APPENDIX A: METHODOLOGY

Maintenance-rate specifications. In exploring whether the 1991 fee reform is associated with a distortion in the PTO's granting patterns across technology categories with varying maintenance-rate levels, we estimate the following specification (with a unit of observation at the technology-category-year level):[1]

$$GR_{c,t} = \alpha + \gamma_c + \lambda_t + \beta_1 (POST_t * m_c) + \beta_2 X_{c,t} + \varepsilon_{c,t} \quad (1)$$

where $GR_{c,t}$ is the grant rate for technology category c (based on the National Bureau of Economic Research ("NBER") patent subcategories) in year t (grant rates are calculated as specified below). Category fixed effects and year fixed effects are specified by γ_c and λ_t, accounting for fixed differences in grant rates across technologies and years. $POST_t$ represents an indicator variable for being in the postreform (i.e., post-1991) period. Maintenance rates specific at the technology-category level are represented by m_c (calculated as specified below). $X_{c,t}$ includes certain time-varying covariates specific to technology categories, including the average number of patent claims, the average number of citations to the relevant patents, and the percentage of patentees representing various inventor types (e.g., individual, corporate, government, etc.).[2]

The coefficient of interest is represented by β_1, capturing the degree to which the passage of the 1991 fee reform is associated with a differential grant rate across technology categories with varying maintenance rates. A positive coefficient suggests that the PTO may respond to the adoption of a user-fee-funded system by granting relatively more patents within those categories that generally garner higher maintenance fees. This coefficient can be interpreted as an effect of the reform under an assumption of conditional mean independence (E [ε | POST*m, $X, \gamma, \lambda, \alpha$] = E [ε | $X, \gamma, \lambda, \alpha$])—that is, under an assumption that there are no unobservable shocks in

1. This specification is modeled after the approach taken by Daron Acemoglu and Amy Finkelstein in their investigation into the differential response across hospitals with varying levels of Medicare representation to the imposition of Medicare's Prospective Payment System. *Input and Technology Choices in Regulated Industries: Evidence from the Health Care Sector*, 116 J. POL. ECON. 837 (2008).

2. Data on claims, assignee types, and citations by technology category were obtained from the National Bureau of Economic Research Patent Data Project, *available at* https://sites.google.com/site/patentdataproject/Home.

granting patterns that are correlated with being in a high-maintenance category in the postreform period.

Entity-size specifications. In exploring whether the 1991 fee reform is associated with a distortion in the PTO's granting patterns between large- and small-entity patent applicants, we estimate the following specification (with a unit of observation at the entity-size–technology-category-year level):

$$GR_{e,c,t} = \alpha + \gamma_c + \lambda_t + LARGE + \beta_1 (POST_t * LARGE) + \beta_2 X_{c,t} + \beta_3 m_{e,c} + \varepsilon_{e,c,t} \qquad (2)$$

where $GR_{c,t}$, γ_c, λ_t, $POST_t$, and $X_{c,t}$ are defined as above. *LARGE* represents an indicator for patents with large-entity status, while *e* indicates a given entity-size classification. A positive coefficient for β_1 suggests that the PTO may respond to the adoption of a user-fee-funded system by granting relatively more to patentees with large-entity status. This coefficient can likewise be interpreted as an effect of the reform under a similar assumption of conditional mean independence ($E [\varepsilon | POST*LARGE, X, \gamma, \lambda, LARGE, \alpha] = E [\varepsilon | X, \gamma, \lambda, LARGE, \alpha]$)—that is, under an assumption that there are no unobservable shocks in granting patterns that are correlated with being a large entity in the postreform period.

To the extent that large entities also happen to carry higher maintenance rates (even after controlling for technology effects), it may be difficult to isolate whether the PTO's preferential granting toward large entities arises from the possibility of higher maintenance fees or from the large-entity component itself within the fee structure. To help separate these influences, in some specifications, we include controls for the maintenance rates specific to entity sizes and technologies (as represented by $m_{e,c}$ above.)

While focusing on entity size, the above specification includes technology-specific fixed effects. By accounting for fixed and inherent differences across technologies, we can alleviate concerns that the estimated findings are attributable to a scenario in which the incidence of large-entity patentees increases over time within technology categories that happen to experience higher grant rates historically.

Postreform trends. The results presented in Part IV demonstrate an increasing impact of the imposition of a user-fee-funded system over time. Whether this is attributable to a worsening financial position of the PTO or a lag and evolving alteration of PTO practices, this dynamic suggests that a more proper parameterization of the postreform period may be a trend variable, as opposed to a single indicator variable.[3] Accordingly, we also estimate specifications that modify the above specification to interact the category-specific maintenance rates (or the indicator for large-entity status) with a trend variable that equals zero prior to 1991 and that linearly increases from a value of one beginning in 1991. In yet other specifications, we also consider the addition of category-specific linear time trends to account for the possibility of slowly moving trends in grant rates within technologies over time.[4]

Triple differences. Finally, we explore a richer specification premised on the assumption that the PTO will target its distortionary granting practices even more intensely on large-entity patents within high-maintenance-rate technologies (in a sense beyond just the additive effect resulting from the fact that the PTO may prefer both large entities and high-maintenance-rate classes independently). Consider a low-maintenance-rate technology. Within that category, the PTO may extend a preferential grant rate to large entities following the 1991 reform as a result of the higher large-entity fees. What this assumption presumes is that this large-entity–grant-rate bump is even higher with respect to large entities within high-maintenance-rate technologies.[5] Why? Perhaps because the PTO is trying to limit its distortionary practices to only those few areas where it can really earn the highest funds (consistent with a benevolent PTO's intentions to distort as little as possible or with a self-interested PTO's desire to reduce its likelihood of detection).

Accordingly, to test the hypothesis that the PTO extends even higher grant rates following the 1991 reform to large entities within

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3. Acemoglu & Finkelstein, *supra* note 1, at 856.

4. It may not be the case, of course, that unobserved technology-specific factors follow a linear trend, in which case the imposition of such a trend could confound the estimates. We also consider the imposition of technology-specific quadratic trends to account for nonlinear unobservable trends within technologies over time, though this approach runs the risk of having these trends consume the very effect we are trying to identify. Considering that the response to the 1991 reform appears to be one that grows over time (arguably as a result of the deterioration of the Agency's financial health over time), one may be concerned that imposing technology-category-specific linear time trends in the baseline specification may be picking up much of the treatment effect of interest (thereby potentially washing away a true treatment effect). As such, we elect to perform a specification check that imposes such technology-category-specific linear time trends on that specification that models the fee reform not as a dichotomous variable but as a trend variable that begins at the time of the reform. By modeling the reform as a post-reform linear trend, the subsequent addition of category-specific linear trends to this specification imposes fewer concerns that such category-specific linear trend variables will wash away a true response to the reform that happens to grow over time.

5. Likewise consider small-entity patents. We may assume that within the set of small entities, the PTO would extend preferential treatment to high-maintenance-rate technologies considering the possibility of higher renewal fees in the future. What this assumption presumes is that the grant-rate bump for high-maintenance-rate technologies will be even higher among large-entity patents.

high-maintenance-rate categories, even after accounting for across-the-board preferential responses to the reform for large entities and high-maintenance-rate technologies independently, we estimate the following difference-in-difference-in-difference ("triple-differences") specification:[6]

$$GR_{e,c,t} = \alpha + \gamma_c + \lambda_t + \partial_{c,t} + \delta_{e,t} + LARGE + \beta_1(POST_t * LARGE) + \beta_2(POST_t * m_c) + \beta_3(LARGE * m_c) + \beta_4(POST_t * LARGE * m_c) + \varepsilon_{e,c,t} \quad (3)$$

The coefficient of interest is β_4, capturing the degree to which the PTO extends preferential treatment following the 1991 reform to this interaction of being a large entity within a high-maintenance-rate category. A positive coefficient confirms this more targeted granting story, while at the same time lending general support to the independent stories in which the PTO's fee structure induces it to grant more to large entities and to high-maintenance-rate technologies, thereby also lending support to the most general claim that the PTO's fee structure biases it toward granting. A key benefit of this approach is that it also allows us to account for (i.e., rule out the potentially confounding influence of) unobservable factors that are specific to (1) given years and entity-size categories and (2) given years and technology categories. That is, the above approach will allow us to capture the effect of the fee reform on differential granting patterns while even controlling for the possibility, for instance, that grant rates would rise after 1991 within a particular technology that generally carries a high maintenance rate. What is required is an assumption that grant rates do not happen to spike following 1991 specifically for those large-entity patents within high-maintenance-rate technologies.

<u>*Variables*</u>.

Grant rates. In the preferred specifications, patent grant rates for each technology-category-year cell are calculated as the number of patent allowances within the relevant cell divided by the number of patent disposals within that cell. Patent disposals, in turn, equal the number of patents allowed plus the number of patents abandoned.[7]

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6. The general triple-differences methodology is motivated by Gruber. Jonathan H. Gruber, *The Incidence of Mandated Maternity Benefits*, 84 AM. ECON. REV. 622, 627 (1994).

7. The data received from the PTO does not treat requests for continued examinations as abandonments.

Alternative grant rates. allowance percentages. For the purposes of a robustness check, we follow Quillen and Webster[8] and calculate an allowance rate for each technology-category-year cell as the number of patent allowances for that cell divided by the number of original patent applications filed within that cell.

Maintenance rates:

1990 maintenance rate. In the preferred specification, following the relevant difference-in-difference precedent (based on a differential response to a national reform across institutional types),[9] we assign maintenance rates to technology categories according to the maintenance rates observed in the year prior to the reform—i.e., 1990.[10] The four-year maintenance rate as of 1990 is determined as the percentage of all patents issued after September 1, 1981[11] and due for their four-year renewal payment by 1990 that in fact paid their four-year renewal fee.[12] We calculate a similar rate for eight-year renewals.

Time-invariant, all years. In alternative specifications, we assign maintenance rates to technology categories according to the mean renewal rates observed in the respective categories over the full sample period—i.e., the rate by which all patents issued after September 1, 1981 and prior to January 1, 2007 renewed their patents at the four-year post-issuance mark. We calculate a similar rate for eight- and twelve-year renewals.

In differentiating across technology categories based on renewal rates, we follow the relevant difference-in-difference literature in applying consistency in how we categorize each technology group's renewal proclivities. In other words, in our

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8. Cecil D. Quillen, Jr. & Ogden H. Webster, *Continuing Patent Applications and Performance of the U.S. Patent and Trademark Office*, 15 FED. CIR. BAR J. 635 (2006).

9. *See, e.g.*, Acemoglu & Finkelstein, *supra* note 1; *see also* David S. Abrams, *Did TRIPS Spur Innovation? An Analysis of Patent Duration and Incentives to Innovate*, 157 U. PA. L. REV. 1613, 1615 (2009).

10. This creates stability in the classification throughout the difference-in-difference specification in an attempt to isolate the reform impact as opposed to any compositional impact in high-maintenance-rate categories. This concern is of relatively little significance, however, as maintenance rates remain relatively stable within classes and technology categories over time. Moreover, the difference-in-difference results remain virtually unchanged when we use maintenance rates that are time-varying in nature or that represent an average over the entire period.

11. The PTO began collecting data on renewal events after this date.

12. This preferred approach assumes that the PTO would assess a technology's renewal likelihood using all information on that technology to date. The same results are achieved when we specify a 1990 maintenance rate according to just the renewal percentage of those applications due for their four-year payments in 1990 itself.

preferred regression specifications, we specify the category-specific maintenance rates as time-invariant measures, allowing us to focus on how grant rates change in response to variations in fee policies and in the PTO's need for revenues (i.e., sustainability score). A concern would arise, of course, if maintenance rates varied considerably within technology categories over time. In such an instance, it would be difficult to interpret a change over time in the grant rates of those categories labeled "high maintenance" as actually being reflective of any higher maintenance rate. This concern is perhaps slightly less relevant in the period of time following the reform considering that some amount of within-category change in renewal rates may be attributable to the PTO's differential treatment of that category.

Overall, the data implicate little concern over the possibility of substantial within-technology variation in renewal rates over time. Rather, they demonstrate relative stability within categories in the percentage of patents due for renewal in a given year that actually renew. In the pre-1991 period, for instance, only 10% of the overall category-year variation in maintenance rates can be attributable to variations within categories over time. Moreover, the composition of categories in the various quartiles of annual maintenance rates remain nearly unchanged in that time period.

In any event, in Appendix B below, we discuss dynamic regression results based on a difference-in-difference approach that nonetheless interacts an indicator variable for being in the post-1991 period with a time-varying and technology-specific maintenance rate (where, for instance, the four-year maintenance rate in 1992 is calculated as the percentage of patents issuing in 1988 that, in fact, renewed in 1992 as due). This alternative approach also identifies the relationship between fees and differential granting behavior across technologies using changes in technology-specific renewal rates.

Sustainability score. In Part I, we predicted that the PTO would be more likely to trigger its sustainability (i.e., break-even) constraint as the ratio between its incoming post-allowance fee collections to outgoing examination expenditures fell. We predicted that this would be more likely to occur upon the following developments: an increase in the PTO's backlog, a decrease in its annual maintenance-fee collections, an increase in its average examination complexity (i.e., the average number of hours allocated to each examination disposed of in a given year), and a decrease in the percentage of patentees that are large entities. While we consider regressions that interact each of these factors separately with the 1991-reform indicator, we also estimate regressions that aggregate each of these factors into one sustainability measure so that we can determine whether the PTO, on net, faces sustainability concerns. For instance, if over time, backlog grows considerably while annual maintenance rates actually increase somewhat (which characterizes much of the sample period), how can we determine whether the PTO is in fact experiencing changes in its financial outlook? For these purposes, we construct the following sustainability measure, which captures the impact of each measure on the PTO's financial balance in a manner that facilitates across-factor comparisons in such impacts.

Broadly, the sustainability score in a given year equals the amount of incoming post-allowance fees for that year divided by the net examination costs associated with all of the patent applications awaiting examination at that time. More specifically:

$$SUST_t = \frac{MAINT\_FEE\_COLLECTIONS_t + ISSUANCE\_FEE\_COLLECTIONS_t}{DEMAND(LE)_t * NET\_COST(LE)_t + DEMAND(SE)_t * NET\_COST(SE)_t}$$

Where

$$\begin{aligned} MAINT\_FEE\_COLLECTIONS_t &= (\,ISSUANCES(LE)_{t-12} * MAINT\_RATE(12yr)_t * \mathrm{MAINT\_FEE(12yr)}) \\ &+ \left(ISSUANCES(SE)_{t-12} * MAINT\_RATE(12yr)_t * \frac{1}{2} * \mathrm{MAINT\_FEE(12yr)}\right) \\ &+ (\,ISSUANCES(LE)_{t-8} * MAINT\_RATE(8yr)_t * \mathrm{MAINT\_FEE(8yr)}) \\ &+ \left(ISSUANCES(SE)_{t-8} * MAINT\_RATE(8yr)_t * \frac{1}{2} * \mathrm{MAINT\_FEE(8yr)}\right) \\ &+ (\,ISSUANCES(LE)_{t-4} * MAINT\_RATE(4yr)_t * \mathrm{MAINT\_FEE(4yr)}) \\ &+ \left(ISSUANCES(SE)_{t-4} * MAINT\_RATE(4yr)_t * \frac{1}{2} * \mathrm{MAINT\_FEE(4yr)}\right) \end{aligned}$$

where

$ISSUANCE\_FEE\_COLLECTIONS_t = ISSUANCES(LE)_t * ISSUE\_FEE + ISSUANCES(SE)_t * ISSUE\_FEE * 1/2$;

where

$$NET\_COST(LE)_t = AVG\_EXAM\_COST\left(\frac{COMPLEXITY_t}{COMPLEXITY(REFERENCE)}\right) - EXAM\_FEE;$$

where

$$NET\_COST(SE)_t = AVG\_EXAM\_COST\left(\frac{COMPLEXITY_t}{COMPLEXITY(REFERENCE)}\right) - 1/2 * EXAM\_FEE;$$

where

$$DEMAND(LE)_t = BACKLOG_t * LARGE\_ENTITY\_FILING\_RATE_t;$$

and where

$$DEMAND(SE)_t = BACKLOG_t * SMALL\_ENTITY\_FILING\_RATE_t.$$

The above score is not meant to reflect the actual profits accruing to the PTO in a given year. Rather, it is meant to simulate how variations in the above-mentioned factors (keeping all other factors fixed) affect its general profitability. That is, it provides a meaningful and empirically relevant way of assessing the relative contributions to the PTO's financial position of each of these factors. Also, while an actual annual profitability measure may consider the costs associated with those applications disposed of during a given year, this measure considers the costs associated with all of those applications awaiting examination at that time—i.e., the backlog. As discussed in Part III, the costs associated with examining the backlog represent a better sense of the external pressures being placed upon the PTO (as opposed to the costs associated with those patents the PTO elected to dispose of during the year, which would be, in part, a reflection of the PTO's own response to its financial pressures). Our goal is then to evaluate how these external pressures to the agency's financial position induce it to take certain actions.

The sustainability score keeps fixed over time the fee amounts themselves (based on the 2011 amounts), again focusing only on variations in the above-mentioned factors. However, our preliminary extensions of this score based on our current understanding of fee amendments suggest that the regression results persist under this extension. Likewise, in calculating the average cost per examination, the only factor changing over time is the average complexity of the patents disposed of during that year. To calculate net costs, we multiply the average examination cost in 2010 by the ratio of the average examination complexity for the given year (based on the distribution of patents disposed of during the year) to the average examination complexity of 2010, the reference year.

Examination hours / complexity of the art. Examination complexity is based on the hours of examination allocated to each patent application. Examination-hour schedules are set at the PTO classification level (and remain unchanged over the sample period). To form examination hours at the coarser technology category, we calculate the average hours over the classes within those categories, weighted by disposals per class. Data on examination complexity schedules by PTO class was likewise obtained from the PTO.

TABLE A1. PATENT CHARACTERISTICS BY TECHNOLOGY CATEGORY

	(1)	(2)	(3)	(4)	(5)
Technology Category	**4-Year Maint. Rate (%)**	**8-Year Maint. Rate (%)**	**12-Year Maint. Rate (%)**	**Examinat ion Hours**	**% Small-Entity Applica nts**
Agriculture, Food, Textiles	77.5	50.4	31.1	19.3	16.6
Coating	85.4	63.2	43.4	20.9	22.0
Gas	84.1	58.6	36.3	21.7	29.6
Organic Compounds	83.6	59.5	38.0	18.8	12.8
Resins	87.1	65.7	44.6	19.3	11.1
Miscellaneous Chemical	85.0	62.0	41.6	18.8	22.4
Communications	89.5	71.9	51.9	18.9	15.9
Computer Hardware & Software	91.4	74.9	55.5	23.4	15.9
Computer Peripherals	93.0	77.2	59.2	21.9	10.1
Information Storage	92.6	76.7	57.3	14.2	10.3
Electronic Business Methods and Software	90.7	77.0	58.1	27.4	25.8
Drugs	84.9	63.2	42.3	17.2	34.2
Surgical and Medical Instruments	86.7	68.2	50.2	15.3	43.2
Genetics	91.9	80.4	64.9	24.8	27.2
Miscellaneous Drugs and Medical	84.4	62.3	42.2	18.8	47.9
Electrical Devices	87.2	66.7	47.1	17.8	16.8
Electrical Lighting	83.2	60.1	40.3	18.7	27.4
Measuring & Testing	85.2	61.4	40.5	17.9	24.5
Nuclear & X-rays	87.3	64.4	44.1	19.8	20.8
Power Systems	87.0	65.9	44.5	18.7	19.0
Semiconductor Devices	93.4	78.6	60.8	20.6	6.9
Miscellaneous	89.4	70.8	50.9	17.6	16.4

Electrical					
Mat. Proc & Handling	81.9	57.6	37.5	19.1	32.8
Metal Working	84.2	60.6	40.2	19.2	21.3
Motors & Engines & Parts	84.5	61.4	41.1	18.4	20.2
Optics	88.2	67.5	46.5	17.1	15.9
Transportation	78.1	51.5	31.3	16.9	39.5
Miscellaneous Mechanical	78.8	54.2	35.0	17.9	42.1
Agriculture, Husbandry and Food	76.2	50.9	32.5	18.5	52.0
Amusement Devices	69.6	40.9	22.1	17.2	59.0
Apparel & Textile	74.6	47.4	28.9	17.3	53.8
Earth Working & Wells	82.3	56.4	35.3	17.6	35.2
Furniture, House Fixtures	71.1	43.2	25.2	16.6	63.8
Heating	79.6	52.9	32.8	13.8	36.7
Pipes & Joints	82.8	60.0	41.1	16.6	33.5
Receptacles	74.6	49.1	31.6	15.3	53.1
Miscellaneous Other	80.1	55.8	36.5	18.4	42.9

Maintenance rates are calculated as the percentage of all patents filed after September 1, 1981 that renewed their patents at the respective four-year, eight-year, and twelve-year marks (excluding patents filed within the last four, eight, and twelve years respectively). Examination-hour schedules are set at the PTO classification level (and remain unchanged over the sample period). To form examination hours at the coarser technology category, we calculate the average hours over the classes within those categories, weighted by disposals per class. Note that the indicated maintenance rates are averaged over available sample years, while the preferred regression specification, as indicated above, sets four-year maintenance rates according to their average level as of 1990.

APPENDIX B: ROBUSTNESS ANALYSIS / SPECIFICATION CHECKS

In this Appendix, we demonstrate and discuss the robustness of the findings presented in Table 2 and in Figures 1–4 to a range of specification checks and other robustness exercises. Generally, the results of these exercises demonstrate the flexibility of the findings to a number of alternative approaches and demonstrate the robustness of the conclusions to the consideration of various potentially confounding stories.

TABLE A2. VARIOUS SPECIFICATION CHECKS

	(1)	**(2)**

Difference-in-Difference Coefficient Estimate Under the Following Alterations to Baseline Specification:	**Maintenance-Rate Specification** (frame of reference: Column 1 of Panel A, Table 2)	**Entity-Size Specification** (frame of reference: Column 1 of Panel B, Table 2)
1) Replace grant rate level with its natural log	94.66*** (30.76)	11.82*** (2.94)
2) Define grant rate as allowances / total original filings (i.e., excluding continuation filings)	79.33** (34.15)	4.67* (2.46)
3) Include control for RCE / CPA filing count (at technology-year level or technology-year–entity-size level, respectively)	53.35*** (18.94)	4.83*** (1.61)
4) Include control for RCE / CPA filing count and its square (at technology-year level or technology-year–entity-size level, respectively)	56.13*** (20.04)	4.38*** (1.60)
5) Include control for rate of RCE / CPA filings relative to total filings (at technology-year level or technology-year–entity-size level, respectively)	59.40*** (19.46)	5.26*** (1.72)
6) Specification of maintenance rates as % maintained within category over entire sample period (as opposed to just prior to 1991)	59.76*** (13.91)	-
7) Use of 8-year maintenance rate (as opposed to 4-year maintenance rate)	34.21*** (8.81)	-
8) Use of 12-year maintenance rate (as opposed to 4-year maintenance rate)	32.44*** (9.22)	-

9)	Use of average of 4-, 8-, and 12-year maintenance rates (as opposed to 4-year maintenance rate)	39.78*** (10.19)	-
10)	Specification of 1991 fee reform variable as postreform linear trend (as opposed to single dummy for post-1991 period)	6.45*** (1.70)	0.74*** (0.14)
11)	Specification of 1991 fee reform variable as postreform linear trend, with addition of category-specific linear time trends	29.95*** (6.44)	0.53*** (0.09)
12)	Specification of 1991 fee reform variable as postreform linear trend, with addition of category-specific linear and quadratic time trends	33.39*** (8.33)	0.53*** (0.10)
13)	Specification of 1991 fee reform variable as postreform linear trend, with addition of entity-size specific linear time trends	-	2.15*** (0.64)
14)	Categorizing technologies according to PTO classes (as opposed to the NBER subcategories)	31.94*** (8.68)	3.33* (1.83)
15)	Categorizing technologies according to NBER 6-level categories (as opposed to the NBER subcategories)	88.38** (22.22)	7.05** (2.22)
16)	Maint. rate regression: include category-year controls for % of small-entity filings (reported coefficient of *MAINTAIN*POST*)	63.08** (23.8)	-
17)	Maint. rate regression: include interaction between fee reform and category-specific % of	25.8 (40.7)	-

small-entity filings and examination hours (reported coefficient of MAINTAIN*POST)		
18) Entity-size regression: include control for technology-entity-size maintenance rate (reported coefficient of LARGE*POST)	-	6.74*** (1.42)
19) Specification of fee reform based on % of agency's funding attributable to user fees (as opposed to single dummy variable for post-1991 period)	153.33*** (48.68)	15.90*** (3.97)
20) Dropping technology categories covering software patents and business methods patents.	54.62*** (19.80)	5.36** (1.59)
21) Include interaction between post-fee-reform period and expected patent duration increase for the relevant category associated with TRIPS	52.03** (21.05)	6.14*** (1.54)
22) Include interaction between post-1995 period and expected patent duration increase for the relevant category associated with TRIPS	43.83** (20.41)	5.90*** (1.68)

* significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are reported in parentheses and are clustered to correct for autocorrelation within patent categories over time (Column 1) and for autocorrelation within patent-category / entity-size combinations over time (Column 2). All regressions include patent-category fixed effects and year fixed effects to control for fixed differences in grant rates across patent categories and across years, respectively. Regressions in Column 2 include entity-size fixed effects as well. Regressions are weighted by the number of disposals used to form each observation's grant rate. Data on patent-processing statistics and maintenance rates were obtained from the PTO.

Sensitivity to dropping technologies. In addition (not shown), the primary difference-in-difference coefficients for the entity-size and maintenance-rate regressions persist (in terms of sign, magnitude, and statistical significance) when we estimate a series of regressions that systematically, one-by-one drop each technology category from the sample, confirming that no single category is responsible for the observed results. The same holds true when we specify technologies according to PTO classifications and to the broader six-level NBER categories.[13]

Control variables and dynamic regression results. Columns 1 and 4 of Table A3 present detailed results for the coefficients graphed in Figures 1 and 2. In Columns 2 and 5 we demonstrate the effect of adding the following category-year covariates: average number of claims in the relevant patents, average number of citations to the relevant patents, and the percentage of the relevant patents attributable to various inventor types (e.g., individual, government, corporation, etc.). Data on covariates is only available prior to 2005. For those years in which such variables are available, the table demonstrates the robustness of the baseline specifications to their inclusion. Finally, in Columns 3 and 6, we demonstrate the effect of adding controls for the usage of requests for continued examination ("RCE") filings (including RCE filing counts and their squares).[14]

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13. Only with respect to the dropping of one broad six-level NBER category (signifying "other" technologies) does the estimate lose statistical significance. However, even in that one instance the estimated coefficient itself remains positive and similar in magnitude.

14. The findings remain virtually unchanged under alternative specifications of the intensity of usage of RCEs, including controls for the level of RCE filings and for the rate of usage of RCEs (as a percentage of total filings). Considering that successive RCE utilization may increase an applicant's chances of allowance (by effectively buying a longer prosecution time), these controls address concerns that the proliferation of usage of RCEs following their initiation in 2000, to a potentially varying degree across patent types, is responsible for the observed successes (in terms of allowance percentages) among high-maintenance-rate technologies and large entities. One could conceivably address this concern as well by building RCEs into the denominator of the grant rate (i.e., including each RCE filing as a rejection and abandonment). Any such calculation, however, would attenuate the calculated grant rate toward zero considering the nonindependence of each RCE filing within a given initial patent application effort. Consider, for instance, an applicant that unsuccessfully abandons its applications after having filed several RCEs. If all RCEs were included as separate abandonments in a grant rate denominator, this one single application would be responsible for at least several zeros in the grant rate calculation, even though there was likely some high level of persistence in the granting decision across each such RCE filing. That is, it is inaccurate to treat each such filing as an independent evaluation of the PTO's granting tendencies by which we can capture a metric of the PTO's inclinations to grant, especially considering that the filing of an RCE is evaluated by the same examiner without returning to the beginning of the examination queue. Accordingly, considering that this nonindependence concern attenuates the grant rate calculation in the direction of zero, simply including RCEs in the denominator of the grant rate would also attenuate toward zero any estimated differential grant rate between a high-fee patent type (e.g., large entities) that may use RCE filings to a greater degree than a low-fee type. With this mathematical concern in mind, we elect to account for the potentially confounding influence of RCE filings by asking whether their differential utilization across patent types can explain any

Randomization inference. Standard errors may be inaccurately estimated in difference-in-difference specifications when there are a limited number of overall analytical or treatment groups.[15] In the case of the basic entity-size specification, there may be little that one can do to address this concern. With respect to the maintenance-rate regressions, this concern is less pronounced considering that (with thirty-seven technology categories each with different maintenance rates) there are effectively a larger number of treatment groups. In any event, we also perform hypothesis tests on the estimated coefficient of the *MAINTAIN*POST* variable in the maintenance-rate regressions using a randomization inference approach,[16] which allows for an estimation of the distribution of the treatment effect that is valid under any number of groups. For these purposes, we run five thousand simulations, where, with each simulation, we randomly assign each technology category a different maintenance rate (based on the distribution of maintenance rates actually observed).[17] We find that the estimated difference-in-difference coefficient reported in Column 1 of Panel A of Table 2 falls within the first percentile of the empirical distribution of the five thousand estimated coefficients from the simulations, consistent with a p-value of less than 0.01.

TABLE A3. DYNAMIC REGRESSION RESULTS, WITH CATEGORY-YEAR COVARIATES

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
		Maint. Rate (TYPE = MAINTAIN)			**Entity-Size (TYPE = LARGE)**	
d(1986) * TYPE	-	-	-	3.92*	3.24	3.90*
				(2.11)	(2.03)	(2.09)
d(1987) * TYPE	28.52	42.18**	28.08	-1.49	-1.66	-1.51
	(20.17)	(19.53)	(20.20)	(1.95)	(1.74)	(1.93)
d(1988) * TYPE	7.21	24.36	6.99	-1.44	-1.44	-1.46
	(27.06)	(29.52)	(27.15)	(1.81)	(1.75)	(1.79)
d(1989) * TYPE	-15.45	-7.61	-15.59	-1.14	-1.28	-1.12
	(18.22)	(18.60)	(18.28)	(1.52)	(1.44)	(1.52)
d(1990) * TYPE	5.32	2.78	5.33	-1.08	-1.21	-1.09
	(14.53)	(16.04)	(14.55)	(1.12)	(1.17)	(1.12)
d(1991) * TYPE (REFERENCE YEAR)	-	-	-	-	-	-

observed differences in the rates of ultimate allowances (i.e., to include this measure as a covariate).

15. *See, e.g.*, Timothy G. Conley & Christopher R. Taber, *Inference with "Difference-in-Differences" with a Small Number of Policy Changes*, 93 REV. ECON. & STAT. 113 (2011).

16. *See, e.g.*, Esther Duflo, Rachel Glennerster & Michael Kremer, *Using Randomization in Development Economics: A Toolkit*, *in* 4 HANDBOOK OF DEVELOPMENT ECONOMICS 3895, 3895–3962 (T. Paul Schultz & John A. Strauss eds., 2007).

17. *See* Jonathan Gruber & Daniel M. Hungerman, *Church Versus the Mall: What Happens When Religion Faces Increased Secular Competition*, 123 Q. J. ECON. 831 (2008).

d(1992) * TYPE	-6.78	-6.64	-6.70	-1.77	-2.04	-1.77
	(20.95)	(22.82)	(20.91)	(1.47)	(1.59)	(1.48)
d(1993) * TYPE	-1.30	-4.66	-1.37	-2.54	-2.91*	-2.53
	(25.36)	(20.99)	(25.15)	(1.68)	(1.70)	(1.67)
d(1994) * TYPE	-31.59	-52.57**	-31.92	-3.48	-4.30*	-3.46
	(19.75)	(22.97)	(19.88)	(2.11)	(2.22)	(2.09)
d(1995) * TYPE	-25.40	-39.88	-24.94	-1.51	-2.11	-1.54
	(21.37)	(24.41)	(21.46)	(1.55)	(1.55)	(1.54)
d(1996) * TYPE	42.95	16.42	43.70	3.26	2.36	3.23
	(30.28)	(27.52)	(30.59)	(3.01)	(2.68)	(3.00)
d(1997) * TYPE	89.51**	73.53**	90.05**	5.66*	4.68*	5.62*
	(40.64)	(32.41)	(40.58)	(2.95)	(2.59)	(2.96)
d(1998) * TYPE	71.64***	58.11**	75.41***	2.36	1.39	2.11
	(20.91)	(22.79)	(21.45)	(2.70)	(2.41)	(2.77)
d(1999) * TYPE	66.11*	50.29	70.80*	3.56	2.42	3.26
	(38.82)	(38.12)	(39.66)	(2.71)	(2.49)	(2.71)
d(2000) * TYPE	64.63**	58.01**	70.73**	4.33*	3.29	3.94
	(27.57)	(27.66)	(28.56)	(2.54)	(2.31)	(2.58)
d(2001) * TYPE	66.75***	70.40**	72.66***	5.03**	3.88*	4.61*
	(23.77)	(31.32)	(25.21)	(2.33)	(1.95)	(2.51)
d(2002) * TYPE	61.73**	74.80***	68.15**	5.89**	4.87**	5.38**
	(24.50)	(24.45)	(25.64)	(2.52)	(2.35)	(2.61)
d(2003) * TYPE	43.69	62.14*	51.81	3.39	2.22	2.75
	(30.50)	(32.77)	(31.74)	(2.88)	(2.62)	(2.92)
d(2004) * TYPE	60.46**	96.35***	70.85***	7.84***	7.00***	7.10***
	(22.36)	(28.10)	(25.03)	(2.46)	(2.18)	(2.57)
d(2005) * TYPE	119.07***	-	131.73***	12.87***	-	11.87***
	(32.37)		(36.85)	(3.11)		(3.19)
d(2006) * TYPE	75.56***	-	92.95***	8.50***	-	7.16***
	(24.83)		(30.41)	(2.22)		(2.69)
d(2007) * TYPE	113.70***	-	127.02***	13.62***	-	11.91***
	(30.56)		(35.59)	(2.74)		(3.18)
d(2008) * TYPE	147.45***	-	159.44***	15.53***	-	13.34***
	(34.34)		(39.08)	(3.10)		(3.57)
d(2009) * TYPE	120.98***	-	126.91***	12.76***	-	9.91***
	(31.71)		(34.54)	(3.03)		(3.72)
d(2010) * TYPE	98.00***	-	98.09***	8.86***	-	5.60*
	(28.45)		(30.15)	(2.56)		(3.23)
Category-year covariates?	NO	YES	NO	NO	YES	NO
Include RCE controls?	NO	NO	YES	NO	NO	YES

* significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are reported in parentheses and are clustered to correct for autocorrelation within patent categories over time (Columns 1–3) and for autocorrelation within patent-category / entity-size combinations over time (Columns 4–6). All regressions include patent-category fixed effects and year fixed effects. Regressions in Column 4–6 include entity-size fixed effects as well. Regressions are weighted by the number of disposals used to form each observation's grant rate. Reported coefficient values represent the differential grant rate between patent types (high- vs. low-maintenance or large- vs. small-entity) for the given year. Values are to be interpreted with reference to 1991, whose differential grant rate between types is normalized to zero. Data on patent-processing statistics and maintenance rates were obtained from the PTO.

Nonparametric treatment of maintenance rates. The primary results explore the interaction between the fee reform and maintenance rates using a linear treatment of category-specific maintenance rates. In the following table, we allocate technology categories into one of four groups, based on their maintenance-rate percentile: (1) bottom 25th percent, (2) 25th–50th percent, (3) 50th–75thpercent, and (4) top 25th percent. We assign each technology category four dummy variables indicating whether or not the respective category falls into the relevant percentile group. We then interact each such dummy variable with the post-1991 dummy variable. We include each interaction in a single regression, leaving out the dummy representing the bottom twenty-fifth percent, which will serve as the reference group. The results suggest a greater degree of differentiation in granting tendencies on the part of the PTO as we move into higher and higher maintenance-rate categories.

TABLE A4. NONPARAMETRIC TREATMENT OF MAINTENANCE RATES

	(1)
(Reference group: 0-25th Percentile)	
POST * (25th-50th Percentile)	3.34 (2.54)
POST * (50th-75th Percentile)	6.47** (2.61)
POST * (75th-100th Percentile)	6.81** (2.70)

* significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are reported in parentheses and are clustered to correct for autocorrelation within patent categories over time. All regressions include patent-category fixed effects and year fixed effects. Regressions are weighted by the number of disposals used to form each observation's grant rate. Data on patent-processing statistics and maintenance rates were obtained from the PTO.

Triple-differences estimation. In the table below, we modify the entity-size regressions to include a term in which we interact the category-specific maintenance rate with a dummy variable for being in the postreform period and with another dummy variable representing large-entity status.[18] The estimated positive coefficient suggests the grant-rate response to the 1991 reform for large entities within high-maintenance-rate technologies does not just represent an additive effect reflective of the independent entity-size and maintenance-rate

18. This regression also includes the pieces of this three-level interaction—e.g., the interaction between large-entity status and post-1991 period.

stories. Rather, it suggests that the PTO may be targeting its distortionary practices within that particular group, consistent with a story, for instance, in which a benevolent PTO would want to target its distortionary practices in that area where it stands to generate the most revenues. As demonstrated by Columns 2 and 3, this exercise is robust to inclusion of technology-year and entity-size-year fixed effects and thus accounts for the possibility that there may be unobservable shocks in the grant rates of particular technologies (e.g., to account for the possibility that some unobserved factor may drive up the grant rates for genetics-related patents over the 1991–2010 period), in addition to unobservable shocks to the grant rates of large entities in this postreform period.

TABLE A5. DIFFERENCE-IN-DIFFERENCE-IN-DIFFERENCE RESULTS

	(1)	**(2)**	**(3)**
POST * MAINTAIN * LARGE	42.79*** (17.92)	48.29* (26.23)	40.41** (19.14)
Include technology-year fixed effects?	NO	YES	YES
Include entity-size-year fixed effects?	NO	NO	YES

* significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are reported in parentheses and are clustered to correct for autocorrelation within patent-category / entity-size combinations over time. All regressions include patent-category fixed effects, year fixed effects and entity-size fixed effects. Regressions are weighted by the number of disposals used to form each observation's grant rate. Data on patent-processing statistics and maintenance rates were obtained from the PTO.

Alternative Difference-in-Difference Formulation. We also estimate difference-in-difference specifications that focus only on the post-1990 period and that, instead of relying upon the 1991 fee reform, identify the relationship between the PTO's fee structure and its granting practices using variations over time in the PTO's sustainability score—that is, variations over time in its need of funds. Consistent with the interaction results presented in Table 2 of this Article, the results presented in Table A6 (as evidenced by the negative coefficient estimates) suggest that the PTO is more likely to grant at an incrementally higher rate to high-fee patent types (i.e., large entities and high-maintenance-rate technologies) during periods of time in which it has greater difficulties covering the examination costs demanded of it by its incoming crop of maintenance fees (as proxied by a lower sustainability score).

TABLE A6. SUSTAINABILITY DIFFERENCE-IN-DIFFERENCE RESULTS (POST-1990 PERIOD)

	(1)	(2)
SUSTAINABILITY * MAINTAIN	-291.78*** (93.02)	-
SUSTAINABILITY * LARGE	-	-38.28*** 8.00)

* significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are reported in parentheses and are clustered to correct for autocorrelation within patent categories over time (Column 1) and for autocorrelation within patent-category / entity-size combinations over time (Column 2). All regressions include patent-category fixed effects and year fixed effects. Regressions in Column 2 include entity-size fixed effects as well. Regressions are weighted by the number of disposals used to form each observation's grant rate. Data on patent-processing statistics and maintenance rates were obtained from the PTO.

More selected filings following fee reform? As discussed in Part IV, a concern arises that perhaps the observed differential responses to the fee reform (and to changes in sustainability measures) are a reflection of selection concerns—i.e., to the changing composition of patents within the delineated patent types. Primarily, if large-entity applicants or applicants within high-maintenance-rate technologies begin to file at a lower rate following 1991 (or following declines in the PTO's financial balance), one may be concerned that the observed increases in grant rates for these types are a reflection of the more selective (and potentially higher-quality) applicant pools remaining. Appeasing these concerns, as demonstrated by Table A7 below, if anything, we find that the 1991 reform was associated with an increase in the rate of filings for large entities and for high-maintenance-rate technologies relative to small entities and low-maintenance-rate technologies. Likewise, the negative coefficients estimated in the sustainability difference-in-difference specifications (Rows 2 and 4) suggest that, if anything, we find an increase (as opposed to a potentially concerning decrease) in the rate of filings for large entities and for high-maintenance-rate technologies relative to small entities and low-maintenance-rate technologies as the PTO experiences a decrease in its sustainability score.

In addition, the key results presented in Table 2 are robust to the inclusion of controls for filing rates (for initial applications) specific to (1) technology-category-year cells (Panel A) and (2) technology-category–entity-size-year cells (Panel B).

TABLE A7. EFFECT OF FEE-REFORM AND SUSTAINABILITY FLUCTUATIONS ON RELATIVE FILING RATES ACROSS PATENT TYPES

	(1)	(2)	(3)	(4)
Panel A: Maintenance-Rate Specifications. Dependent variable: natural log of initial filings count (filings – total continuation filings)				
REFORM*MAINTAIN	8.81* (4.82)	-	-	-
SUSTAINABILITY*MAINTAIN (post-1990)	-	-10.57*** (5.02)	-	-
Panel B: Entity-Size Specifications. Dependent variable: natural log of initial filings count (filings – total continuation filings)				
REFORM*LARGE	-	-	0.11 (0.28)	-
SUSTAINABILITY*LARGE (post-1990)	-	-	-	-0.13 (0.37)

* significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are reported in parentheses and are clustered to correct for autocorrelation within patent categories over time (Panel A) and for autocorrelation within patent-category / entity-size combinations over time (Panel B). All regressions include patent-category fixed effects and year fixed effects. Regressions in Panel B include entity-size fixed effects as well. Regressions are weighted by the number of disposals used to form each observation's grant rate. Data on patent-processing statistics and maintenance rates were obtained from the PTO.

Components of Sustainability Score. Rather than simply exploring how the differential grant rate across patent types changes in connection with fluctuations in the composite sustainability score, we also estimate regressions that break out the key components to that score and estimate how the differential grant rate across patent types changes in connection with fluctuations within each of these components, independently (though the reported regressions include all of the independent factors in the same regression, allowing us to partial out any correlations). For the purposes of this illustration, we break out the following factors:

(1) The PTO's backlog of pending examinations for the given year normalized by the stock of patents available to generate post-allowance fees that year—i.e., the sum of the patents issued that year, four years previously, eight years previously, and twelve years previously (an increase in this backlog ratio would suggest a weakening in the PTO's financial balance, in connection with which one would presume to observe an increase in granting),

(2) the average maintenance rate for patents eligible for renewal that year, averaging the four-year, eight-year, and twelve-year rates for ease of presentation (a decrease in this rate would suggest a weakening in the PTO's financial balance, in connection with which one would presume to observe an increase in granting),

(3) the average examination complexity (i.e., average examination hours) of the patents disposed of that year (an increase in this average complexity would suggest a weakening in the PTO's financial balance, in connection with which one would presume to observe an increase in granting), and

(4) the percentage of the patent stock available to generate post-allowance fees that year (e.g., the patents issued that year and each of four-, eight,- and twelve-years previously) that are large entities (a decrease in this rate would suggest a weakening in the PTO's financial balance, in connection with which one would presume to observe an increase in granting).

The sign of the estimated coefficients for the backlog, exam complexity, and entity-size percentage specifications are consistent with the above predictions; however, only the backlog finding is statistically distinguishable from zero. It is worth noting that the backlog factor varied to the greatest degree over the sample period out of the four factors. These findings suggest that the growing examination demand facing the PTO, relative to the existing stock of patents by which the PTO may generate post-allowance fees, is primarily responsible for the observed sustainability-score findings.

Further, the results of this study remain virtually unchanged when we construct an alternative aggregated sustainability score that is matched to each technology-year cell after removing the influence of the components of the aggregate sustainability score that are attributable to that particular, disaggregated cell—e.g., the sustainability score that is attached to the Organic Compounds Technology Category is calculated in a manner that ignores fluctuations in the maintenance rates for that technology group, focusing instead on fluctuations in the renewal proclivities of the collective remaining technologies. In the face of each observation in the sample, the resulting measure will continue to provide a valid sense of the overall financial health of the Agency during the relevant year. This exercise eases endogeneity concerns regarding a linkage between the measure identifying variations in Agency financial health and the measure used to allocate fee-generating potentials of different technologies.

TABLE A8. EFFECT OF KEY COMPONENTS OF SUSTAINABILITY SCORE ON DIFFERENTIAL GRANT RATE ACROSS PATENT TYPES

	(1)	(2)
	TYPE = MAINTAIN	TYPE = LARGE
TYPE * BACKLOG RATIO	61.27***	9.91***
	(20.81)	(2.26)
TYPE * AVG RENEWAL RATE	257.90	14.08
	(243.05)	(18.30)
TYPE * AVG EXAM COMPLEXITY	9.63	1.64
	(67.38)	(5.32)
TYPE * LARGE ENTITY %	-405.70	-52.29
	(449.08)	(40.36)

* significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors are reported in parentheses and are clustered to correct for autocorrelation within patent categories over time (Column 1) and for autocorrelation within patent-category / entity-size combinations over time (Column 2). All regressions include patent-category fixed effects and year fixed effects. Regressions in Column 2 include entity-size fixed effects as well. Regressions are weighted by the number of disposals used to form each observation's grant rate. Data on patent-processing statistics and maintenance rates were obtained from the PTO.