is also consistent with the fact that the military shock, while beneficial for some defense contractors, is negatively related to overall innovation. We will explore this effect further in section VI.

III.B Robustness Tests

As mentioned in the data section, it is important to use the full sample of both innovative and non-innovative firms to avoid selection bias issues. Nevertheless, having a large number of non-innovative firms, or firms that innovate very little, may mean that the coefficient estimates in Table II, Panels A and C are influenced mostly by the difference between innovative and non-innovative firms. To address this concern, in Table II, Panel D, we estimate regressions for the sub-sample of innovative firms, defined as those that received at least one patent in a given year (columns 1 and 2), and those with larger than median citations per patent in a given year (columns 3 and 4). We still find a very strong negative relation between *EDS* and the quantity and quality of innovative output, even though the sample size is much smaller than the full sample.

In Table II, Panel E, we address a potential criticism that the years of the military

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conflicts coincide with increased political uncertainty that could have a negative relation with innovation. Before discussing the results, we note why political uncertainty might not be a serious concern. First, as Atanassov et al. (2024) demonstrate, political uncertainty appears to be positively related to R&D and innovation, possibly because it acts as a growth option that provides a potential upside for innovation. Second, as Ramey (2011) argues and demonstrates in some detail, these military conflicts were likely exogenous and were not the result of any political or economic uncertainty. If there is any increase in uncertainty, it is likely caused by the military conflicts and not the other way around. It is still possible, however, that the military conflicts caused both an increase in government spending and borrowing and an increase in uncertainty, and it was uncertainty that affected innovation and not the crowding-out by the government. To that end, we control for measures of uncertainty to confirm that it does not negate the relation between government military spending and innovation.

Our robustness tests in Table II, Panel E control for economic policy uncertainty at the macro level following Baker et al. (2016). Their approach is to analyze the news and extract keywords that reflect uncertainty in economic policy to construct an EPU Index. As indicated in the table, the inclusion of this index does not affect our main findings on the relation between defense expenditures and citations per patent. Furthermore, consistent with Atanassov et al. (2024), the EPU Index is weakly positively related to the number of citations per patent in year t+3, while defense expenditures remain highly significant and negatively related to the number of patents, the propensity to patent and

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the citations per patent. In untabulated results, we use several different modifications of the index as well as other measures that capture policy and political uncertainty and find that our measure of exogenous defense spending continues to have a negative and highly significant relation to innovation. For instance, we use the modified version of the index from Baker et al. (2014). We also use several measures such as government share of GDP and regulatory burden and obtain similar results. Finally, we include an interaction term between the unexpected military expenditures and uncertainty and find it to be insignificant. These tests indicate that economic and policy uncertainty does not account for the government spending and borrowing channel.

Our sample spans six decades (1950–2009) characterized by substantial variation in political climate, fiscal policy regimes, financial market development, and macroeconomic conditions (see, e.g., Poterba (1989), Friedman (1986)). A natural question is whether the negative relation between government borrowing and corporate innovation is stable across these different environments or is instead driven by a particular subperiod. We investigate this question using three complementary approaches. First, we interact *EDS* with a linear time trend to test parsimoniously whether the slope of the *EDS*–innovation relationship has been systematically changing over time (see, e.g., Wooldridge (2010), for the use of interaction terms to test parameter stability). Figure 8 plots the resulting implied time-varying *EDS* coefficient with 95% confidence intervals for our primary specification (patent counts at $t + 4$). The visual evidence shows that the implied *EDS* coefficient is negative for the vast majority of the modern sample period, the trend line is nearly flat,

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and the trend interaction term is not statistically significant (p-value of 0.40). This pattern is consistent with a broadly stable negative relationship over time, although the early sample remains imprecise. Internet Appendix Figures IA-F16 through IA-F21 confirm that this pattern holds across all six outcome×horizon combinations (patent counts, propensity to patent, and citations per patent, each at $t+3$ and $t+4$).

Second, we interact the continuous *EDS* measure with period indicators in the full sample to allow the coefficient to shift across decades. As shown in Internet Appendix Figures IA-F10 through IA-F15, the coefficient is predominantly negative across all six outcome×horizon combinations, with a moderate negative relation persisting through the 2000s, and no period produces a statistically significant positive coefficient. Third, we estimate the model separately for three twenty-year subperiods: 1950–1970, 1970–1990, and 1990–2009. For these regressions, we use OLS with $\ln(1 + \text{Patents})$ as the dependent variable and cluster standard errors by firm to accommodate the smaller samples (Tables IA-VIIA - IA-VIIC). For the most recent period (1990–2009), where Compustat coverage is densest, *EDS* is strongly and significantly negatively related to all three innovation measures. For the middle period (1970–1990), the negative relations remain significant for patent counts and the propensity to patent at $t+4$, though not for citations per patent. For the earliest period (1950–1970), the sub-sample shrinks significantly and the estimates become imprecise. The only statistically significant *EDS* coefficient across all three subperiod tables is still negative, consistent with the crowding-out hypothesis. Taken together, the trend interaction tests, the decade interaction analysis, and the sub-period

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regressions suggest that the negative association between government borrowing and corporate innovation is not driven by a single decade, although precision varies considerably across subperiods.

For verification and consistency, we replicate the analysis using the older NBER patent dataset (Hall et al. (2001)). Internet Appendix Tables IA-VIA, IA-VIB, and IA-VIC report the results. The coefficients remain similar in statistical significance. Their magnitudes are notably larger, which likely reflects the greater measurement noise in the NBER data: a larger share of firms are recorded as having zero patents or citations when, in reality, they do have innovative output, amplifying the estimated relation. In addition, the truncation bias that affects citation counts toward the end of the NBER sample is substantially reduced in the newer dataset.

Next, in Table III Panel A we use the indicator variable *ExogWar* (Ramey and Shapiro (1998), and Ramey (2011)) as our main explanatory variable. As noted earlier, *ExogWar* is equal to 1 for 1950 (the Korean war), 1965 (the unexpected escalation of the Vietnam war), 1980 (the unexpected Soviet invasion of Afghanistan), and 2001 (9/11). The standard errors are clustered at the firm and year level. There is a strong negative relation between *ExogWar* and innovative output in terms of the number of patents in all specifications. The results suggest that unexpected shocks to government spending that are unrelated to the business cycle and to the change in aggregate demand and GDP, are followed by a decline in corporate innovation. The results are economically significant. An exogenous shock to defense spending is followed by a 9.90% and 10.95% decrease in the

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number of patents after 3 years (column 1) and 4 years (column 2), respectively. This finding is consistent with the hypothesis that government spending crowds out corporate investment and is associated with lower innovation.

Table III Panel B reports the results in terms of the propensity to patent. We find that the unexpected shocks to military expenditures not only relate to the quantity of innovation, but also to firms' decisions on whether to innovate or not. In some ways, this can be viewed as a more significant decision. It can be closely related to the availability of financing due to crowding out by government spending and borrowing. The results are also economically significant. We find that a shock to exogenous defense spending is followed by a 5.3% and 7.9% decrease in the propensity to patent after 3 years (column 1) and 4 years (column 2), respectively.

In Table III Panel C, we investigate the relation between shocks to military spending and the quality of innovative output as measured by citations per patent, using the full set of publicly-traded firms from Compustat. The quality of the patents decreases in year t+4, as indicated by the lower number of citations per patent following the unexpected shock to defense expenditures. The results are again economically significant. An exogenous shock to defense spending is followed by a 5.8% decrease in the number of citations per patent after 4 years (column 2).

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IV The Credit Channel

In this section we conduct cross-sectional and time-series tests of the financing channel. We hypothesize that the credit channel is a plausible way in which government spending is related to innovation. We recognize that there may be other, complementary channels through which government spending and taxes could be related to private investment and innovation.

IV.A Cross-Sectional Analysis: Short-Term Debt, External Financial Dependence, Financial Constraints, and Credit Ratings

In this sub-section, we look at the cross-sectional evidence for a financing channel. We specifically hypothesize that if there is crowding out in credit markets, firms that are more sensitive to the availability of external financing will tend to be disproportionately affected. We use four main proxies of financial sensitivity. First, we argue that the negative relation between government spending and innovation is likely to be stronger for firms that have a higher level of short-term debt. These are firms that may have greater difficulty obtaining long-term financing. This argument follows from the gap-filling theory proposed by Greenwood, Hanson, and Stein (2010) which argues that government borrowing is more likely to crowd-out firms that borrow at the short-term end of the maturity spectrum. Second, we expect that firms with greater dependence on external financing will be disproportionately affected if there is crowding out by government borrowing relative to

firms that rely more on internal financing. Third, we argue that firms that are more financially constrained will be more negatively affected by government borrowing. Finally, we posit that firms with lower credit ratings would be affected more, because as the availability of financing for private sector firms diminishes, riskier borrowers are more likely to be excluded than healthier ones.

To test the hypotheses we utilize the following variables. We create an indicator variable STDH, equal to 1, if a given firm is in the top quintile of short-term debt to total assets in a given year. We follow Duchin et al. (2010) and define short-term debt as net short-term debt that includes the portion of long-term debt maturing in less than one year. We proxy for external financial dependence, ExFD, by using the median industry financial dependence measure developed by Rajan and Zingales (1997) and Duchin et al. (2010). We use the index developed by Whited and Wu (2006) to create the variable FCon that measures financial constraints. The authors argue that this index captures firms' need of external capital. Finally, we use the S&P credit ratings to assess if a firm is creditworthy. We create an indicator variable IGrade equal to 1, if the firm has credit ratings of BBB or higher (investment grade), and zero if the ratings are lower than BBB (speculative grade).

We report the results for the interaction between exogenous defense spending and firm short-term debt indicator in columns (1) and (2) of Table IV Panel A for the number of patents and Table IV, Panel B for the number of citations per patent. The results for external financial dependence are in columns (3) and (4) of Table IV, Panel A for the number of patents, and Table IV, Panel B for citations per patent. For financial

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constraints, the regressions are in columns (5) and (6) of Table IV Panel A for the number of patents and Table IV, Panel B for citations per patent. For credit ratings, the results are in columns (7) and (8) of Table IV Panel A for the number of patents and Table IV, Panel B for citations per patent. Specifically, we estimate the following regression specification:

$$\begin{aligned} y_{i(t+n)} &= \alpha_i + \beta_1 EDS_t + \beta_2 FinSensitivity_{it} \\ &\quad + \beta_3 EDS_t \times FinSensitivity_{it} + \gamma X_{it} + \epsilon_{it}, \end{aligned} \tag{4}$$

where, as before, i indexes firms, t indexes time, $y_{i(t+n)}$ is the dependent variable, which is Patents or Citations/Patent, and n is the number of years after the current time period t. *FinSensitivity* proxies for the short-term debt (Table IV, Panel A, columns 1-2), the degree of external financial dependence (columns 3-4), financial constraints (columns 5-6) and or for credit ratings (columns 7-8). The coefficient on the interaction term $EDS_t \times FinSensitivity_{it}$ represents the difference-in-difference estimate described in the methodology section. In all regressions, we control for firm-fixed effects α_i, and cluster standard errors by year, following Bertrand, Duflo and Mullainathan (2003).[10]

In Table IV Panel A we still find that *EDS* has a strong negative relation with the quantity of innovative output. More importantly, we document that firms experience an even stronger decline in innovative output when they are in the top quintile of short-term debt, as indicated by the negative interaction term in columns (1) and (2). The results are

[10]Because of the significantly increased number of clusters added by the interaction terms, we do not cluster by both firm and year in these specifications. The results are robust to clustering by firm and year, where the coefficients on the interaction term are the same in magnitude and similar in significance. They appear in the Internet Appendix in tables IA-IV, Panels A and B.

economically significant. For firms in the bottom 4 quintiles of short-term debt, a one-standard deviation increase in EDS is associated with 3.7% (2.9%) fewer patents 3 (4) years later. For firms in the top quintile of short-term debt, the same one standard deviation increase in EDS is associated with 6.5% (8.7%) fewer patents, which is about 75% (200%) higher.

We also find that the negative association between unexpected military spending and innovation is disproportionately larger for firms operating in industries that rely more on external financing. The interaction term is only significant in t+4 (column (4)). At the mean of external financial dependence, a one-standard deviation increase in EDS is associated with 4.8% fewer patents 4 years later. If external financial dependence increases by one standard deviation from the mean, the same one standard deviation increase in EDS is associated with 5.2% fewer patents, which is about 8% higher.

Next, we document that the negative relation between exogenous defense spending and innovation is greater for firms that are more financially constrained. At the mean of financial constraints, a one-standard deviation increase in EDS is associated with 5.5% (4.8%) fewer patents 3 (4) years later. If financial constraints increase by one standard deviation from their mean, the same one standard deviation increase in EDS is associated with 7.2% (6.0%) fewer patents, which is about 30% (26%) higher. Finally, we find that the coefficient on the interaction term between unexpected military spending and the credit rating indicator variable is negative, though statistically insignificant.

We repeat the analysis in Table IV Panel B, where the dependent variable is the

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number of citations per patent. We find the interaction terms between unexpected military spending and the level of short-term debt (columns (1) and (2)) are not significant. The coefficient on the interaction term between exogenous military spending and external financial dependence (columns 3 and 4), however, are significantly negative three and four years after the shock. At the mean of external financial dependence, a one-standard deviation increase in EDS is associated with 2.2% (3.5%) fewer citations per patent, 3 (4) years later. If financial constraints increase by one standard deviation from their mean, the same one standard deviation increase in EDS is associated with 2.3% (3.7%) fewer citations per patent, which is about 7% (4%) higher.

Next, we document that the negative relation between exogenous defense spending and innovation is greater for firms that are more financially constrained. The coefficient on the interaction term is significant only in t+4. At the mean of financial constraints, a one-standard deviation increase in EDS is associated with 3.6% fewer citations per patent, 4 years later. If financial constraints increase by one standard deviation from their mean, the same one standard deviation increase in EDS is associated with 5.0% fewer citations per patent, which is about 40% higher.

Furthermore, unlike the results in columns (7) and (8) of Table IV Panel A, we find that the negative association between unexpected military spending and innovation is also disproportionately larger for firms with lower credit ratings (speculative grade) (columns (7) and (8)). For firms with speculative grade credit ratings, a one-standard deviation increase in EDS is associated with 4.2% (3.7%) fewer patents 3 (4) years later. For firms

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with investment grade credit ratings, the same one standard deviation increase in EDS is associated with only 1.7% (0.7%) fewer patents, which is about 60% (80%) smaller. Overall, these results provide strong support for the crowding-out hypotheses and the credit channel.

IV.B Time-Series Analysis: A Predicted-Value and an Instrumental Variable Approach

In this section, we directly test if an increase in government military spending is followed by an increase in short-term government borrowing (first-stage) and, further, whether this increase is associated with lower innovation (second-stage). We focus on short-term government borrowing since, as shown in Greenwood, Hanson and Stein (2010, 2015), short-term borrowing is especially relevant for crowding out. In addition, short maturity borrowing is expected to be more important for innovative firms that are more sensitive to external financing, since they are likely to be less able to borrow at longer maturities.

To measure short-term government borrowing we use the variable *AbnSTGovBor*, which is equal to the difference between the actual value of short-term government debt minus the predicted value of short-term government debt obtained from a regression of short-term government debt on a time trend. In other words, *AbnSTGovBor* measures the deviation of the actual value from the predicted trend value. Specifically we estimate the following simple model to obtain the *AbnSTGovBor* variable :

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$$STGovBor_t = \alpha_i + \beta_1 * T + \epsilon_{it}, \tag{5}$$

where t indexes time, $STGovBor_t$ is the dependent variable, and T is the time variable measured in years. Following Greenwood, Hanson, and Stein (2015), we set the amount of *STGovBor*, which is government short-term treasury debt equal to the sum of all payments due in 1 year or less, divided by total payments in all future periods.[11] We denote the predicted value from the trend regression model by *PredictSTGovBor*. The abnormal short-term government borrowing variable is calculated as the difference between the actual and the predicted value *i.e., AbnSTGovBor = STGovBor - PredictSTGovBor*.

In Table V, we estimate a two-stage model. Table V, Panel A presents the first-stage results. We use a Newey-West estimation techniques to control for autocorrelation in the time-series. We use 1-lag model in columns 1 and 2 and 5-lag model in columns 3 and 4. Supportive of our proposed credit channel, we find that *AbnSTGovBor* is positively related to exogenous defense spending (*EDS*) in all models. This finding is consistent with the hypothesis that an increase in exogenous government spending is associated with more abnormal short-term government borrowing. As control variables, we also include variables that appear in the second-stage of the estimation, such as the log of GDP, real investment, total market capitalization, the value-weighted total stock market

[11] These are nominal amounts. We use the CRSP treasuries dataset from 1925 to 2014, aggregated at the year level to calculate this measure.

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return, and the excess return on the top three defense contractors. The predictors are relevant, as indicated by regression F-statistics > 10.[12]

We next investigate if the increase (decrease) in short-term government borrowing, associated with increased spending is related to corporate innovation. We obtain the predicted values of *AbnSTGovBor* from Table V Panel A, and relate these values to the number of patents and the number of citations per patent in Panel B. Our expectation is that an increase in short-term government borrowing associated with an exogenous increase in defense spending will crowd out private borrowing and is associated with lower innovation.

In Table V, Panel B, we report the results using the predicted values of *AbnSTGovBor* from regressing *AbnSTGovBor* on *EDS* on the number of patents (columns (1) and (2)) and the number of citations per patent (columns (3) and (4)). We find a strong negative relation between the exogenous increase of short-term government borrowing and the quantity and quality of innovative output. The results in Table V are useful to illustrate the first and second stage of the relation between short-term borrowing and innovation. They also estimate the first and second stage using the most appropriate estimation models: Newey-West in the first stage and fixed effects Poisson in the second stage. The standard errors using this sequential estimation technique could be of concern, however, because the equations are not estimated simultaneously, in a unified regression framework.

[12]The F-statistic is 4.82, when only *ExogDefenseExp* and no control variables are included.

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To correct for any potential misspecification, in Table VI we conduct an instrumental variable regression, where we use unexpected military spending to instrument for the abnormal short-term government borrowing. Given estimation constraints in the simultaneous equations two-stage least squares technique, we use a log-linear specification, where the dependent variable is *Ln(1+Patents)* in columns 1-2 and *Ln(1+Citations/Patent)* in columns 3-4. The results again demonstrate a negative and strongly significant relation between abnormal, short-term government borrowing and the quantity and quality of innovation. Overall, the findings from Tables V and VI are consistent with the hypothesis that government borrowing crowds out corporate investment and innovations, possibly because it decreases the availability of credit. This finding also has important policy implications in terms of the maturity of debt issuance. Our results suggest that there is a negative unintended association between government borrowing at the short-end of the maturity spectrum and corporate innovation.

IV.C The Relation between Exogenous Federal Government Spending and R&D Expenditures and the Economic Value of Patents

We have shown above that shocks to government spending and taxes are related to the quantity and quality of innovative output. We have also provided some evidence that the credit channel contributes to crowding out. To provide further support for our hypotheses, we examine two additional innovation metrics. We first test if the shocks to government spending are related to a key innovation input: R&D expenditures. They

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provide an intermediate step in the innovation process. If the credit channel story is valid, we should observe that firms cut R&D expenditures after an increase in unexpected government defense spending.

We report the results in Table VII. We find a negative relation between exogenous changes in government military expenditures and corporate R&D expenditures in the same year (columns 1 and 3). We find that firms respond immediately to these shocks with lower R&D. We do not find a significant change in R&D in the following year. The results support the hypothesis that increased exogenous government spending is associated with lower availability of financing for R&D. These results support the conjecture that unexpected changes in military spending are followed by an immediate decrease in R&D, and that is followed by a decrease in patents and citations per patent 3-4 years later as documented in the previous section.

Our second test addresses the concern that changes in patents or citations may not be significantly associated with shareholder value. More specifically, the concern is that, even though the number of patents and citations per patent declines, firms might be focusing on their most valuable innovations, and therefore shareholder value might not be affected. To test this hypothesis, we use the measure of the real economic value of patents as our dependent variable.[13] The measure is developed by Kogan et al. (2017) and uses the stock market reaction to a patent grant. The results in Table VII, columns 5-8, support our crowding-out hypothesis. We find that unexpected increases in government spending

[13]For robustness, we also use the nominal value and find similar results.

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are followed by lower real economic patent value 2 and 3 years later. This finding suggests that not only is innovative output adversely associated with government spending, but these innovations are less valuable and shareholder value diminishes.

IV.D Military Industry Analysis

In the preceding sections, we documented that unexpected government military spending is followed by a decrease in innovation, especially for firms with weaker balance sheets. In this section, we investigate if there are specific industries that might potentially benefit from the increased military spending. An obvious candidate is an industry that could be sourced to provide the military with new technology, or that receives a greater amount of government subsidies or contracts. To this end, we look at the differential association of unexpected military spending with innovation in industries related to the military. In particular, we consider the following industries: Transportation Equipment (SIC code 37), National Security and International Affairs (SIC code 97), Transportation by Air (SIC code 45) and Transportation Services (SIC code 47). These industries were selected based on reading industry descriptions to determine which industries were likely to conduct business with the military. For example, Transportation Equipment includes manufacturing aircraft, aircraft engines, missiles and space vehicles, and tanks for the military. The results are reported in Table VIII. We find that the interaction term on the military-related industry indicator variable with unexpected military spending is positive and significant in all regressions, suggesting that these firms exhibit an increase in patents

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and citations per patent after unexpected military shocks and the subsequent increase in defense spending.

V The Relation between Exogenous Federal Taxes and the Quantity and Quality of Innovative Output

In this section, we provide an additional test for the credit channel. If unexpected defense spending increases the government's need to borrow and crowds out private borrowers, we should expect the opposite effect when there is an unexpected increase in government revenue. We do this by exploiting another type of unexpected change in government fiscal policy that can similarly affect the government's need to borrow, especially in the short-term, and "crowd-in" (if government's need to borrow is reduced) firms back into the credit markets. Instead of expenditures, we now focus on exogenous changes in taxes, which should affect government borrowing in the opposite direction. We estimate the following model:

$$y_{i(t+n)} = \alpha_i + \beta ExogenousTax_t + \gamma X_{it} + \epsilon_{it}, \tag{6}$$

where, as before, i indexes firms, t indexes time, $y_{i(t+n)}$ is the dependent variable, which is either patents, propensity to patent and citations/patent in Table IX Panel A, while R&D expenses and economic value of patents are dependent variables in Table IX Panel B and n is the number of years after the current time period t. *RomerExogTax* is a variable that

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measures the present discounted value of exogenous changes in government revenue from taxes as described in Romer and Romer (2010). It is equal to the exogenous tax change in a given year divided by real GDP. The regressions include firm-fixed effects α_i. The vector X_{it} includes variables similar to those in Tables II and III to control for various firm attributes such as size, profitability, the amount of tangible assets, the availability of cash and financial leverage. Since changes in real GDP can be a factor that influences both tax changes and innovation, we also include the log of real GDP and the log of real aggregate investment in our regression models.

We argue that an unexpected increase in tax revenues will reduce crowding out because the government will have more funds and will need to borrow less from the financial markets. A possible concern is that by increasing taxes, the government takes productive resources away from the private sector, causing innovation to decline. However, as noted, we focus predominantly on taxes that are unexpected and exogenous to the individual firm. In particular, we exclude taxes that could directly affect the incentives of firms to innovate and invest in R&D and focus mostly on the indirect effect through the government borrowing channel.

As noted earlier, Romer and Romer (2010) use a narrative approach of Congressional legislation that affects future tax revenues. They classify the motivation for each tax change into one of four categories, of which they argue that two can be taken as exogenous: (i) dealing with an inherited budget deficit; and (ii) achieving some long-run goal, such as higher normal growth, increased fairness, or a smaller role for government.

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The variable *RomerExogTax* is equal to the sum of these two types of tax changes divided by GDP.

Table IX Panel A, columns 1 and 2 report the results for the number of patents, columns 3 and 4 report the results for the propensity to patent and columns 5 and 6 report the results for the number of citations per patent. We find a positive and significant relation between *RomerExogTax* and the propensity to patent and number of citations to patent in years t+4. We find no significant relation with the number of patents. The results suggest that unexpected increases in exogenous taxes that are unrelated to the business cycle and to the change in aggregate demand and GDP, are associated with an increase in the quality of corporate innovation and the choice to patent, but are not significantly related to the quantity of innovation. The results are economically significant, but smaller in magnitude than those for the exogenous defense spending. A one standard deviation (0.67) increase in exogenous tax revenue from the mean is followed by a 0.6% increase in the propensity to patent, and a 1.2% increase in the number of citations per patent 4 years later.

In Table IX, Panel B, we examine the relation between exogenous taxes and R&D expenditures and the real economic value of patents. Just like for the change in exogenous defense spending, we find that a change in exogenous taxes is followed by an immediate increase in R&D investment in the same year, but not in the following year. We also find that the real economic value of patents is higher 2 and 3 years after the change in exogenous taxes. Overall, the results in Table IX support our main hypothesis of a credit

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channel in the crowding-out relation of government spending. When tax receipts increase unexpectedly for reasons unrelated to economic fluctuations, the government's need to borrow decreases, followed by a greater immediate investment in R&D and a subsequent increase in the quality of future innovation.

VI Conclusion

In this paper we document evidence consistent with unexpected exogenous shifts in federal government spending and borrowing crowding out corporate borrowing. We find that these shifts are followed by lower corporate investment in R&D and by declines in the quantity, quality, and economic value of innovative output. We show that these associations are robust across several complementary specifications based on exogenous variation in government expenditures due to military buildups and draw-downs. We also use exogenous changes in taxes, especially those aimed at reducing an inherited budget deficit.

We find support for a credit or financial markets channel through which unexpected spending or taxes is followed by lower corporate R&D and innovation. Specifically, we document that shocks to government spending are followed by a disproportionately greater reduction in innovative activity by firms with more short-term debt, larger dependence on external finance, greater financial constraints and lower credit ratings. The shocks to federal government spending are shown to be related to short-term government borrowing, which, in turn, is followed by lower corporate innovation. Our findings suggest that government fiscal policy may have adverse consequences not only in the short-run, but also

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for long-run economic growth through its possible association with corporate innovation, especially for firms that are financially constrained and more sensitive to availability of external financing.

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Appendix A: Variable Definitions

AbnSTGovBor$_t$**:** Equal to the difference between the actual value of short-term government debt minus the predicted value of short-term government debt obtained from a regression of the amount of short-term government debt on a time trend (Source: CRSP).

BudgetSurpl$_t$**:** The federal government's budget surplus in year t divided by GDP (Source: FRED, St. Louis Fed).

Cash$_{it}$**:** Cash of firm i in year t divided by its *Assets* (Source: Compustat).

Citations/Patent$_{it}$**:** Measures the number of citations per patent applied for in year t by firm i. The weight of each patent is the number of citations received by a patent applied for in year t divided by the total number of citations received by all patents applied for in year t (Source: NBER Patent Data).

EDS$_t$**:** The present discounted value of exogenous changes in military expenditures divided by real GDP (Source: Ramey (2011)).

ExFD**:** The median industry financial dependence measure developed by Rajan and Zingales (1997) and Duchin et al. (2010). (Source: CRSP/Compustat Merged Database, Rajan and Zingales (1997); Duchin et al. (2010)).

ExogTax$_t$**:** Measures the unanticipated changes in tax revenue divided by real GDP (Source: Romer and Romer (2010)).

ExogWar$_t$**:** Equals 1 if the year is 1950 (the Korean War), 1965 (the escalation of the Vietnam War), 1980 (the Soviet invasion of Afghanistan), or 2001 (9/11), and 0 otherwise (Source: Ramey (2011)).

FCon**:** An index that measures financial constraints (Source: CRSP/Compustat Merged Database; Whited and Wu (2006)).

HI$_{it}$**:** Herfindahl index of firm i in year t constructed based on sales in the 4-digit SIC industry (Source: Compustat).

IGrade$_{it}$**:** A dummy variable equal to 1 if firm i in year t has a credit rating of BBB or higher, and 0 otherwise (Source: Compustat).

Leverage$_{it}$**:** Total debt of firm i in year t divided by its total assets (Source: Compustat).

LnRDefExp$_t$**:** The natural logarithm of inflation-adjusted total defense expenditures (Source: Ramey (2011)).

LnRGDP$_t$**:** The natural logarithm of inflation-adjusted GDP (Source: Ramey (2011)).

LnRInv$_t$**:** The natural logarithm of inflation-adjusted aggregate investment (Source: Ramey (2011)).

LnSales$_{it}$**:** The natural logarithm of sales by firm i in year t (in $ million) (Source: Compustat).

LnTotCap$_t$**:** The natural logarithm of total stock market capitalization (Source: CRSP Stock File Indexes — Annual Index Built on Market Capitalization).

MilInd$_{it}$**:** Equals 1 if firm i in year t belongs to a military-related industry (SIC codes 37, 45, 47, or 97), and 0 otherwise (Source: Compustat).

Patent$_{it}$**:** Count of patents applied for in year t by firm i divided by the mean number of patents across all firms in that year t (Source: NBER Patent Data).

Profitability$_{it}$**:** Earnings before interest, depreciation, taxes, and amortization (EBITDA) of firm i in year t divided by its total assets (Source: Compustat).

RD/TA$_{it}$**:** Research & Development expenditures by firm i in year t divided by its total assets (Source: Compustat).

***STDH*:** Indicator variable equal to 1 if a firm is in the top quintile of short-term debt to total assets in a given year. Short-term debt includes the portion of long-term debt maturing in less than one year (Source: CRSP/Compustat Merged Database; Duchin et al. (2010)).

Tangibility$_{it}$**:** Net property, plant, and equipment of firm i in year t (NPPE$_{it}$) divided by its total assets (Source: Compustat).

***Tax*:** Federal tax receipts divided by GDP (Source: Ramey (2011); Bureau of Economic Analysis).

***Top3Xret*:** Stock return of the top three defense contractors (Source: Fisher and Peters (2010)).

***VWR*:** Total stock market value-weighted return (Source: CRSP/Compustat).

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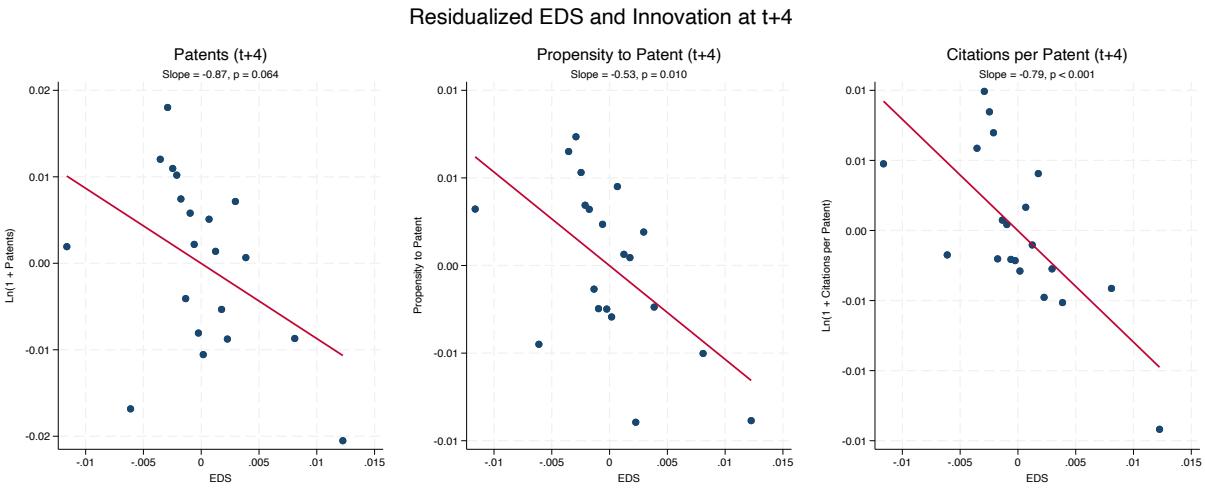


Figure 1: Binscatter: Residualized EDS and Innovation at $t + 4$

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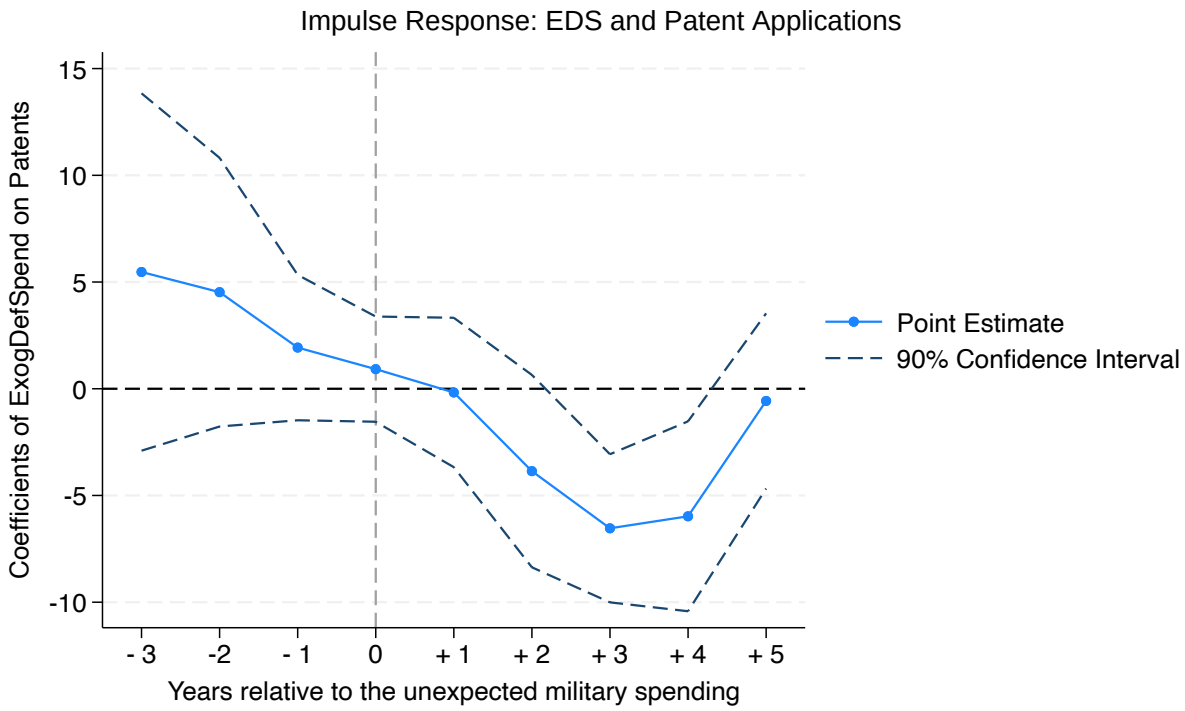


Figure 2: Impulse Response: EDS and Patent Applications

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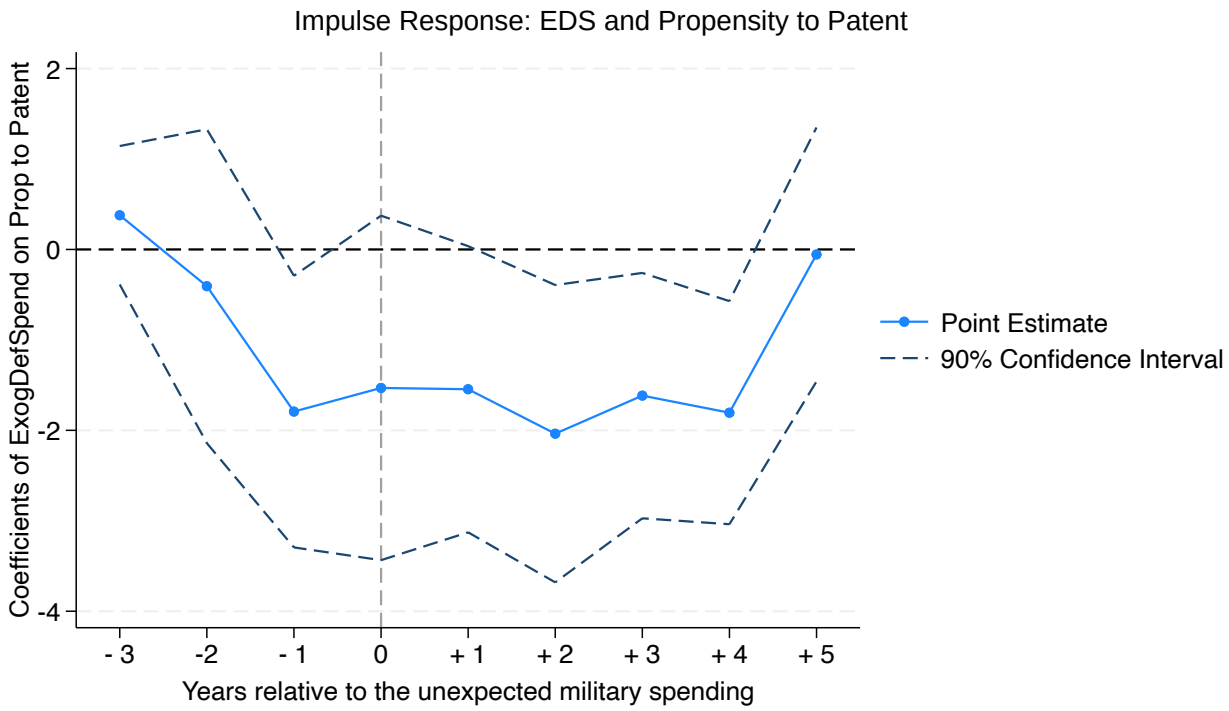


Figure 3: Impulse Response: EDS and Propensity to Patent

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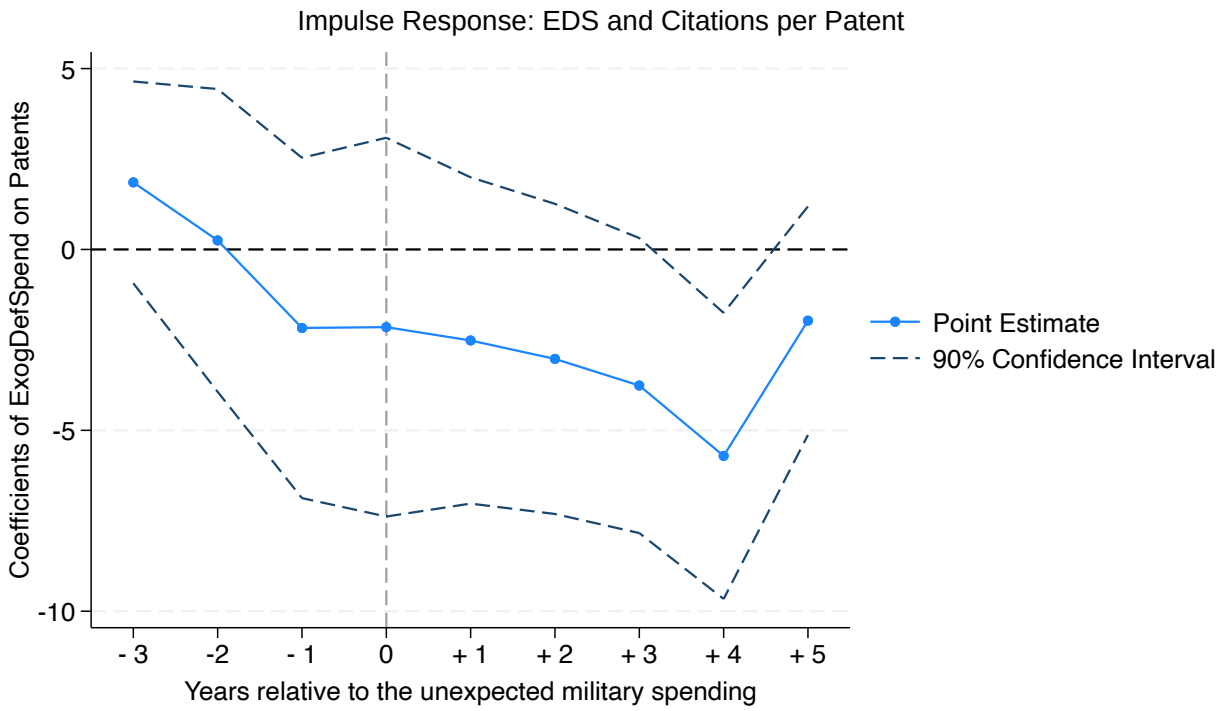


Figure 4: Impulse Response: EDS and Citations per Patent

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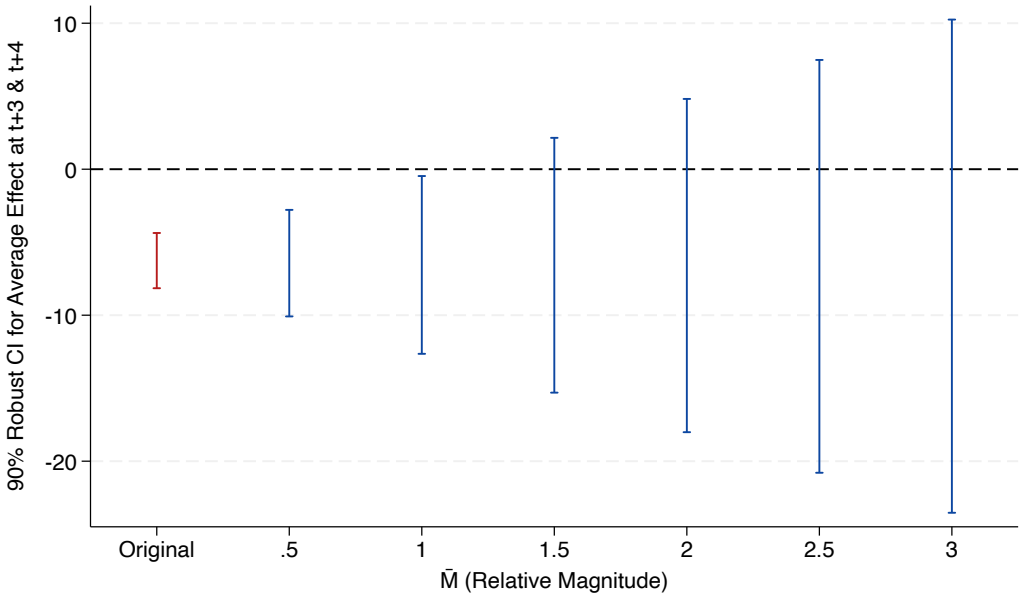


Figure 5: HonestDiD Sensitivity: Patent Applications

Notes: This figure plots robust 90% confidence intervals for the average coefficient on exogenous defense spending for patent counts across horizons $t+3$ and $t+4$ following Rambachan and Roth (2023). The horizontal axis shows $\bar{M}$, the relative magnitude parameter that bounds the ratio of post-period to pre-period violations of parallel trends. The breakdown value is between 1.0 and 1.5.

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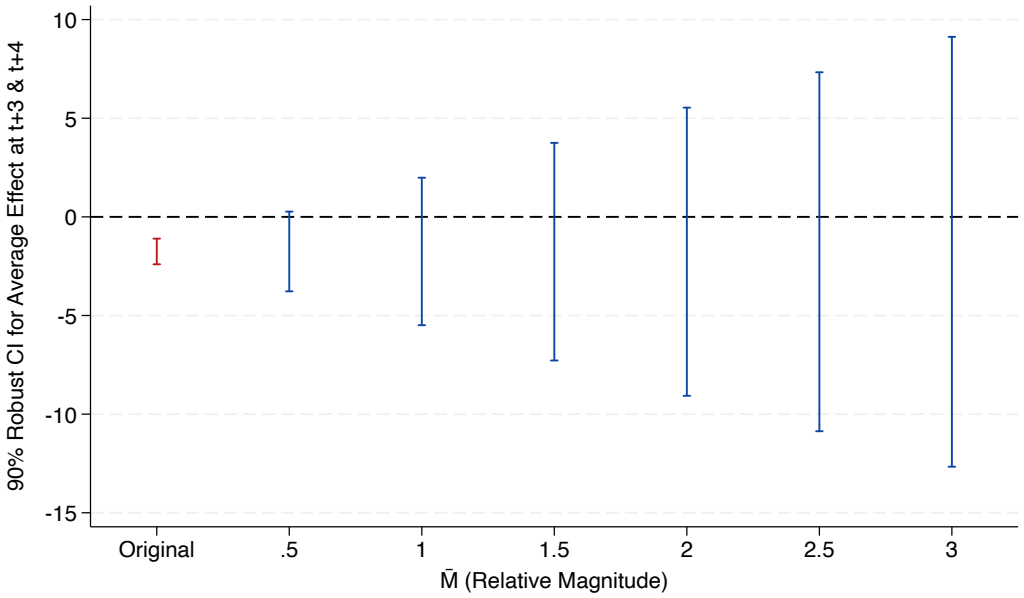


Figure 6: HonestDiD Sensitivity: Propensity to Patent

Notes: This figure plots robust 90% confidence intervals for the average coefficient on exogenous defense spending for the propensity to patent across horizons $t+3$ and $t+4$ following Rambachan and Roth (2023). The horizontal axis shows $\bar{M}$, the relative magnitude parameter that bounds the ratio of post-period to pre-period violations of parallel trends. The breakdown value is below 0.5.

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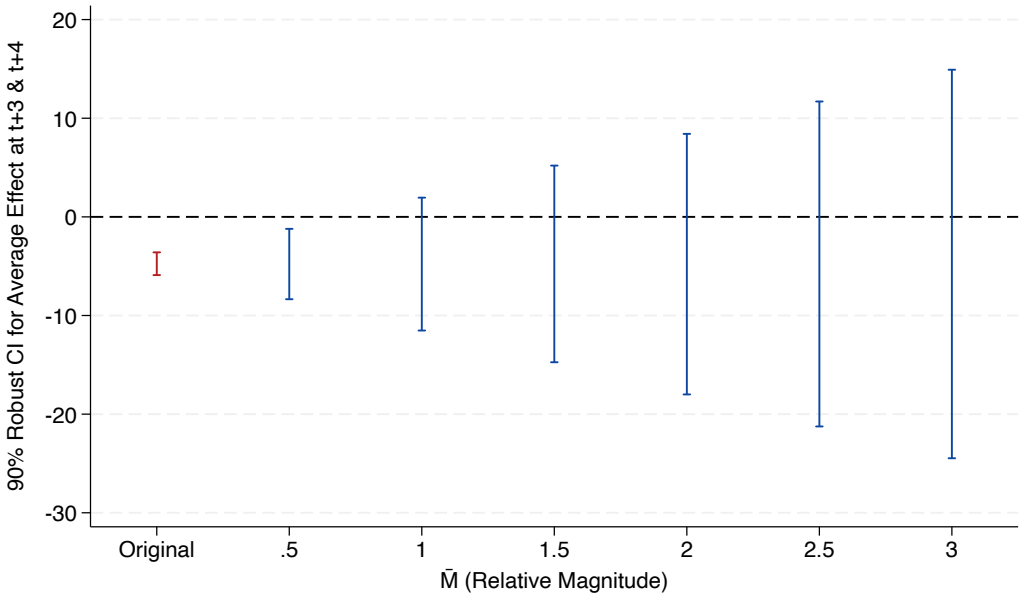


Figure 7: HonestDiD Sensitivity: Citations per Patent

Notes: This figure plots robust 90% confidence intervals for the average coefficient on exogenous defense spending for citations per patent across horizons $t+3$ and $t+4$ following Rambachan and Roth (2023). The horizontal axis shows $\bar{M}$, the relative magnitude parameter that bounds the ratio of post-period to pre-period violations of parallel trends. The breakdown value is approximately 0.75 to 1.0.

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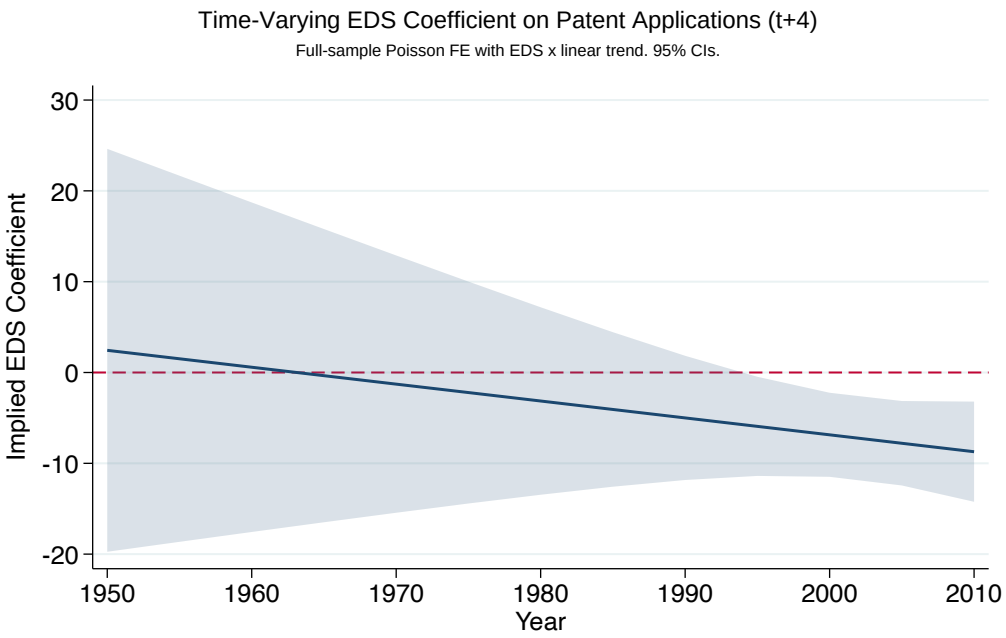


Figure 8: Temporal Stability: Time-Varying EDS Coefficient on Patent Applications at $t+4$

Notes: This figure plots the implied time-varying *EDS* coefficient from a Poisson QMLE specification with firm fixed effects, where the continuous *EDS* measure is interacted with a linear time trend. The dependent variable is the number of patent applications at horizon $t+4$. The shaded region represents 95% confidence intervals based on standard errors clustered at the firm and year level.

Table I
Summary Statistics

Variable	Mean	Median	SD	Min	Max
Patents	8.1	0	81	0	8891
PatentDum	.24	0	.43	0	1
Citations/Patent	.32	0	1.3	0	87
RD/TA	.034	0	.085	0	.61
LnSales	4.6	4.6	2.4	-6.9	13
Profitability	.06	.1	.49	-134	24
Tangibility	.28	.22	.25	0	1
Cash/TA	.092	.038	.14	0	1
Leverage	.25	.21	.38	0	1
HI	.19	.14	.16	.013	1.3
HI^2	.06	.02	.12	.00016	1.6
LnRGDP	9.1	9.2	.33	7.9	9.6
LnRInv	7.4	7.3	.35	6	7.9
LRDefExp	6.3	6.3	.18	6	6.6
BudgSurpl/GDP	-2.1	-2.5	1.9	-5.7	2.3
Tax	.18	.18	.0095	.16	.2
Top3Xret	1.1	1.1	.34	.22	1.7
LnTotMktVal	22	22	1.1	19	24
VWR	.11	.16	.19	-.38	.45
ExogWar	.053	0	.22	0	1
EDS	.00038	0	.006	-.022	.018

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Table IIA:
The Relation between Unexpected Military Spending and the Number of Patents

This table reports the results relating the number of patents to exogenous changes in military expenditures. Specifically we estimate a firm-fixed effects Poisson model of $Patent_{it}$ on EDS_t, which is equal to the present discounted value of unexpected military spending scaled by GDP. Other controls include LnSales, RD/TA, Profitability (Profit.), Tangibility (Tang.), Cash, Leverage (Lev.), LnRGDP (LnRGDP), LnRInv (LnRInv), BudgetSurpl/GDP (BS/GDP), Herfindahl index HI, RealDefExp (RDefExp), the total federal receipts divided by GDP (Tax), the log of total market capitalization (LnTotCap), the Value Weighted Total Stock Market Return (VWR), and the excess stock return of the top three defense contractors (Top3Xret). All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm and year level. Data is for the period 1950 to 2010. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4	t+5
	1	2	3	4	5	6	7	8	9
EDS	5.470	4.525	1.930	.919	-.173	-3.858*	-6.538***	-5.975***	-.572
	(4.271)	(3.211)	(1.738)	(1.257)	(1.786)	(2.300)	(1.770)	(2.270)	(2.094)
LnSales	.633***	.687***	.704***	.691***	.654***	.607***	.556***	.503***	.445***
	(.049)	(.047)	(.046)	(.047)	(.047)	(.047)	(.046)	(.046)	(.048)
RD/TA	.392	.686	.749*	.715*	.379	.157	-.036	.040	.342
	(.556)	(.474)	(.437)	(.433)	(.439)	(.432)	(.468)	(.546)	(.621)
Profit.	-.948***	-.950***	-.854***	-.644***	-.612***	-.446***	-.360**	-.167	-.085
	(.237)	(.206)	(.184)	(.177)	(.160)	(.156)	(.176)	(.179)	(.066)
Tang.	.205	.251	.223	.142	.049	-.100	-.198	-.327	-.423
	(.337)	(.332)	(.347)	(.364)	(.370)	(.377)	(.387)	(.410)	(.440)
Cash	.117	.060	.029	.032	.036	.053	.221	.250	.148
	(.267)	(.244)	(.223)	(.222)	(.203)	(.194)	(.191)	(.187)	(.198)
Lev.	-.487***	-.428***	-.393**	-.392**	-.461***	-.478***	-.436***	-.343**	-.266
	(.166)	(.164)	(.163)	(.165)	(.155)	(.148)	(.152)	(.162)	(.176)
LnRGDP	-1.822**	-1.977***	-1.692***	-1.191**	-1.644***	-1.598***	-1.544***	-.724	.070
	(.719)	(.590)	(.511)	(.486)	(.436)	(.521)	(.482)	(.625)	(.756)
LnRInv	.981**	.661*	.182	-.121	-.021	-.282	-.578***	-1.222***	-1.485***
	(.440)	(.364)	(.292)	(.257)	(.232)	(.249)	(.198)	(.269)	(.345)
BS/GDP	.156***	.159***	.160***	.159***	.127***	.092***	.056***	.040*	.037**
	(.025)	(.021)	(.019)	(.015)	(.015)	(.017)	(.020)	(.021)	(.018)
HI	-3.409***	-3.412***	-3.419***	-3.477***	-3.369**	-3.189**	-2.947**	-3.023**	-2.908**
	(1.076)	(1.099)	(1.193)	(1.339)	(1.351)	(1.346)	(1.271)	(1.280)	(1.252)
HI^2	3.220***	3.171***	3.102***	3.068**	3.010**	2.880**	2.646**	2.761**	2.676**
	(1.112)	(1.100)	(1.165)	(1.273)	(1.262)	(1.242)	(1.137)	(1.115)	(1.068)
RDefExp	.622*	.533*	.365	.258	.149	-.056	-.213	-.193	-.005
	(.324)	(.286)	(.264)	(.215)	(.194)	(.200)	(.170)	(.189)	(.163)
LnTotCap	.062	.169	.209**	.160**	.311***	.440***	.565***	.533***	.383***
	(.138)	(.109)	(.093)	(.077)	(.068)	(.090)	(.094)	(.120)	(.132)
Tax	-31.448***	-31.651***	-28.900***	-25.340***	-20.557***	-16.321***	-12.171***	-6.947**	-1.659
	(3.204)	(2.785)	(2.637)	(2.666)	(2.751)	(2.890)	(2.713)	(2.723)	(2.886)
VWR	-.201	-.133	-.134	-.066	-.161***	-.190**	-.335***	-.288***	-.168
	(.165)	(.134)	(.104)	(.071)	(.058)	(.095)	(.089)	(.109)	(.105)
Top3Xret	.027	.061	.124*	.077	.008	-.017	-.016	.045	.037
	(.128)	(.096)	(.067)	(.053)	(.057)	(.052)	(.057)	(.066)	(.077)
Obs.	75419	81526	87407	92835	87013	81563	76385	71489	66772
P-R2	.924	.926	.925	.922	.924	.924	.925	.925	.926

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Table IIB:
The Relation between Unexpected Military Spending and the Propensity to Patent

This table reports the results relating the propensity to patent to exogenous changes in military expenditures (EDS). Specifically we estimate a firm-fixed effects model of $PatDum_{it}$ on the variable EDS_t, which is equal to the present discounted value of unexpected military spending scaled by GDP. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, BudgetSurpl/GDP, Herfindahl index HI, RealDefExp, the total federal receipts divided by GDP (Tax), the log of total market capitalization (LnTotCap), the Value Weighted Total Stock Market Return (VWR), and the excess stock return of the top three defense contractors (Top3Xret). All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm and year level. Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4	t+5
	1	2	3	4	5	6	7	8	9
EDS	.379	-.406	-1.792**	-1.531	-1.545	-2.037**	-1.616*	-1.805**	-.055
	(.465)	(1.055)	(.913)	(1.158)	(.962)	(.999)	(.825)	(.750)	(.854)
LnSales	.103***	.123***	.129***	.116***	.107***	.095***	.085***	.077***	.066***
	(.011)	(.011)	(.010)	(.010)	(.011)	(.011)	(.010)	(.011)	(.011)
RD/TA	.124	.355***	.375***	.272***	.277***	.155*	.053	.071	.069
	(.081)	(.075)	(.073)	(.077)	(.081)	(.085)	(.090)	(.096)	(.084)
Profitability	-.068***	-.064***	-.046***	-.007	.004	-.023	-.0006	-.029***	-.014
	(.024)	(.021)	(.009)	(.020)	(.029)	(.028)	(.030)	(.009)	(.019)
Tangibility	-.016	-.001	.077	.031	-.056	-.083	-.029	-.031	-.004
	(.061)	(.065)	(.066)	(.059)	(.058)	(.065)	(.068)	(.070)	(.072)
Cash	.013	-.0007	.095**	.139***	.161***	.126***	.131***	.092**	.071*
	(.047)	(.039)	(.044)	(.038)	(.039)	(.039)	(.042)	(.043)	(.039)
Leverage	-.014	-.075**	-.148***	-.195***	-.198***	-.169***	-.153***	-.101***	-.073**
	(.027)	(.030)	(.028)	(.039)	(.044)	(.049)	(.031)	(.038)	(.036)
LnRGDP	-.417**	-.455***	-.378**	-.215	-.361**	-.570***	-.687***	-.682***	-.560***
	(.176)	(.164)	(.150)	(.207)	(.173)	(.181)	(.149)	(.165)	(.152)
LnRInv	.163*	.029	-.152**	-.330***	-.323***	-.237**	-.147	-.187**	-.226**
	(.091)	(.074)	(.077)	(.109)	(.103)	(.096)	(.091)	(.095)	(.095)
BudgetSurpl/GDP	.033***	.034***	.033***	.026***	.015**	.0001	-.008	-.006	-.003
	(.005)	(.006)	(.006)	(.007)	(.007)	(.008)	(.007)	(.007)	(.006)
HI	.084	.144	.297*	.324*	.323**	.198	.179	.246	.372*
	(.165)	(.159)	(.161)	(.175)	(.164)	(.174)	(.186)	(.185)	(.191)
HI^2	-.152	-.182	-.331*	-.383**	-.312*	-.184	-.168	-.239	-.375*
	(.184)	(.176)	(.175)	(.193)	(.178)	(.184)	(.195)	(.193)	(.197)
RealDefExp	.015	-.030	-.084	-.083	-.061	-.017	.034	.106**	.156***
	(.059)	(.065)	(.060)	(.064)	(.056)	(.050)	(.050)	(.051)	(.048)
LnTotCap	.042	.081**	.098***	.083*	.123***	.167***	.183***	.175***	.144***
	(.028)	(.035)	(.030)	(.045)	(.039)	(.042)	(.034)	(.037)	(.033)
Tax	-7.100***	-6.736***	-5.030***	-2.291**	-.380	1.199	1.438	1.315	1.533
	(.713)	(.737)	(.901)	(1.032)	(1.070)	(1.094)	(1.090)	(.992)	(1.003)
VWR	-.007	-.020	-.029	-.006	-.080*	-.100**	-.100***	-.067	-.053
	(.030)	(.031)	(.039)	(.056)	(.048)	(.047)	(.038)	(.041)	(.034)
Top3Xret	-.012	-.007	.007	-.027	-.045	-.074***	-.089***	-.031	-.003
	(.025)	(.028)	(.027)	(.032)	(.031)	(.023)	(.024)	(.028)	(.034)
Obs.	75419	81526	87407	92835	87013	81563	76385	71489	66772
P-R2	.156	.158	.157	.156	.155	.154	.154	.153	.152

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Table IIC:
The Relation between Unexpected Military Spending and the Number of Citations per Patent

This table reports the results relating the number of patents to exogenous changes in military expenditures. Specifically we estimate a firm-fixed effects Poisson model of $Citation/Patent_{it}$ on an indicator variable EDS_t, which is equal to the present discounted value of unexpected military spending scaled by GDP. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, BudgetSurpl/GDP, Herfindahl index HI, RealDefExp, the total federal receipts divided by GDP (Tax), the log of total market capitalization (LnTotCap), the Value Weighted Total Stock Market Return (VWR), and the excess stock return of the top three defense contractors (Top3Xret). All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm and year level. Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4	t+5
	1	2	3	4	5	6	7	8	9
EDS	1.855	.251	-2.169	-2.147	-2.515	-3.026	-3.761*	-5.706***	-1.968
	(1.423)	(2.135)	(2.400)	(2.671)	(2.301)	(2.187)	(2.080)	(2.017)	(1.612)
Sales	.103***	.111***	.100***	.069***	.063***	.048***	.043***	.041***	.034**
	(.015)	(.015)	(.013)	(.013)	(.014)	(.013)	(.014)	(.015)	(.015)
RD/TA	.092	.375**	.434***	.308**	.246*	.189	.005	.011	.126
	(.149)	(.165)	(.105)	(.128)	(.143)	(.140)	(.145)	(.149)	(.124)
Profitability	-.135*	-.107*	-.056***	.0003	.028	-.019	-.012	-.059***	-.024
	(.069)	(.063)	(.016)	(.042)	(.037)	(.040)	(.041)	(.016)	(.030)
Tangibility	-.079	-.062	-.024	-.091	-.185**	-.288***	-.217**	-.237**	-.124
	(.100)	(.099)	(.093)	(.091)	(.082)	(.087)	(.091)	(.101)	(.119)
Cash	-.009	-.030	.062	.218***	.224***	.153**	.193***	.148**	.071
	(.074)	(.065)	(.055)	(.063)	(.053)	(.062)	(.066)	(.066)	(.075)
Leverage	-.064	-.106**	-.183***	-.160*	-.212***	-.215***	-.199***	-.120*	-.070
	(.043)	(.051)	(.046)	(.093)	(.070)	(.062)	(.052)	(.062)	(.064)
LnRGDP	-.651**	-.811***	-.613**	-.529*	-.821***	-1.124***	-1.591***	-1.730***	-1.571***
	(.257)	(.270)	(.282)	(.311)	(.306)	(.315)	(.276)	(.306)	(.289)
LnRInv	.455***	.374**	.110	-.087	-.091	-.023	.165	-.007	-.185
	(.142)	(.160)	(.181)	(.212)	(.235)	(.211)	(.191)	(.177)	(.200)
BudgetSurpl/GDP	.012	.016	.025***	.025**	.014	.001	-.017*	-.022*	-.021**
	(.008)	(.010)	(.010)	(.012)	(.011)	(.011)	(.010)	(.012)	(.009)
HI	-.661**	-.505*	-.287	-.201	.040	.056	.356	.691**	.693**
	(.282)	(.285)	(.278)	(.306)	(.286)	(.286)	(.297)	(.301)	(.321)
HI^2	.331	.322	.106	.007	-.143	-.158	-.427	-.791***	-.732**
	(.293)	(.289)	(.268)	(.298)	(.261)	(.271)	(.280)	(.286)	(.317)
RealDefExp	.029	-.032	-.099	-.081	-.120	-.096	-.115	-.148	-.097
	(.076)	(.112)	(.113)	(.140)	(.120)	(.117)	(.111)	(.122)	(.094)
LnTotCap	-.067	.002	.011	.014	.103*	.174***	.260***	.333***	.318***
	(.047)	(.057)	(.061)	(.072)	(.058)	(.059)	(.059)	(.071)	(.061)
Tax	-5.949***	-6.602***	-5.303***	-2.111	.323	2.711	4.195***	4.285***	5.506***
	(1.178)	(1.290)	(1.754)	(1.963)	(1.803)	(1.708)	(1.594)	(1.641)	(1.658)
VWR	.074	.065	.069	.048	-.050	-.045	-.103	-.149**	-.109
	(.051)	(.070)	(.090)	(.104)	(.099)	(.086)	(.076)	(.069)	(.074)
Top3Xret	-.149***	-.161***	-.123**	-.101	-.100	-.125**	-.132**	-.027	.030
	(.042)	(.052)	(.059)	(.072)	(.070)	(.056)	(.052)	(.044)	(.056)
Obs	75062	81119	86938	92334	86525	80981	75658	70771	66041
P-R2	.25	.252	.252	.25	.25	.248	.249	.249	.249

Table II, Panel D:
The Relation between Exogenous Defense Spending and Innovation: Innovative Firms

This table reports the results relating the number of patents and citations per patent to exogenous changes in military expenditures. Specifically we estimate a firm-fixed effects Poisson model of $Patent_{it}$ (columns 1 and 2) and $Citations/Patent_{it}$ (columns 3 and 4) on a variable exogenous defense spending EDS, which is the present discounted value of exogenous military expenditures divided by real GDP. In columns 1 and 2, we analyze a subsample of firm-years with at least one patent. In column 3 and 4, we analyze a subsample of firms that have above the median number of citations per patent in a given year. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level in columns 1 and 2 and at the firm and year level in columns 3 and 4. Data is for the period 1950 to 2010. ***, ** and * denote significance at 1%, 5% and 10% respectively.

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	$Patent_{t+3}$	$Patent_{t+4}$	$Cit/Patent_{t+3}$	$Cit/Patent_{t+4}$
	1	2	3	4
EDS	-6.842***	-6.168***	-3.578*	-4.722**
	(1.747)	(2.246)	(1.903)	(2.283)
LnSales	.544***	.493***	.004	.007
	(.048)	(.048)	(.013)	(.014)
RD/TA	-.071	.017	.069	.242*
	(.484)	(.568)	(.166)	(.139)
Profitability	-.394**	-.238	.009	-.009
	(.191)	(.203)	(.049)	(.060)
Tangibility	-.125	-.252	-.295***	-.318***
	(.391)	(.418)	(.097)	(.094)
Cash	.194	.212	.113*	.043
	(.199)	(.195)	(.063)	(.067)
Leverage	-.428***	-.343**	-.095*	-.091
	(.157)	(.169)	(.053)	(.057)
LnRGDP	-1.490***	-.675	-1.467***	-1.477***
	(.487)	(.629)	(.290)	(.285)
LnRInv	-.572***	-1.217***	.281	.100
	(.199)	(.272)	(.199)	(.178)
BudgSurpl	.053***	.037*	-.008	-.013
	(.020)	(.021)	(.010)	(.010)
HI	-2.972**	-3.042**	.271	.456*
	(1.314)	(1.330)	(.269)	(.269)
HI^2	2.686**	2.796**	-.186	-.498*
	(1.176)	(1.163)	(.273)	(.275)
LnRDef	-.211	-.191	-.102	-.137
	(.173)	(.191)	(.109)	(.118)
LnTotCap	.557***	.526***	.183***	.231***
	(.095)	(.121)	(.056)	(.067)
Tax	-11.737***	-6.431**	3.140**	3.359**
	(2.730)	(2.714)	(1.520)	(1.565)
VWR	-.328***	-.283***	-.072	-.060
	(.089)	(.110)	(.076)	(.067)
Top3Xret	-.018	.040	-.114**	-.072
	(.057)	(.066)	(.056)	(.046)
Obs.	38127	35857	37585	35367
$P - R^2$	.913	.914	.174	.176

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Table II, Panel E:
The Relation between Exogenous Defense Spending and Innovation: Controlling for Policy Uncertainty

This table reports the results relating the number of patents, the propensity to patent and citations per patent to exogenous changes in military expenditures. Specifically we estimate a firm-fixed effects Poisson model of $Patent_{it}$ (columns 1 and 2), $PatentDum_{it}$ (columns 3 and 4) and $Citations/Patent_{it}$ (columns 5 and 6) on a variable exogenous defense spending EDS, which is the present discounted value of exogenous military expenditures divided by real GDP. The main control variable EPU, controls for policy uncertainty using Baker et al. (2016), who create an index based on policy uncertainty related news. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level in columns 1 and 2 and at the firm and year level in columns 3 and 4. Data is for the period 1950 to 2010. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Patent_{t+3}$	$Patent_{t+4}$	$PatentDum_{t+3}$	$PatentDum_{t+4}$	$Cit/Patent_{t+3}$	$Cit/Patent_{t+4}$
	1	2	3	4	5	6
EDS	-6.837***	-5.966***	-1.649*	-1.943***	-3.548*	-5.647***
	(1.912)	(2.218)	(.842)	(.726)	(1.909)	(1.734)
EPU	-.0006	.00007	-.0002	-.0002	.001*	.001
	(.001)	(.0009)	(.0004)	(.0004)	(.0006)	(.0007)
LnSales	.553***	.501***	.083***	.077***	.040***	.040***
	(.047)	(.047)	(.010)	(.011)	(.014)	(.015)
RD/TA	-.004	.039	.067	.084	.042	.029
	(.470)	(.547)	(.091)	(.098)	(.150)	(.154)
Profitability	-.381**	-.166	.005	-.028***	.003	-.058***
	(.183)	(.179)	(.030)	(.009)	(.044)	(.017)
Tangibility	-.199	-.338	-.027	-.015	-.245***	-.246**
	(.376)	(.405)	(.068)	(.069)	(.095)	(.100)
Cash	.213	.251	.125***	.097**	.178***	.152**
	(.192)	(.190)	(.042)	(.043)	(.065)	(.067)
Leverage	-.430***	-.334**	-.151***	-.092**	-.206***	-.114*
	(.153)	(.164)	(.031)	(.038)	(.052)	(.062)
LnRGDP	-1.372*	-.746	-.658***	-.636***	-1.866***	-2.023***
	(.737)	(.784)	(.201)	(.204)	(.323)	(.341)
LnRInv	-.649**	-1.201***	-.156	-.203**	.278	.108
	(.319)	(.339)	(.100)	(.096)	(.190)	(.174)
BudgSurpl	.053***	.040*	-.009	-.007	-.011	-.016
	(.021)	(.021)	(.007)	(.008)	(.010)	(.013)
HI	-2.936**	-3.018**	.200	.248	.404	.694**
	(1.275)	(1.288)	(.188)	(.185)	(.294)	(.302)
HI^2	2.651**	2.770**	-.187	-.237	-.484*	-.800***
	(1.137)	(1.122)	(.197)	(.193)	(.278)	(.288)
LnRDef	-.266	-.190	.026	.092*	-.043	-.085
	(.198)	(.190)	(.059)	(.054)	(.102)	(.107)
LnTotCap	.548***	.533***	.180***	.170***	.290***	.366***
	(.113)	(.132)	(.038)	(.041)	(.063)	(.074)
Tax	-11.774***	-7.028**	1.515	1.434	3.276**	3.316*
	(3.028)	(2.849)	(1.140)	(1.041)	(1.665)	(1.745)
VWR	-.357***	-.286***	-.109***	-.078**	-.066	-.114*
	(.086)	(.098)	(.039)	(.037)	(.077)	(.065)
Top3xsret	-.021	.043	-.091***	-.032	-.126**	-.021
	(.056)	(.066)	(.024)	(.028)	(.055)	(.047)
Obs.	75404	70546	75404	70546	74683	69836
$P - R^2$	.925	.925	.154	.153	.249	.249

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Table IIIA:
The Relation between Exogenous Wars and the Number of Patents

This table reports the results relating the number of patents to exogenous changes in military expenditures. Specifically we estimate a firm-fixed effects Poisson model of $Patent_{it}$ on a variable ExogWar, which is an indicator variable equal to one, if the year is 1950 (Korean War), 1965 (the escalation of the Vietnam War), 1980 (the Soviet invasion of Afghanistan) or 2001 (9/11). Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm and year level. Data is for the period 1950 to 2010. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Patent_{t+3}$	$Patent_{t+4}$
	1	2
ExogWar	-.104***	-.116***
	(.037)	(.038)
LnSales	.554***	.501***
	(.046)	(.046)
RD/TA	-.0007	.073
	(.472)	(.547)
Profitability	-.383**	-.194
	(.179)	(.184)
Tangibility	-.173	-.305
	(.391)	(.412)
Cash	.229	.257
	(.192)	(.188)
Leverage	-.422***	-.330**
	(.154)	(.164)
LnRGDP	-1.308***	-.477
	(.490)	(.647)
LnRInv	-.635***	-1.290***
	(.228)	(.301)
BudgSurpl	.060***	.046**
	(.020)	(.021)
HI	-2.958**	-3.030**
	(1.262)	(1.271)
HI^2	2.652**	2.765**
	(1.127)	(1.104)
LnRDef	-.154	-.147
	(.167)	(.180)
LnTotCap	.505***	.473***
	(.085)	(.112)
Tax	-11.060***	-5.874**
	(2.751)	(2.784)
VWR	-.299***	-.255**
	(.085)	(.102)
Top3Xret	-.054	.015
	(.068)	(.075)
Obs.	76385	71489
$P - R^2$	.924	.925

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Table IIIB:
The Relation between Exogenous Wars and the Propensity to Patent

This table reports the results relating the propensity to patent to exogenous changes in military expenditures. Specifically we estimate a firm-fixed effects Poisson model of $PatDum_{it}$ on a variable ExogWar, which is an indicator variable equal to one, if the year is 1950 (Korean War), 1965 (the escalation of the Vietnam War), 1980 (the Soviet invasion of Afghanistan) or 2001 (9/11). Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm and year level. Data is for the period 1950 to 2010. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$PatDum_{t+3}$	$PatDum_{t+4}$
	1	2
ExogWar	-.054***	-.082***
	(.014)	(.013)
LnSales	.084***	.077***
	(.010)	(.011)
RD/TA	.049	.067
	(.091)	(.097)
Profitability	-.003	-.030***
	(.029)	(.008)
Tangibility	-.024	-.025
	(.068)	(.069)
Cash	.132***	.093**
	(.042)	(.043)
Leverage	-.151***	-.099***
	(.031)	(.037)
LnRGDP	-.608***	-.572***
	(.153)	(.172)
LnRInv	-.176*	-.236**
	(.093)	(.099)
BudgSurpl	-.005	-.002
	(.007)	(.007)
HI	.186	.258
	(.185)	(.184)
HI^2	-.174	-.250
	(.194)	(.192)
LnRDef	.047	.114**
	(.049)	(.052)
LnTotCap	.165***	.153***
	(.031)	(.034)
Tax	1.734	1.725
	(1.156)	(1.062)
VWR	-.083**	-.048
	(.036)	(.039)
Top3Xret	-.090***	-.027
	(.026)	(.027)
Obs.	76385	71489
$P-R^2$	.154	.153

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Table III Panel C: The Relation between Exogenous Wars and the Number of Citations per Patent

This table reports the results relating the number of citations per patent to exogenous changes in military expenditures. Specifically we estimate a firm-fixed effects Poisson model of $Citations/Patent_{it}$ on a variable ExogWar, which is an indicator variable equal to one, if the year is 1950 (Korean War), 1965 (the escalation of the Vietnam War), 1980 (the Soviet invasion of Afghanistan) or 2001 (9/11). Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm and year level. Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$\frac{Citations}{Patent}_{t+3}$	$\frac{Citations}{Patent}_{t+4}$
	1	2
ExogWar	-.025	-.060**
	(.052)	(.028)
LnSales	.042***	.040***
	(.014)	(.015)
RD/TA	.009	.021
	(.145)	(.150)
Profitability	-.015	-.061***
	(.041)	(.015)
Tangibility	-.209**	-.223**
	(.091)	(.103)
Cash	.198***	.154**
	(.066)	(.067)
Leverage	-.198***	-.117*
	(.052)	(.062)
LnRGDP	-1.506***	-1.576***
	(.281)	(.309)
LnRInv	.185	.005
	(.190)	(.197)
BudgSurpl	-.013	-.016
	(.010)	(.012)
HI	.352	.690**
	(.296)	(.299)
HI^2	-.429	-.797***
	(.279)	(.286)
LnRDef	-.048	-.052
	(.097)	(.110)
LnTotCap	.223***	.274***
	(.052)	(.063)
Tax	4.465***	4.758***
	(1.580)	(1.725)
VWR	-.057	-.079
	(.064)	(.065)
Top3Xret	-.159***	-.064
	(.048)	(.048)
Obs.	75658	70771
$P-R^2$	.249	.249

Table IV, Panel A: Short-term debt, External Financial Dependence, Financial Constraints and Credit Ratings and the Quantity of Innovation

This table reports the results relating the number of patents to exogenous changes in military expenditures, and its interaction with corporate credit ratings. Specifically we estimate a firm-fixed effects Poisson model of $Patent_{it}$ on a variable EDS, which is the present discounted value of exogenous changes in military expenditures divided by real GDP, STDH (columns 1-2), which is an indicator variable equal to 1, if a firm is in the top quintile of short-term debt to total assets in a given year, ExtFD (columns 3-4), which measures industry-level external financial dependence in each year, *FCon* (columns 5-6), which is the Whited-Wu index of financial constraints, and IGrade, which is equal to one if the firm in a given year has a credit rating of BBB and above, and zero if the credit rating is below BBB. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, HI, HI^2, LnRGDP, LnRInv, Tax, BudgSurpl, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the year level. Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

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	Pat_{t+3}	Pat_{t+4}	Pat_{t+3}	Pat_{t+4}	Pat_{t+3}	Pat_{t+4}	Pat_{t+3}	Pat_{t+4}
	1	2	3	4	5	6	7	8
EDS	-6.229***	-4.902**	-5.907***	-4.555**	-13.069***	-10.843***	-2.687	-5.164
	(2.069)	(2.401)	(1.473)	(2.161)	(2.704)	(2.887)	(4.686)	(5.404)
STDH	.023	.068**						
	(.039)	(.033)						
STDH*EDS	-4.992**	-10.289***						
	(2.417)	(3.766)						
ExFD			-.001	-.004				
			(.002)	(.005)				
ExFD*EDS			-2.045	-3.353**				
			(1.589)	(1.585)				
FCon					-.126*	-.168*		
					(.075)	(.086)		
FCon*EDS					-17.588***	-12.999*		
					(6.091)	(6.706)		
IGrade							.072	-.059
							(.054)	(.054)
IGrade*EDS							-2.697	-.008
							(3.972)	(4.053)
LnSales	.544***	.489***	.546***	.494***	.565***	.508***	.625***	.569***
	(.029)	(.027)	(.029)	(.028)	(.027)	(.027)	(.027)	(.026)
RD/TA	-.365*	-.350	-.336	-.302	.186	.304	-.515	-.698
	(.198)	(.247)	(.207)	(.268)	(.224)	(.267)	(.482)	(.507)
Profitability	-.282***	-.086*	-.274***	-.088*	-.359***	-.161	-.202	.031
	(.096)	(.051)	(.095)	(.052)	(.114)	(.124)	(.175)	(.211)
Tangibility	-.113	-.212*	-.131	-.240*	-.207	-.356**	-.303*	-.379*
	(.128)	(.128)	(.128)	(.140)	(.127)	(.144)	(.180)	(.211)
Cash	.276**	.322***	.246**	.277***	.159	.175	.093	.120
	(.118)	(.095)	(.110)	(.094)	(.131)	(.122)	(.147)	(.178)
Leverage	-.448***	-.387***	-.384***	-.285***	-.392***	-.296***	-.230***	-.132
	(.066)	(.083)	(.078)	(.077)	(.082)	(.079)	(.088)	(.088)
LnRGDP	-1.874***	-1.076**	-1.649***	-.913*	-1.610***	-.817	-1.456***	-.505
	(.401)	(.492)	(.419)	(.516)	(.413)	(.514)	(.458)	(.576)
LnRInv	-.647***	-1.313***	-.547***	-1.194***	-.530***	-1.162***	-.506**	-1.186***
	(.162)	(.210)	(.172)	(.234)	(.165)	(.219)	(.222)	(.261)
BudgSurpl	.067***	.058***	.044**	.030	.058***	.042**	.055***	.042**
	(.017)	(.018)	(.021)	(.021)	(.017)	(.019)	(.020)	(.021)
HI	-2.659***	-2.680***	-3.186***	-3.279***	-3.015***	-3.063***	-3.859***	-3.987***
	(.400)	(.404)	(.393)	(.435)	(.383)	(.408)	(.458)	(.471)
HI^2	2.662***	2.757***	3.184***	3.363***	2.732***	2.816***	3.592***	3.709***
	(.409)	(.423)	(.457)	(.508)	(.410)	(.447)	(.461)	(.473)
LnRDef	-.095	-.027	-.283*	-.228	-.185	-.168	-.124	-.122
	(.128)	(.128)	(.163)	(.165)	(.155)	(.166)	(.174)	(.177)
LnTotCap	.657***	.626***	.594***	.575***	.556***	.531***	.442***	.384***
	(.098)	(.120)	(.095)	(.119)	(.084)	(.106)	(.094)	(.118)
Tax	-13.701***	-9.012***	-11.624***	-6.643***	-12.768***	-7.488***	-12.764***	-8.028***
	(1.613)	(1.856)	(1.930)	(2.003)	(1.716)	(1.972)	(1.998)	(2.190)
VWR	-.369***	-.317***	-.353***	-.315***	-.332***	-.288**	-.261**	-.208*
	(.098)	(.118)	(.093)	(.116)	(.091)	(.114)	(.104)	(.126)
Top3Xret	.054	.128*	.001	.080	-.026	.033	-.078	.003
	(.057)	(.069)	(.066)	(.080)	(.055)	(.065)	(.066)	(.077)
Obs.	73945	69129	68229	63638	70204	65681	24393	23702
$P - R^2$	.926	.927	.923	.925	.926	.927	.912	.912

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Table IV, Panel B: Short-term debt, External Financial Dependence, and Financial Constraints and the Quality of Innovation

This table reports the results relating the number of citations per patent to exogenous changes in military expenditures, and its interaction with short-term debt levels, external financial dependence and financial constraints. Specifically we estimate a firm-fixed effects Poisson model of $Citations/Patent_{it}$ on a variable EDS, which is the present discounted value of exogenous changes in military expenditures divided by real GDP, STDH (columns 1-2), which is an indicator variable equal to 1, if a firm is in the top quintile of short-term debt to total assets in a given year, ExtFD (columns 3-4), which measures industry-level external financial dependence in each year, *FCon* (columns 5-6), which is the Whited-Wu index of financial constraints, and IGrade, which is equal to one if the firm in a given year has a credit rating of BBB and above, and zero if the credit rating is below BBB. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, HI, HI^2, LnRGDP, LnRInv, Tax, BudgSurpl, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the year level. Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

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	Cit/Pat$_{t+3}$	Cit/Pat$_{t+4}$	Cit/Pat$_{t+3}$	Cit/Pat$_{t+4}$	Cit/Pat$_{t+3}$	Cit/Pat$_{t+4}$	Cit/Pat$_{t+3}$	Cit/Pat$_{t+4}$
	1	2	3	4	5	6	7	8
EDS	-3.668	-5.969***	-1.962	-4.495**	-4.597*	-9.191***	-7.155***	-6.318
	(2.267)	(2.085)	(2.109)	(2.206)	(2.660)	(1.832)	(2.773)	(4.008)
STDH	-.018	.003						
	(.015)	(.016)						
STDH*EDS	-.186	-.422						
	(2.649)	(2.063)						
ExtFD			.002**	-.001				
			(.0008)	(.001)				
ExFD*EDS			-1.521***	-1.374***				
			(.395)	(.530)				
FCon					-.039	-.017		
					(.087)	(.072)		
FCon*EDS					-3.147	-14.922**		
					(7.664)	(6.957)		
IGrade							.044	.036
							(.032)	(.028)
IGrade*EDS							4.372*	5.211**
							(2.312)	(2.529)
LnSales	.037***	.037***	.037***	.036***	.054***	.050***	.088***	.080***
	(.012)	(.010)	(.012)	(.011)	(.012)	(.011)	(.013)	(.015)
RD/TA	.002	.003	-.023	-.006	.175	.083	.680**	.889***
	(.116)	(.119)	(.112)	(.123)	(.121)	(.144)	(.277)	(.308)
Profitability	-.010	-.059***	-.009	-.059***	-.002	-.046**	-.002	.018
	(.035)	(.013)	(.036)	(.013)	(.051)	(.022)	(.108)	(.117)
Tangibility	-.215***	-.242***	-.133**	-.157**	-.272***	-.225***	-.310**	-.267*
	(.075)	(.078)	(.063)	(.079)	(.075)	(.081)	(.139)	(.142)
Cash	.208***	.170***	.221***	.185***	.128**	.095	.254*	.127
	(.054)	(.050)	(.053)	(.048)	(.055)	(.059)	(.133)	(.106)
Leverage	-.192***	-.119**	-.201***	-.124**	-.204***	-.123**	-.224***	-.162***
	(.041)	(.056)	(.039)	(.058)	(.038)	(.059)	(.061)	(.053)
LnRGDP	-1.672***	-1.855***	-1.681***	-1.901***	-1.701***	-1.875***	-1.653***	-1.637***
	(.269)	(.282)	(.257)	(.274)	(.270)	(.265)	(.231)	(.238)
LnRInv	.217	.046	.146	.023	.244	.068	.311*	.101
	(.186)	(.165)	(.172)	(.154)	(.193)	(.165)	(.171)	(.153)
BudgSurpl	-.016*	-.022**	-.005	-.014	-.011	-.017	-.002	-.010
	(.009)	(.011)	(.011)	(.013)	(.009)	(.011)	(.008)	(.010)
HI	.282	.636***	.218	.694***	.392**	.617***	.165	.480**
	(.199)	(.180)	(.229)	(.231)	(.188)	(.181)	(.196)	(.204)
HI^2	-.382**	-.760***	-.336	-.862***	-.484***	-.727***	-.180	-.540***
	(.171)	(.161)	(.216)	(.236)	(.161)	(.165)	(.185)	(.184)
LnRDef	-.115	-.153	-.007	-.077	-.106	-.160	-.084	-.121
	(.109)	(.122)	(.141)	(.155)	(.109)	(.118)	(.101)	(.133)
LnTotCap	.262***	.345***	.245***	.331***	.243***	.331***	.224***	.277***
	(.058)	(.068)	(.059)	(.068)	(.058)	(.065)	(.042)	(.065)
Tax	3.848***	3.831***	3.730***	3.896**	3.230**	3.195**	.795	1.596
	(1.411)	(1.407)	(1.367)	(1.527)	(1.391)	(1.312)	(.921)	(1.338)
VWR	-.100	-.163**	-.092	-.155**	-.080	-.160**	-.052	-.119
	(.075)	(.066)	(.070)	(.064)	(.080)	(.068)	(.079)	(.072)
Top3Xret	-.126**	-.019	-.108*	.005	-.128**	-.011	-.084*	-.024
	(.051)	(.043)	(.057)	(.047)	(.052)	(.042)	(.045)	(.034)
Obs.	73249	68457	67673	63041	69520	65018	24132	23394
$P - R^2$	.249	.249	.246	.246	.247	.248	.249	.248

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Table V, Panel A
The Relation between Exogenous Defense Spending and Abnormal Short-Term Government Borrowing

This table reports the results relating Exogenous Defense Spending to short-term government borrowing. Specifically we estimate a Newey-West model of AbnSTGovBor, which measures the abnormal level of short-term (1 year) government borrowing on EDS, which is the present discounted value of exogenous changes in military expenditures divided by real GDP. The model controls for autocorrelation over time with one lag in columns (1) and (2) and 5 lags in column (3) and (4). Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% levels respectively.

	AbnSTGovBor t+1	AbnSTGovBor t+2	AbnSTGovBor t+1	AbnSTGovBor t+2
	1	2	3	4
EDS	2.743***	2.671***	2.743**	2.671***
	(1.028)	(.907)	(1.099)	(.872)
LnRInv	.155	.255**	.155	.255*
	(.145)	(.122)	(.172)	(.140)
LnRGDP	-.307	-.507***	-.307	-.507**
	(.206)	(.169)	(.252)	(.203)
LnTotCap	.008	.046*	.008	.046
	(.027)	(.024)	(.036)	(.030)
Tax	-2.514***	-2.756***	-2.514***	-2.756***
	(.781)	(.691)	(.842)	(.736)
VWR	-.074*	-.066**	-.074*	-.066**
	(.038)	(.030)	(.038)	(.028)
Top3Xret	-.064*	-.096***	-.064	-.096***
	(.035)	(.030)	(.042)	(.036)
Obs.	57	56	57	56
F statistic	91.022	73.673	70.09	57.065

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Table V, Panel B: The Relation between Short-term Government Borrowing and the Number of Patents and Citations per Patent: Predicted Value Approach using Exogenous Defense Expenditures

This table reports the results relating the number of patents to the predicted value of short-term government borrowing from Table V, Panel A. In the first stage in Table V, Panel A, we regress abnormal short-term government borrowing on exogenous defense spending, which is the present discounted value of exogenous changes in military expenditures divided by real GDP. In columns 1 and 2 of Table V, Panel B, we then estimate a firm-fixed effects Poisson model of $Patent_{it}$ on a variable AbnSTGovBorPredExp, which is the predicted value of AbnSTGovBor from Table V, Panel A, column 1. In columns 3 and 4 of Table V, Panel B, we then estimate a firm-fixed effects Poisson model of $CitPatent_{it}$ on a variable AbnSTGovBorPredExp, which is the predicted value of AbnSTGovBor from column 1 in Table V, Panel A. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Patent_{t+3}$	$Patent_{t+4}$	$Cit/Patent_{t+3}$	$Cit/Patent_{t+4}$
	1	2	3	4
AbnSTGovBorPredExp	-2.384***	-2.179***	-1.371*	-2.081***
	(.626)	(.821)	(.759)	(.736)
LnSales	.556***	.503***	.043***	.041***
	(.046)	(.046)	(.014)	(.015)
RD/TA	-.036	.040	.005	.011
	(.468)	(.546)	(.145)	(.149)
Profitability	-.360**	-.167	-.012	-.059***
	(.176)	(.179)	(.041)	(.016)
Tangibility	-.198	-.327	-.217**	-.237**
	(.387)	(.410)	(.091)	(.101)
Cash	.221	.250	.193***	.148**
	(.191)	(.187)	(.066)	(.066)
Leverage	-.436***	-.343**	-.199***	-.120*
	(.152)	(.162)	(.052)	(.062)
LnRGDP	-2.276***	-1.393**	-2.012***	-2.368***
	(.524)	(.639)	(.356)	(.402)
LnRInv	-.208	-.884***	.378**	.315*
	(.214)	(.278)	(.182)	(.184)
BudgSurpl	.056***	.040*	-.017*	-.022*
	(.020)	(.021)	(.010)	(.012)
HI	-2.947**	-3.023**	.356	.691**
	(1.271)	(1.280)	(.297)	(.301)
HI^2	2.646**	2.761**	-.427	-.791***
	(1.137)	(1.115)	(.280)	(.286)
LnRDef	-.213	-.193	-.115	-.148
	(.170)	(.189)	(.111)	(.122)
LnTotCap	.585***	.551***	.271***	.350***
	(.095)	(.120)	(.062)	(.074)
Tax	-18.164***	-12.424***	.747	-.946
	(3.115)	(3.297)	(2.388)	(2.388)
VWR	-.511***	-.449***	-.204*	-.302***
	(.094)	(.110)	(.115)	(.102)
Top3Xret	-.170**	-.095	-.220***	-.161***
	(.073)	(.082)	(.057)	(.057)
Obs.	76385	71489	75658	70771
$P - R^2$	.925	.925	.249	.249

Table VI:
The Relation between Short-term Government Borrowing and the Number of Patents: Instrumental Variable Approach using Exogenous Defense Expenditures

This table reports the results relating the number of citations per patent to short-term government borrowing, using exogenous changes in military expenditures and exogenous taxes as instruments. In columns 1 and 2, we then estimate a firm-fixed effects log-linear IV OLS model of $\text{Ln}(1+Patent_{it})$ on a variable AbnSTGovBor-Instrum, using the exogenous changes in military expenditures (EDS) as an instrument. In columns 3 and 4, we estimate a firm-fixed effects log-linear IV OLS model of $\text{Ln}(1+Cit/Patent_{it})$ on a variable AbnSTGovBor-Instrum, using the exogenous changes in military expenditures (EDS) as an instrument. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Patent_{t+3}$	$Patent_{t+4}$	$Cit/Patent_{t+3}$	$Cit/Patent_{t+4}$
	1	2	3	4
AbnSTGovBor-Instrum	-2.222***	-1.576***	-.997***	-1.540***
	(.445)	(.467)	(.244)	(.256)
LnSales	.094***	.092***	.010***	.011***
	(.006)	(.007)	(.002)	(.002)
RD/TA	.033	.114	-.017	-.027
	(.075)	(.080)	(.037)	(.040)
Profitability	-.013	-.019**	.005	-.007
	(.009)	(.008)	(.004)	(.007)
Tangibility	-.061*	-.042	-.028**	-.037***
	(.032)	(.035)	(.011)	(.012)
Cash	.147***	.136***	.032***	.022*
	(.028)	(.029)	(.012)	(.013)
Leverage	-.030	-.034	-.011	-.011
	(.024)	(.025)	(.009)	(.008)
LnRGDP	-.733***	-.604***	-.395***	-.466***
	(.078)	(.080)	(.038)	(.041)
LnRInv	-.024	-.130***	.054***	.040***
	(.028)	(.028)	(.014)	(.015)
BudgSurpl	.050***	.039***	.019***	.029***
	(.008)	(.009)	(.005)	(.005)
HI	-.112	-.068	.079**	.123***
	(.132)	(.142)	(.039)	(.042)
HI^2	.201	.138	-.073*	-.110***
	(.143)	(.153)	(.039)	(.041)
LnRDef	-.180***	-.057	-.098***	-.150***
	(.055)	(.057)	(.028)	(.029)
LnTotCap	.068***	.080***	.013	.003
	(.017)	(.018)	(.009)	(.009)
Tax	-11.431***	-8.042***	-4.262***	-6.710***
	(1.974)	(2.074)	(1.119)	(1.163)
VWR	-.100***	-.063***	-.031***	-.042***
	(.011)	(.012)	(.006)	(.007)
Top3Xret	.028*	.044***	.010	.043***
	(.015)	(.016)	(.009)	(.009)
Obs.	146531	135362	146531	135362
R^2	.009	.013	.005	-.009

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Table VII
The Relation between Exogenous Government Spending and R&D Expenditures and the Economic Value of Patents

This table reports the results relating R&D expenditures and the Real Economic Value of Patents (Kogan et al. (2017)), to exogenous changes in military expenditures . Specifically we estimate a firm-fixed effects model of RD/TA_{it} and $RealEconPatent_{it}$ (columns 5-8)) on a variable EDS , which is the present discounted value of exogenous changes in military expenditures divided by real GDP. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level (columns (1-2) and (5-6)) and at the firm and year level (columns (3-4) and (7-8)). Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	RD	RDt+1	RD	RDt+1	EconPatt+2	EconPatt+3	EconPatt+2	EconPatt+3
	1	2	3	4	5	6	7	8
EDS	-.080***	-.008	-.080*	-.008	-17.161***	-15.475***	-17.161**	-15.475*
	(.018)	(.018)	(.041)	(.070)	(1.629)	(1.693)	(8.716)	(8.334)
LnSales	-.005***	-.004***	-.005***	-.004***	.315***	.302***	.315***	.302***
	(.0008)	(.0005)	(.0009)	(.0005)	(.043)	(.047)	(.052)	(.057)
Profitability	-.017*	-.020***	-.017*	-.020***	.081*	.111**	.081	.111*
	(.009)	(.004)	(.009)	(.003)	(.045)	(.055)	(.059)	(.065)
Tangibility	.038***	.014***	.038***	.014***	-.064	.232	-.064	.232
	(.003)	(.002)	(.005)	(.003)	(.242)	(.266)	(.242)	(.274)
Cash	-.006*	.018***	-.006	.018***	.495***	.488***	.495***	.488***
	(.003)	(.003)	(.005)	(.004)	(.165)	(.177)	(.168)	(.174)
Leverage	.003	-.0008	.003	-.0008	-.033	-.021	-.033	-.021
	(.002)	(.001)	(.002)	(.0009)	(.049)	(.049)	(.053)	(.053)
LnRGDP	.035***	.022***	.035***	.022***	1.812***	3.823***	1.812	3.823**
	(.004)	(.004)	(.009)	(.008)	(.424)	(.472)	(1.434)	(1.550)
LnRInv	-.015***	-.012***	-.015***	-.012***	-2.961***	-3.817***	-2.961***	-3.817***
	(.002)	(.002)	(.004)	(.004)	(.228)	(.259)	(.907)	(.918)
BudgSurpl	-.0003*	-.0005***	-.0003	-.0005	-.050***	-.114***	-.050	-.114**
	(.0001)	(.0001)	(.0003)	(.0003)	(.017)	(.020)	(.055)	(.058)
HI	-.018***	-.005	-.018***	-.005	3.729***	4.516***	3.729***	4.516***
	(.005)	(.005)	(.006)	(.006)	(1.112)	(1.208)	(1.158)	(1.248)
HI^2	.015***	.004	.015**	.004	-2.702**	-3.515***	-2.702**	-3.515**
	(.005)	(.005)	(.006)	(.005)	(1.250)	(1.337)	(1.283)	(1.368)
LnRDef	-.009***	-.005***	-.009***	-.005	-1.416***	-1.650***	-1.416***	-1.650***
	(.001)	(.001)	(.003)	(.004)	(.163)	(.180)	(.463)	(.475)
LnTotCap	.0003	.0007	.0003	.0007	1.130***	.907***	1.130***	.907***
	(.0008)	(.0008)	(.002)	(.002)	(.089)	(.095)	(.300)	(.286)
Tax	.071***	.207***	.071	.207***	15.803***	24.473***	15.803**	24.473***
	(.023)	(.024)	(.050)	(.036)	(3.062)	(3.416)	(7.853)	(7.735)
VWR	-.005***	-.001*	-.005***	-.001	-.376***	-.411***	-.376	-.411
	(.0008)	(.0007)	(.001)	(.002)	(.064)	(.072)	(.374)	(.417)
Top3Xret	.005***	.002**	.005***	.002	.466***	.248***	.466*	.248
	(.0007)	(.0007)	(.002)	(.001)	(.067)	(.075)	(.254)	(.223)
Obs.	187452	172261	187452	172261	159025	146531	159025	146531
R^2	.804	.814	.804	.814	.636	.64	.636	.64

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Table VIII
The Relation between Defense Expenditures and the Number of Patents and the Number of Citations per Patent for Firms in Industries Related to the Military

This table reports the results relating the number of citations per patent to exogenous changes in military expenditures, and its interaction with military industry dummy. Specifically, we estimate a firm-fixed effects Poisson model of $Patent_{it}$ (columns 1-2) and $Citations/Patent_{it}^{Time}$ (columns 3-4) on a variable EDS, which is the present discounted value of exogenous changes in military expenditures divided by real GDP, MilInd, which is a dummy variable equal to 1 if a firm has an industry SIC code related to the military (37, 97, 45 and 47), and the interaction term EDS×MilInd. MilInd is subsumed by the firm-fixed effects and therefore it is not included in the table by itself. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	$Patent_{t+3}$	$Patent_{t+4}$	$\frac{Citations}{Patent}_{t+3}$	$\frac{Citations}{Patent}_{t+4}$
	1	2	3	4
EDS	-7.412***	-7.046***	-4.197*	-6.368***
	(2.204)	(2.617)	(2.200)	(1.984)
EDS*MilInd	11.710**	13.733***	10.499***	11.597***
	(4.814)	(4.926)	(3.559)	(3.463)
LnSales	.554***	.502***	.040***	.040***
	(.028)	(.027)	(.011)	(.011)
RD/TA	-.029	.027	.040	.032
	(.213)	(.265)	(.115)	(.122)
Profitability	-.370***	-.179*	-.001	-.058***
	(.097)	(.105)	(.037)	(.013)
Tangibility	-.207*	-.331**	-.234***	-.229***
	(.122)	(.133)	(.072)	(.080)
Cash	.225*	.255**	.178***	.152***
	(.122)	(.104)	(.051)	(.050)
Leverage	-.440***	-.344***	-.201***	-.108**
	(.074)	(.073)	(.039)	(.054)
LnRGDP	-1.552***	-.730	-1.621***	-1.769***
	(.415)	(.519)	(.256)	(.276)
LnRInv	-.568***	-1.210***	.182	.010
	(.165)	(.220)	(.186)	(.168)
BudgSurpl	.056***	.041**	-.016*	-.022**
	(.017)	(.019)	(.009)	(.011)
HI	-2.939***	-3.019***	.416**	.701***
	(.391)	(.410)	(.194)	(.190)
HI^2	2.639***	2.751***	-.496***	-.807***
	(.419)	(.449)	(.168)	(.170)
LnRDef	-.211	-.190	-.102	-.145
	(.156)	(.166)	(.107)	(.117)
LnTotCap	.564***	.530***	.264***	.339***
	(.085)	(.107)	(.055)	(.065)
Tax	-12.145***	-6.997***	4.067***	4.115***
	(1.730)	(2.015)	(1.399)	(1.425)
VWR	-.333***	-.286**	-.104	-.152**
	(.093)	(.114)	(.076)	(.068)
Top3Xret	-.020	.043	-.132***	-.026
	(.055)	(.065)	(.050)	(.041)
Obs.	75190	70368	74469	69658
χ^2 statistic	4328.233	3219.469	932.071	778.353

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Table IXA
The Relation between Exogenous Changes in Tax Revenue and Patents, the Propensity to Patent and Patent Citations

This table reports the results relating the number of citations per patent to exogenous changes in tax revenue (Romer and Romer (2010)). Specifically we estimate a firm-fixed effects Poisson model of $Patent_{it}$, $PatentDummy_{it}$ and $Citations/Patent_{it}$on a variable ExogTax (columns 1 and 2), which measures the exogenous changes in tax revenue (Romer and Romer (2010)), and RomerExogDeficit, which measures exogenous changes in tax revenue due to decreasing the budget deficit. Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	Pat_{t+3}	Pat_{t+4}	$Patdum_{t+3}$	$Patdum_{t+4}$	Cit/Pat_{t+3}	Cit/Pat_{t+4}
	1	2	3	4	5	6
ExogTax	-.004	-.009	.004	.009**	.001	.018**
	(.007)	(.007)	(.004)	(.004)	(.007)	(.007)
LnSales	.548***	.505***	.083***	.074***	.042***	.037***
	(.042)	(.042)	(.008)	(.008)	(.012)	(.013)
RD/TA						
Profitability	-.461**	-.352	-.018	-.004	-.027	-.043
	(.200)	(.224)	(.036)	(.032)	(.045)	(.053)
Tangibility	-.105	-.240	-.018	-.015	-.207**	-.199**
	(.395)	(.405)	(.064)	(.067)	(.092)	(.098)
Cash	.231	.252	.148***	.097**	.216***	.170**
	(.200)	(.205)	(.042)	(.042)	(.067)	(.072)
Leverage	-.406***	-.339**	-.148***	-.105***	-.181***	-.115*
	(.150)	(.156)	(.034)	(.038)	(.052)	(.063)
LnRGDP	-1.579***	-1.024**	-.724***	-.704***	-1.417***	-1.695***
	(.374)	(.440)	(.107)	(.109)	(.188)	(.198)
LnRInv	-.438**	-.967***	-.089	-.125**	.133	.110
	(.203)	(.221)	(.056)	(.057)	(.103)	(.106)
BudgSurpl	.053***	.038***	-.008**	-.005	-.014**	-.017**
	(.014)	(.014)	(.004)	(.004)	(.007)	(.007)
HI	-2.982**	-2.892**	.148	.254	.269	.673**
	(1.256)	(1.204)	(.183)	(.189)	(.277)	(.290)
HI^2	2.655**	2.617**	-.131	-.245	-.359	-.783***
	(1.115)	(1.037)	(.194)	(.197)	(.287)	(.296)
LnRDef	-.107	-.103	.061*	.138***	-.035	-.033
	(.103)	(.116)	(.034)	(.035)	(.057)	(.059)
LnTotCap	.540***	.544***	.174***	.163***	.209***	.279***
	(.063)	(.075)	(.022)	(.023)	(.039)	(.041)
Tax	-11.139***	-6.564***	1.652***	1.412**	4.725***	4.639***
	(2.439)	(2.282)	(.597)	(.601)	(1.067)	(1.117)
VWR	-.252***	-.167***	-.063***	-.030	-.081**	-.062
	(.054)	(.060)	(.022)	(.023)	(.040)	(.041)
Top3Xret	-.093**	-.055	-.114***	-.057***	-.146***	-.085***
	(.040)	(.048)	(.016)	(.016)	(.029)	(.030)
Obs.	74268	69495	74268	69495	73680	68813
$P - R^2$	.924	.925	.154	.153	.248	.248

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Table IXB
The Relation between Exogenous Changes in Tax Revenue and R&D and the Economic Value of Patents

This table reports the results relating the number of citations per patent to exogenous changes in tax revenue (Romer and Romer (2010)). Specifically we estimate a firm-fixed effects Poisson model of $R\&D_{it}$ (columns 1 and 2), and $EconPatVal_{it}$ (columns 3 and 4) on a variable ExogTax , which measures the exogenous changes in tax revenue (Romer and Romer (2010)). Other controls include LnSales, RD/TA, Profitability, Tangibility, Cash, Leverage, LnRGDP, LnRInv, Tax, LnTotCap, VWR and Top3Xret. All regressions are estimated with firm-fixed effects, and the standard errors reported in the parentheses are corrected for the panel in all the models and are clustered at the firm level. Data is for the period 1950 to 2009. ***, ** and * denote significance at 1%, 5% and 10% respectively.

	RD_t	RD_{t+1}	$EconPatVal_{t+2}$	$EconPatVal_{t+3}$
	1	2	3	4
ExogTax	.0003***	.00009	.046***	.018**
	(.0001)	(.0001)	(.007)	(.008)
LnSales	-.005***	-.004***	.306***	.295***
	(.0009)	(.0005)	(.043)	(.047)
Profitability	-.018	-.021***	.208***	.263***
	(.011)	(.004)	(.065)	(.078)
Tangibility	.038***	.013***	-.089	.147
	(.003)	(.002)	(.239)	(.263)
Cash	-.007**	.018***	.565***	.538***
	(.003)	(.003)	(.168)	(.178)
Leverage	.002	-.0008	-.031	-.012
	(.002)	(.0009)	(.047)	(.043)
LnRGDP	.032***	.025***	2.440***	4.600***
	(.004)	(.004)	(.460)	(.515)
LnRInv	-.012***	-.014***	-2.959***	-3.969***
	(.002)	(.002)	(.243)	(.279)
BudgSurpl	-.0001	-.0005***	-.031*	-.096***
	(.0001)	(.0001)	(.016)	(.019)
HI	-.019***	-.006	3.575***	4.334***
	(.005)	(.005)	(1.149)	(1.245)
HI^2	.015***	.006	-2.573*	-3.331**
	(.005)	(.005)	(1.319)	(1.412)
LnRDef	-.007***	-.005***	-1.032***	-1.295***
	(.001)	(.001)	(.151)	(.166)
LnTotCap	-.0001	.0002	.893***	.673***
	(.0008)	(.0007)	(.083)	(.090)
Tax	.061**	.212***	17.055***	25.716***
	(.024)	(.025)	(3.122)	(3.479)
VWR	-.003***	-.002**	-.260***	-.349***
	(.0008)	(.0007)	(.062)	(.070)
Top3Xret	.004***	.002***	.385***	.198***
	(.0007)	(.0007)	(.063)	(.071)
Obs.	182449	167662	154779	142586
R^2	.803	.813	.636	.641

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