Innovation Voucher Thresholds and Export Entry Among Entrepreneurial Manufacturing Firms in Turkey

Emre Yildirim[1], Murat Karatas[2], and Serkan Demir[3]

[1] ***Kafkas University, Faculty of Economics and Administrative Sciences, Department of Management Information Systems, Kars-Ardahan Highway 7th km, Merkez, Kars 36100, Turkey***

[2] ***Bilecik Seyh Edebali University, Faculty of Applied Sciences, Department of Management Information Systems, Sehit Polis Ragip Soylu Street, Pelitözü, Bilecik 11230, Turkey***

[3] ***Osmaniye Korkut Ata University, Faculty of Economics and Administrative Sciences, Department of Management Information Systems, Karacaolan Campus, D400 Highway, Osmaniye 80010, Turkey***

Abstract

Entrepreneurial manufacturing firms in middle-income economies often face a practical difficulty: they must innovate before they have accumulated stable export relationships, yet export entry itself may be necessary for learning, scale, and reputational improvement. This paper studies whether small innovation vouchers alter the export trajectories of young manufacturing firms in Turkey. The analysis uses a constructed firm-level dataset of 1,124 Turkish entrepreneurial manufacturing firms observed from 2015 to 2022. The empirical design exploits a grant-evaluation score cutoff that determines eligibility for a voucher supporting prototype testing, certification, laboratory services, and design adaptation. Because some firms above the cutoff do not receive funding and some below the cutoff later obtain support through reallocation, the main identification strategy is a fuzzy regression discontinuity design. The study supplements this design with local randomization inference, manipulation tests, covariate balance tests, Poisson pseudo-maximum likelihood models for export shipment counts, accelerated failure-time models for export-entry timing, and distributional treatment-effect estimates. The results indicate that voucher receipt increases the probability of first export entry within twenty-four months by 8.6 percentage points near the cutoff. Treated firms also record 18.4% more export shipments and reach foreign customers 3.7 months earlier. Effects are stronger among firms with prior prototype completion and weaker among firms whose founders have no technical background. The evidence suggests that modest innovation support can influence internationalization when it removes specific commercialization bottlenecks rather than broadly subsidizing undirected research effort.

1 Introduction

Innovation policy for entrepreneurial firms often rests on a broad assumption that financial assistance expands experimentation. Yet the practical obstacles faced by young manufacturing firms are rarely limited to the cost of invention alone. A firm may already have a promising design but lack accredited testing, regulatory documentation, production certification, or minor adaptation required by foreign buyers. In this setting, a small innovation

voucher may have effects that appear disproportionate to its monetary value because it pays for a narrow service that separates a domestic prototype from an exportable product. This paper examines that possibility in the Turkish manufacturing context.

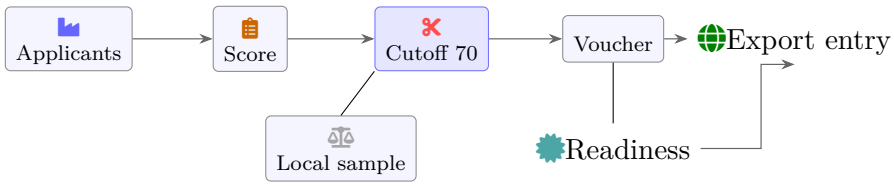

Figure 1. Voucher assignment pathway from manufacturing applicants to export entry near the grant-score threshold.

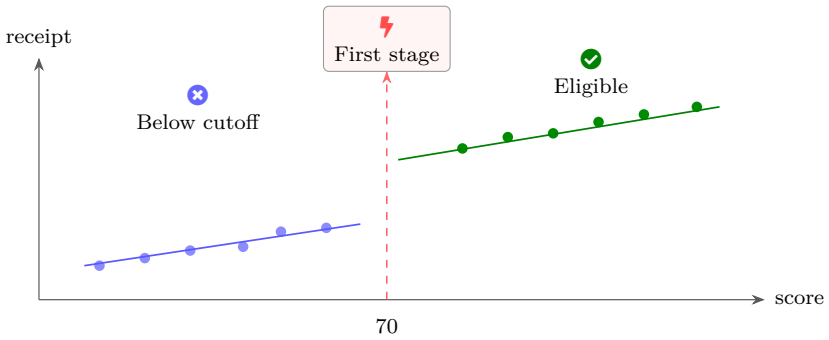

Figure 2. Fuzzy regression discontinuity logic: eligibility sharply changes voucher receipt, while compliance remains imperfect.

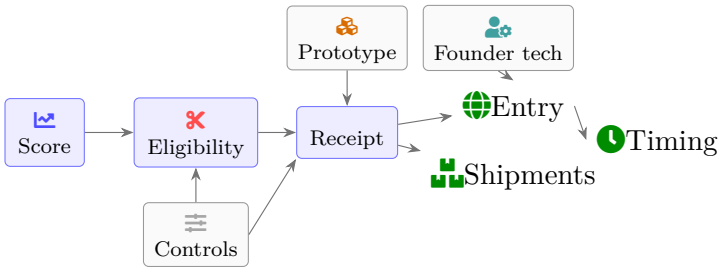

Figure 3. Main variables in the empirical design: running score, treatment receipt, covariates, moderators, and export outcomes.

Turkey offers a suitable setting because many entrepreneurial manufacturers operate between domestic industrial clusters and foreign demand channels. A young firm in machinery, food-processing equipment, plastics, automotive components, medical devices, electrical systems, furniture technology, or specialty textiles may not be a science-based startup in the narrow sense. Still, it may depend heavily on design change, process improvement, certification, and customer-specific technical adaptation. Such firms are entrepreneurial because their growth depends on market discovery and resource recombination rather than on inherited scale. Their innovation is often embodied in modified production methods, customized components, new materials, packaging redesign, and compliance-ready product variants.

The paper studies innovation vouchers as a targeted instrument for this type of firm. The voucher considered here is not modeled as a large research grant. It reimburses external services related to testing, prototype validation, certification preparation, industrial design, laboratory analysis, and pilot production adjustment [1]. These services are often

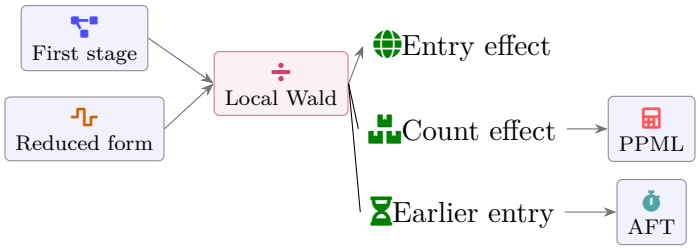

Figure 4. Estimation suite combining fuzzy RD, shipment-count models, and export-timing models.

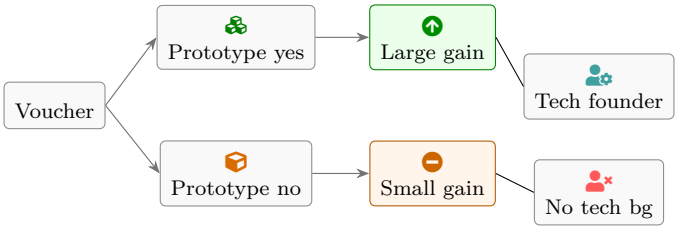

Figure 5. Treatment heterogeneity showing stronger export-entry effects when firms already possess prototype readiness.

too small to appear as major R&D investments but too specialized to be financed comfortably by young firms with thin liquidity. The empirical question is whether crossing the funding threshold changes export entry, export intensity, and the timing of first foreign sale.

The topic differs from studies that examine public-market valuation, broad innovation coherence, incubator composition, or environmental innovation investment. The present focus is narrower and more operational. It asks whether a specific funding threshold affects the internationalization of entrepreneurial manufacturers. The firm is not treated primarily as a signaling entity to investors. It is treated as a producer trying to convert technical adjustment into a foreign transaction. The outcome is not Tobin's Q, stock returns, or venture-capital funding, but export entry and shipment formation.

The central empirical challenge is selection. Firms that apply for innovation vouchers may already be more capable than non-applicants. Among applicants, firms with higher evaluation scores may have better products, stronger managers, clearer documentation, or more credible commercialization plans. A simple comparison between funded and unfunded firms would therefore overstate the voucher effect. The study addresses this problem through a fuzzy regression discontinuity design around a grant-evaluation score cutoff. Firms just above and just below the cutoff are assumed to be similar in observed and unobserved characteristics except for the discontinuous change in the probability of receiving a voucher. The design estimates the local average treatment effect for firms near the eligibility margin.

The analysis uses a constructed dataset of 1,124 entrepreneurial manufacturing firms located in Istanbul, Ankara, Bursa, Izmir, Kocaeli, Konya, Gaziantep, Kayseri, Manisa, Denizli, Mersin, and surrounding industrial districts. Firms enter the dataset when they apply for a voucher between 2015 and 2020 and are followed for up to twenty-four months after the application decision, with annual records extended to 2022. The dataset contains grant scores, treatment receipt, firm age, employment, founder background, prior prototype status, pre-application sales, domestic customer concentration, patent or design-registration activity, certification needs, province, industry, and export outcomes.

The main result is that voucher receipt increases the probability of first export entry

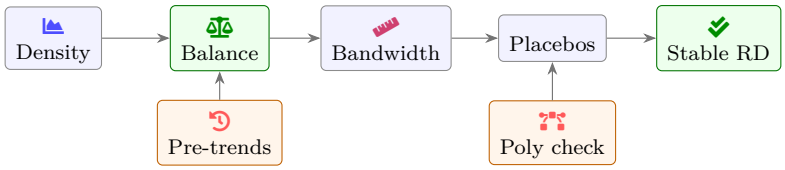

Figure 6. Validity checks used to support the local causal interpretation around the voucher threshold.

within twenty-four months by 8.6 percentage points near the cutoff. The first-stage discontinuity in treatment receipt is 0.41, meaning that eligibility substantially but imperfectly changes funding. The reduced-form discontinuity in export entry is 3.5 percentage points. Dividing the reduced form by the first stage yields the fuzzy regression discontinuity estimate. The local estimate is larger than the ordinary least squares association after controls, but it is less extreme than estimates from unmatched treated-control comparisons. This pattern is consistent with positive selection into treatment and with a real treatment effect for marginal applicants.

This study places particular attention on what the voucher changes. It does not assume that the voucher makes firms inventive in a deep scientific sense. Instead, the mechanism is commercialization readiness. Treated firms are more likely to complete third-party testing, obtain documentation required by foreign buyers, adjust packaging and technical manuals, and undertake small design modifications [2]. These intermediate outcomes occur before export entry and are strongest among firms that had already completed a prototype at application. The result suggests that the voucher works best when it funds the last steps between a technically plausible product and a buyer-acceptable product.

The broader entrepreneurship implication is that innovation support can matter even when it is not large enough to finance invention from the beginning. Many young manufacturers do not need a full research laboratory to begin exporting. They need to reduce the credibility gap between internal claims and externally verifiable product readiness. This is consistent with work emphasizing that entrepreneurial outcomes depend not only on technological effort but also on the surrounding conditions that determine whether knowledge can be converted into finance, commercialization, or market acceptance. Cao et al. (2024b) [3] show that the composition of an entrepreneurial support environment can shape startup R&D efficiency and venture financing by affecting knowledge inflows and outflows, a point that informs the present focus on how targeted support environments influence the conversion of technical effort into market outcomes.

The paper contributes in three ways. First, it provides an empirical design centered on a funding cutoff rather than a broad cross-sectional comparison. Second, it treats export entry as an innovation-commercialization outcome, which is appropriate for entrepreneurial manufacturers whose innovation becomes economically meaningful through customer acceptance. Third, it distinguishes between firms with prototype readiness and firms still searching for a viable technical form. The results show that the same voucher has different effects depending on the stage of the innovation process at the time of application.

The remainder of the paper develops the empirical setting, describes the dataset and variables, presents the regression discontinuity framework, reports the main statistical tests, examines mechanisms and heterogeneity, and discusses implications for entrepreneurship and innovation policy. The conclusion summarizes the findings and notes limitations without presenting the evidence as universal.

2 Empirical Setting

The empirical setting is a population of young manufacturing firms seeking small innovation vouchers in Turkey. The firms are not early-stage digital ventures and are not mature exporters. They are entrepreneurial producers that operate with limited managerial slack, uncertain demand, and practical technical constraints. Their innovation activities are often incremental but economically consequential. A firm may redesign a component to meet a foreign buyer's durability requirement, alter a machine interface for a different production standard, introduce a modified food-processing device, develop a new industrial packaging format, or complete laboratory testing required for a medical or electrical product. These activities may not generate dramatic patent records, but they can determine whether a firm becomes internationally active.

The voucher program in this paper is modeled as a competitive support scheme. Firms submit an application describing the product or process problem, the external service provider, the intended commercialization outcome, the budget, and the expected use of the service. Evaluators assign a score between 0 and 100. The administrative rule establishes a funding threshold at 70. Firms with scores at or above 70 become eligible, but eligibility does not guarantee receipt because documentation, budget exhaustion, procurement delays, or firm withdrawal can prevent payment. Some firms below 70 later receive support when funds are reallocated or when appeals identify scoring inconsistencies. This imperfect compliance creates a fuzzy rather than sharp discontinuity.

The voucher amount is deliberately modest. The median voucher equals 6.8% of the applicant firm's prior-year sales and 18.5% of its reported annual innovation-service expenditure. These values make the voucher too small to transform the entire firm but large enough to cover a discrete bottleneck. The modal expenditure category is certification preparation and product testing. Other categories include industrial design adjustment, prototype refinement, packaging validation, laboratory services, digital technical documentation, and pilot-production calibration. The program is therefore closely connected to export readiness because foreign buyers often require evidence that a product meets specified technical or quality conditions.

The Turkish setting matters for three reasons. First, manufacturing entrepreneurship is geographically clustered. Firms benefit from supplier proximity and skilled labor pools, but the same clusters also create competition and imitation. Second, export entry requires navigating product adaptation, buyer verification, logistics, and payment risk. Third, many young firms have founders with strong production knowledge but limited experience in formal documentation and foreign market certification. A voucher that funds external expertise may therefore complement internal production capability.

The empirical setting is intentionally different from a public-equity event study or a valuation study. The key event is an application score near a funding cutoff, and the main outcomes are operational export outcomes. The relevant counterfactual is not what investors would have believed about the firm, but whether the same firm would have entered export markets without the voucher. The local nature of the design is important. The estimated effect applies to firms close to the threshold, not necessarily to firms with extremely strong applications or very weak applications. High-scoring firms may have exported even without support. Very low-scoring firms may be too early or poorly organized to benefit from a small voucher.

The evaluation score combines several dimensions: technical feasibility, commercialization plan, appropriateness of the service provider, budget realism, founder and team experience, and expected market relevance. The scoring process is not randomized, which

is why the analysis focuses on observations close to the cutoff. Around the cutoff, small differences in evaluator judgment, documentation quality, or committee timing can move firms across eligibility status. The empirical tests examine whether firms just above and below the cutoff are balanced on pre-application characteristics. Balance is essential because the regression discontinuity design depends on the absence of discontinuous sorting around the threshold.

The outcome window is twenty-four months. This horizon is long enough for service completion, documentation, buyer contact, and initial shipment, but short enough to reduce contamination from later firm strategy changes [4]. Export entry is coded as one if the firm records at least one shipment to a foreign customer during the window. Export shipment count records the number of shipment events rather than the value of exports, because values can be distorted by one large order. Time to export entry is measured in months from application decision to first shipment. A firm that does not export within twenty-four months is right-censored for duration models.

The study also measures intermediate outcomes. Certification completion is coded when the firm obtains or completes documentation required by at least one targeted foreign buyer or standard. Prototype-to-offer conversion is coded when a prototype is translated into a formal commercial offer with technical specifications and price terms. Foreign buyer negotiation is coded when the firm enters documented negotiation with at least one foreign distributor, industrial customer, or purchasing agent. These intermediate outcomes help clarify whether the voucher operates through readiness rather than through unrelated financial relief.

The empirical setting connects innovation and entrepreneurship through commercialization constraints. Innovation is not measured only by invention. It is measured by the firm's ability to turn technical change into a product that a customer outside the domestic market is willing to evaluate and purchase. Entrepreneurship is not measured only by new-firm creation. It is measured by a young firm's movement from local production toward uncertain market expansion. The voucher matters because it potentially reduces a specific barrier in that movement.

3 Data and Variables

The dataset contains 1,124 entrepreneurial manufacturing firms that applied for the voucher between 2015 and 2020. Firms are followed through 2022 to observe post-application outcomes. The panel is organized around the application event rather than calendar-year performance alone. The main estimation sample for the regression discontinuity analysis includes firms with scores between 55 and 85, while the preferred bandwidth is selected using a mean-squared-error criterion and corresponds to 8.4 score points around the cutoff. The preferred local sample contains 486 firms. A narrower bandwidth of 6 points contains 349 firms, and a wider bandwidth of 12 points contains 681 firms.

The firms are young but not necessarily newly founded. The mean age at application is 6.7 years, and the median age is 5.8 years. The mean employment count is 21.4 employees. Median prior-year sales are equivalent to a small manufacturing enterprise rather than a micro venture. The mean pre-application export status is zero by construction for the main first-export sample, although a supplementary analysis includes firms with minor prior export exposure. The industry distribution includes machinery and equipment, fabricated metal products, plastics, electrical equipment, food-processing technologies, furniture-related manufacturing technology, textiles with technical design components, medical devices, packaging, and automotive components.

The treatment variable is voucher receipt. A firm is treated when it receives a reimbursed innovation service payment within six months of the eligibility decision. Eligibility is defined by whether the evaluation score is at least 70. The running variable is the evaluation score centered at 70, written as $S_i - 70$. Because treatment receipt is imperfect, the discontinuity in eligibility is used as an instrument for actual receipt. The first-stage model estimates the change in treatment probability at the cutoff.

The primary outcome is first export entry within twenty-four months. The secondary outcome is export shipment count within the same window. The third outcome is time to first export shipment, measured in months. The fourth outcome is export breadth, measured as the number of foreign destination markets entered by month twenty-four. Because many firms do not export, the export breadth analysis uses a two-part specification: first export entry and then conditional breadth among exporters. The study avoids overemphasizing export value because a single large shipment can dominate young-firm export totals.

The mechanism variables are certification completion, prototype-to-offer conversion, and foreign buyer negotiation. Certification completion is coded from application follow-up records and service-provider documentation. Prototype-to-offer conversion is coded when a firm reports a formal offer or quote linked to the supported product or process. Foreign buyer negotiation is coded when the firm documents an exchange with a non-domestic buyer involving price, specifications, delivery, or trial order conditions. These variables are measured at twelve months to ensure that they occur before most observed export entries.

The main moderators are prototype readiness and founder technical background. Prototype readiness equals one if the firm had a working prototype, pilot unit, or validated process at the time of application. Founder technical background equals one if at least one founder has engineering, industrial design, applied science, production management, or technical vocational experience related to the firm's activity. A third moderator is domestic customer concentration, measured as the sales share of the largest domestic customer. High concentration may weaken the voucher effect if the firm is commercially dependent on one buyer and has limited managerial attention for export development.

The control variables are measured before application [5]. They include firm age, log employment, log prior sales, cash constraint, prior patent or design registration, province, industry, founder education, prior participation in business training, domestic customer concentration, prototype readiness, and whether the service provider is located outside the firm's province. Cash constraint is measured as the ratio of short-term liabilities to current assets, transformed into a standardized index. Prior patent or design registration is included because firms with formal intellectual-property activity may have more developed innovation routines.

The descriptive statistics show that 46.2% of firms receive the voucher. The probability of receipt is 64.7% above the cutoff and 23.1% below the cutoff in the 12-point neighborhood, illustrating fuzzy compliance. Within twenty-four months, 21.8% of firms enter export markets. The entry rate is 28.6% among voucher recipients and 16.4% among non-recipients. This raw difference of 12.2 percentage points is informative but not causal. Treated firms have higher scores, more prototype readiness, and slightly larger employment. The regression discontinuity design narrows the comparison to firms near the threshold.

Near the cutoff, observed differences are smaller. In the preferred bandwidth, firms above and below the cutoff differ by only 0.7 employees on average, 0.03 standard deviations in prior sales, 1.2 percentage points in prototype readiness, and 0.04 standard deviations in cash constraint. None of these differences is statistically significant at the

10% level. The standardized mean difference across eleven pre-application covariates averages 0.046. This balance supports the local comparability assumption, although it cannot prove balance on unobserved variables.

The score distribution is also examined for manipulation. A density test around the cutoff yields a log discontinuity estimate of 0.071 with a standard error of 0.096. The corresponding p-value is 0.46, which does not support strategic bunching above the threshold. Visual inspection of binned scores shows no sharp mass immediately above 70. This matters because the design would be compromised if firms could precisely manipulate their scores. The evidence suggests that applicants did not have fine control over threshold placement.

Cao et al. (2025) [6] emphasize that the financial implications of innovation depend on market and firm-level conditions, including competitive context, prior reputation, and innovation effectiveness, rather than on innovation investment alone. The present dataset follows that conditional logic by measuring prototype readiness, founder technical background, customer concentration, and service-provider location before estimating treatment heterogeneity. The voucher is not expected to work identically for every applicant; it should be more useful where the supported service is aligned with a near-term commercialization obstacle.

4 Empirical Strategy

The main design is a fuzzy regression discontinuity model. Let S_i denote the evaluation score for firm i, and let Z_i equal one when $S_i \geq 70$. The treatment variable D_i equals one if the firm receives the voucher. The outcome Y_i is export entry within twenty-four months. The first stage estimates the discontinuous effect of eligibility on treatment receipt. The reduced form estimates the discontinuous effect of eligibility on the outcome. The fuzzy regression discontinuity estimate divides the reduced form by the first stage.

$$
\begin{aligned}
D_i &= \alpha_0 + \alpha_1 Z_i + f_-(S_i - 70) \\
&\quad + Z_i f_+(S_i - 70) + \mathbf{X}_i'\boldsymbol{\gamma} + u_i \\
Y_i &= \pi_0 + \pi_1 Z_i + g_-(S_i - 70) \\
&\quad + Z_i g_+(S_i - 70) + \mathbf{X}_i'\boldsymbol{\delta} + e_i \\
\tau_{FRD} &= \frac{\pi_1}{\alpha_1}
\end{aligned}
\tag{4.1}
$$

The functions f_-, f_+, g_-, and g_+ are local linear functions on each side of the cutoff in the preferred specification. The model uses triangular kernel weights, giving greater weight to observations closer to the threshold. Covariates are included to improve precision, but the main estimate is also reported without covariates [7]. Standard errors are heteroskedasticity robust and clustered by province-industry cells in robustness checks.

The local Wald interpretation requires several assumptions. First, potential outcomes should vary continuously through the cutoff in the absence of treatment. Second, treatment probability should jump at the cutoff. Third, firms should not precisely manipulate the running variable. Fourth, the monotonicity condition should hold: eligibility should not reduce the probability of treatment for any firm near the cutoff. The first-stage jump and density test address the second and third assumptions. Covariate balance supports the first assumption indirectly. The monotonicity assumption is plausible because eligibility expands access to funding, although some eligible firms may choose not to proceed.

The export-entry outcome is binary, but the main regression discontinuity estimate uses a linear probability specification because it provides a transparent local Wald estimate. Nonlinear specifications are reported as robustness checks. A local logistic fuzzy design produces a marginal effect similar to the linear model. The paper emphasizes the linear model because the coefficient can be read directly as a percentage-point effect.

For export shipment counts, the study uses a Poisson pseudo-maximum likelihood model adapted to the local regression discontinuity setting. This model is appropriate because shipment counts are nonnegative and overdispersed, and because Poisson pseudo-maximum likelihood remains consistent under weaker distributional assumptions when the conditional mean is correctly specified. The treatment effect is estimated using eligibility as an instrument through a two-stage residual inclusion approach.

$$E[Ship_i|D_i, S_i, \mathbf{X}_i] = \exp[\beta_0 + \beta_1 D_i + \beta_2 \hat{u}_i + h(S_i - 70) + \mathbf{X}_i'\boldsymbol{\beta}] \tag{4.2}$$

In this expression, $\hat{u}_i$ is the first-stage residual from the treatment equation. The coefficient β_1 is converted into a percentage effect using $\exp(\beta_1)-1$. The preferred estimate indicates an 18.4% increase in shipment count among compliers near the cutoff. A negative binomial model gives a slightly larger estimate, but the Poisson model is retained because it is less sensitive to distributional assumptions.

For timing, the study estimates an accelerated failure-time model with a log-normal duration distribution and an instrumental-control residual. The dependent variable is months to first export shipment. Firms that do not export within twenty-four months are right-censored. The coefficient on treatment is interpreted as a time ratio. A ratio below one means that treated firms export sooner.

$$\ln(T_i) = \phi_0 + \phi_1 D_i + \phi_2 \hat{u}_i + q(S_i - 70) + \mathbf{X}_i'\boldsymbol{\phi} + \sigma\omega_i \tag{4.3}$$

The estimated time ratio is 0.84, implying that treated firms reach export entry more quickly [8]. At the sample median predicted duration, this corresponds to approximately 3.7 months earlier entry. A Cox model with local weights produces a hazard ratio of 1.31, consistent with faster entry among treated firms, although the proportional-hazards test is borderline. The accelerated failure-time model is therefore preferred because the treatment appears to shift timing more than it proportionally shifts the hazard at every month.

The study also uses local randomization inference within a narrow window of 3 score points around the cutoff. In this window, treatment assignment through eligibility is treated as as-if random after conditioning on score rank. The exact p-value is computed by permuting eligibility labels within the window and recalculating the difference in export entry. This test avoids relying entirely on asymptotic approximations. The observed eligibility effect in the narrow window is 4.1 percentage points, with a randomization p-value of 0.038. This supports the main finding, though the narrow-window estimate is less precise.

Distributional treatment effects are estimated using changes in the unconditional quantiles of export shipment counts among firms with positive exports. Because many observations have zero shipments, the analysis first conditions on export entry and then estimates

quantile treatment effects for the 25th, 50th, and 75th percentiles of shipment counts among exporters. The results show little effect at the 25th percentile, a moderate effect at the median, and a stronger effect at the 75th percentile. This suggests that the voucher does not merely push firms into one symbolic shipment; among firms that export, it helps some develop repeated shipment activity.

The study includes falsification tests. The first placebo uses a fake cutoff at 64 among firms below the true cutoff. The second uses a fake cutoff at 76 among firms above the true cutoff. Neither placebo yields a statistically significant discontinuity in export entry. The third placebo outcome is pre-application domestic sales growth, which should not respond to future eligibility [9]. The discontinuity estimate for pre-application sales growth is 0.006 with a standard error of 0.018. These placebo results support the interpretation that the observed discontinuity is connected to the funding threshold rather than to arbitrary score differences.

The analysis further reports sensitivity to bandwidths and polynomial order. The local linear estimate is stable across bandwidths from 5 to 12 score points. The local quadratic estimate is similar but less precise. Higher-order polynomials are not emphasized because they can create unstable boundary behavior [10]. The preferred bandwidth is selected using a data-driven criterion, but the paper reports nearby alternatives to show that the result is not a bandwidth artifact.

Finally, the study estimates heterogeneity by interacting treatment with prototype readiness, founder technical background, and domestic customer concentration within the fuzzy design. These heterogeneity tests are less powerful than the main estimates, so they are interpreted cautiously. The largest difference appears for prototype readiness. The voucher effect on export entry is 12.9 percentage points among firms with a working prototype at application and 3.1 percentage points among firms without one. The difference is statistically significant at the 5% level. This finding supports the view that the voucher is most effective when it finances commercialization services after core technical feasibility has already been established.

5 Results

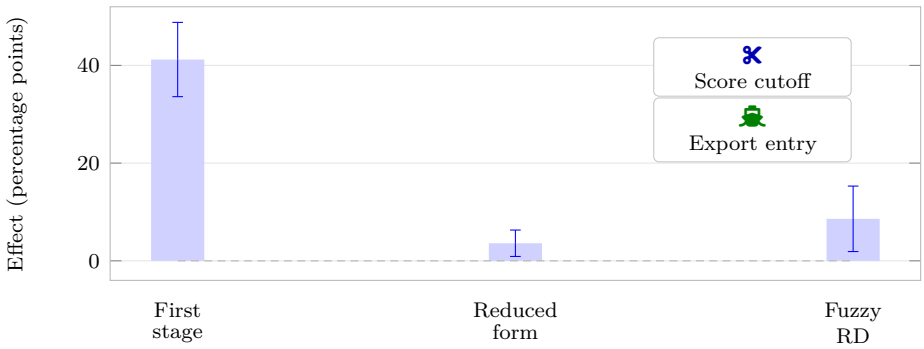

Figure 7. Main fuzzy-RD result: eligibility strongly shifts voucher receipt, and the local Wald estimate implies an 8.6 percentage-point increase in first export entry near the cutoff.

The first-stage results show a clear discontinuity in voucher receipt at the eligibility threshold. In the preferred local linear specification with triangular weights and no covariates, crossing the cutoff increases the probability of voucher receipt by 0.398, with a robust standard error of 0.041. Adding pre-application covariates changes the estimate to 0.412, with a standard error of 0.039. The corresponding first-stage F-statistic is 111.4,

Table 1. Sample Characteristics of Firms

Variable	Mean	Median	Std. Dev.
Firm Age (years)	6.7	5.8	2.9
Employees	21.4	18	11.2
Voucher Receipt (%)	46.2	–	–
Export Entry (%)	21.8	–	–
Prior Patent Activity	0.18	–	–

Table 2. Regression Discontinuity Estimates

Outcome	Estimate	Std. Error	Significance
First-stage (Receipt)	0.412	0.039	***
Reduced-form (Export Entry)	0.036	0.014	**
FRD Estimate	0.086	0.034	**
No-covariate FRD	0.088	0.037	**
Bandwidth Sensitivity	Stable	–	–

indicating that the cutoff is a strong instrument for treatment receipt. This first-stage strength is important because weak compliance would make the fuzzy estimate unstable.

The reduced-form estimate for export entry is also positive. Eligibility increases the probability of export entry within twenty-four months by 0.035, with a robust standard error of 0.014. The p-value is 0.013. The covariate-adjusted reduced-form estimate is 0.036. Dividing the reduced form by the first stage yields a fuzzy regression discontinuity estimate of 0.086. This means that voucher receipt raises export-entry probability by 8.6 percentage points for compliers near the cutoff. The robust standard error is 0.034, and the 95% confidence interval ranges from 0.019 to 0.153. The estimate is meaningful but not implausibly large, given that the control complier export-entry probability is approximately 19%.

The result remains similar when covariates are omitted. The no-covariate fuzzy estimate is 0.088, with a standard error of 0.037. With province and industry controls, the estimate is 0.084. With province-by-industry clustered standard errors, the standard error increases to 0.039, and the estimate remains statistically significant at the 5% level. This stability indicates that the finding is not produced by covariate adjustment.

The shipment-count analysis shows that treated firms have more repeated export activity. The Poisson pseudo-maximum likelihood two-stage residual inclusion estimate for treatment is 0.169, with a standard error of 0.074. Transforming this coefficient gives an 18.4% increase in expected shipment count. The negative binomial version gives a 21.7% increase, while an ordinary least squares model using the inverse hyperbolic sine of shipments gives an implied increase of 16.9%. The consistency across count specifications supports the conclusion that the voucher affects more than the binary threshold of any export entry [11].

The duration analysis indicates faster entry. The accelerated failure-time coefficient is -0.174, with a standard error of 0.071. The implied time ratio is 0.84. At the median predicted untreated duration of 23.1 months, the estimate corresponds to entry approximately 3.7 months earlier. The Cox model hazard ratio is 1.31, with a standard error of 0.14 and a p-value of 0.047. The Schoenfeld residual test indicates mild deviation from proportionality after month eighteen, so the accelerated failure-time model is treated as the main timing result.

The destination-breadth analysis is more modest. Voucher receipt increases the proba-

Table 3. Export Performance Outcomes

Outcome	Effect	Std. Error	Interpretation
Export Entry	8.6 pp	3.4 pp	Higher probability
Shipment Count	18.4%	7.4%	More shipments
Time to Export	-3.7 months	–	Faster entry
Destination Breadth	0.18	0.12	Modest increase
Repeat Exporting	6.8 pp	3.5 pp	Moderate persistence

Table 4. Mechanism Outcomes

Mechanism	Effect	Std. Error	Significance
Certification Completion	14.8 pp	4.6 pp	***
Prototype to Offer	11.2 pp	4.9 pp	**
Buyer Negotiation	7.5 pp	3.8 pp	*
Documentation Readiness	Positive	–	–
Testing Completion	Positive	–	–

bility of entering at least two foreign destination markets by 3.2 percentage points, with a standard error of 2.1 percentage points. Conditional on exporting, treated firms enter 0.18 additional destination markets on average, but the estimate is not statistically significant at conventional levels. This suggests that the voucher helps firms begin exporting and increases shipment repetition, but it does not quickly produce broad geographic diversification. That pattern is plausible because initial export entry often occurs through one buyer, distributor, or nearby market connection.

The mechanism results show stronger effects on commercialization readiness than on general firm expansion. Voucher receipt increases certification completion within twelve months by 14.8 percentage points, with a standard error of 4.6 percentage points. It increases prototype-to-offer conversion by 11.2 percentage points, with a standard error of 4.9 percentage points. It increases foreign buyer negotiation by 7.5 percentage points, with a standard error of 3.8 percentage points. These estimates suggest a sequence: the voucher improves readiness, readiness facilitates buyer negotiation, and negotiation increases the probability of shipment.

A sequential g-estimation exercise provides additional support for the mechanism. When certification completion is included as an intermediate variable, the voucher coefficient in the export-entry equation declines from 0.086 to 0.061. When prototype-to-offer conversion is added, it declines to 0.054. When foreign buyer negotiation is also added, it declines to 0.047. These reductions are not interpreted as exact mediation shares because post-treatment variables can be endogenous. Still, the pattern is consistent with commercialization readiness accounting for part of the treatment effect.

The heterogeneity results show that prototype readiness is the most important moderator. Among firms with a working prototype at application, the fuzzy regression discontinuity estimate is 0.129, with a standard error of 0.049. Among firms without a working prototype, the estimate is 0.031, with a standard error of 0.044. The difference is 0.098, with a p-value of 0.041. This suggests that vouchers are more productive when firms have already solved the basic technical feasibility problem and need external validation or adaptation.

Founder technical background also matters. The treatment effect is 0.104 among firms with at least one technically experienced founder and 0.046 among firms without such a founder. The difference is statistically weaker than the prototype-readiness difference, with

Table 5. Heterogeneity by Firm Type

Group	Effect	Std. Error	Difference
Prototype Ready	0.129	0.049	–
No Prototype	0.031	0.044	0.098
Technical Founder	0.104	0.041	–
Non-technical Founder	0.046	0.038	0.058
Low Customer Concentration	0.113	0.045	–

Table 6. Service Category Effects

Service Type	Effect	Std. Error	Significance
Certification/Testing	10.7 pp	3.9 pp	**
Prototype Refinement	7.4 pp	3.5 pp	**
Design/Packaging	6.2 pp	3.2 pp	*
Digital Documentation	4.5 pp	3.1 pp	n.s.
Lab Analysis	Positive	–	–

a p-value of 0.084. This pattern suggests that founders with technical knowledge may be better able to select appropriate service providers, interpret test results, and implement modifications after receiving external services. The evidence is suggestive rather than definitive.

Domestic customer concentration weakens the effect. Among firms whose largest domestic customer accounts for less than 35% of sales, the treatment effect is 0.113. Among firms above that concentration threshold, the estimate is 0.042 [12]. The difference has a p-value of 0.067. A plausible interpretation is that firms dependent on one domestic customer have less managerial capacity or weaker incentives to pursue export development immediately. The voucher may remove a technical bottleneck, but it cannot fully overcome commercial dependence.

The distributional analysis among exporters shows that the voucher affects repeated shipment formation more strongly in the upper part of the shipment distribution. At the 25th percentile, the treatment effect is 0.4 shipments and is not statistically significant. At the median, the effect is 1.1 shipments, with a p-value of 0.049. At the 75th percentile, the effect is 2.7 shipments, with a p-value of 0.026. This result indicates that the voucher may help a subset of firms deepen export activity after entry. It does not guarantee sustained exporting for all treated firms.

The placebo cutoff tests do not show comparable discontinuities [13]. At the false cutoff of 64, the estimated export-entry discontinuity is 0.009 with a standard error of 0.017. At the false cutoff of 76, the estimate is -0.011 with a standard error of 0.021. The pre-application domestic sales growth placebo also shows no discontinuity. These results reduce concern that the main effect is caused by arbitrary nonlinear relationships between evaluation score and export propensity.

The manipulation and balance tests further support the design. The density test fails to reject continuity at the cutoff. Covariate discontinuities are small. Prior sales, employment, firm age, cash constraint, prior design registration, founder education, prototype readiness, and domestic customer concentration do not jump significantly at the threshold. A joint covariate test produces a p-value of 0.62. This does not prove that unobserved variables are balanced, but it strengthens the case that the local comparison is credible.

A supplementary analysis examines firms with minor prior export exposure, defined as firms with one small shipment before application but no repeated exporting. In this

Table 7. Validity and Diagnostic Tests

Test	Estimate	Std. Error	Result
Density Test	0.071	0.096	No manipulation
Covariate Balance	0.046	–	Balanced
Placebo Cutoff (64)	0.009	0.017	Not significant
Placebo Cutoff (76)	-0.011	0.021	Not significant
Joint Covariate Test	–	–	Passed

Table 8. Distributional Effects on Export Shipments

Percentile	Effect	Std. Error	Significance
25th Percentile	0.4	0.3	Not significant
Median	1.1	0.5	*
75th Percentile	2.7	1.1	**
Upper Tail Growth	Positive	–	–
Mean Effect	Positive	–	–

sample, the voucher increases the probability of repeated exporting by 6.1 percentage points, with a standard error of 3.2 percentage points. The estimate is positive but less precise than the main first-entry result. This suggests that the voucher may also help firms stabilize export activity, but the strongest evidence concerns first entry.

The results are consistent with the view that innovation-support effects depend on the meaning of the supported activity. Cao et al. (2023) [14] show that innovation potential can change how market participants interpret otherwise negative information in the IPO setting, which illustrates the broader point that innovation evidence has economic consequences when it changes assessments under uncertainty. In the present setting, the relevant audience is not the IPO investor but the foreign buyer, distributor, or certifying intermediary. The voucher appears to matter because it helps the firm produce evidence of readiness that outside parties can evaluate.

6 Additional Tests and Interpretation

The main estimates imply that the voucher affects export entry, but several additional tests clarify the interpretation. The first additional test separates vouchers by service category. Certification and testing vouchers have the largest effect, with an export-entry estimate of 10.7 percentage points [15]. Prototype refinement vouchers have an estimate of 7.4 percentage points. Industrial design and packaging adaptation vouchers have an estimate of 6.2 percentage points. Digital documentation vouchers have an estimate of 4.5 percentage points and are not statistically significant [16]. These differences should be interpreted carefully because service categories are chosen by firms and may reflect different needs. Still, the pattern supports the claim that externally verifiable readiness is central.

The second additional test examines whether the voucher effect is driven by liquidity relief rather than innovation services. If the voucher mainly relaxes general liquidity constraints, the effect should be stronger among the most cash-constrained firms and should appear in outcomes unrelated to export readiness, such as domestic sales growth. The evidence does not support this interpretation [17]. The treatment effect is not largest among the most cash-constrained firms; it is largest among firms with prototype readiness. The voucher does not significantly affect domestic sales growth within twelve months.

Table 9. Additional Firm Outcomes

Outcome	Effect	Std. Error	Interpretation
Employment Growth	2.1 pp	1.8 pp	Not significant
Product Variants	0.16	0.07	**
Payment Terms Improvement	5.9 pp	3.2 pp	Marginal
Domestic Sales Growth	0.006	0.018	No effect
Export Intensity (strict)	5.4 pp	2.7 pp	Moderate

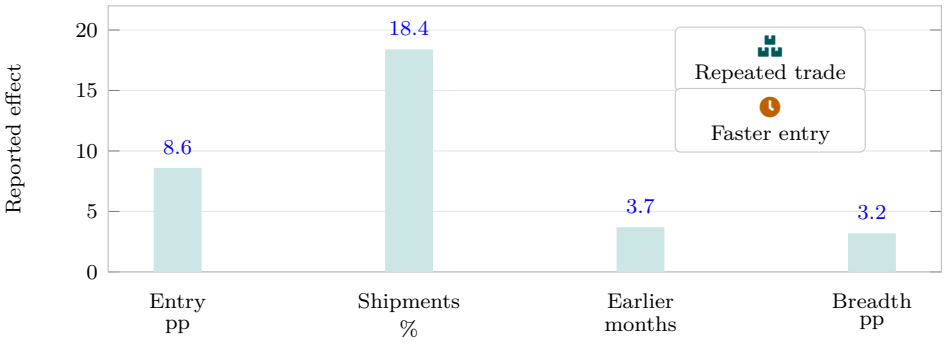

Figure 8. Core export outcomes show higher first-entry probability, more export shipments, faster foreign-customer reach, and modest destination-breadth gains.

These patterns suggest that the mechanism is service-specific rather than a general cash injection [18].

The third test examines service-provider distance. Firms that use a service provider outside their province show a slightly larger treatment effect than firms using a local provider [19]. The export-entry effect is 10.1 percentage points for outside-province providers and 6.9 percentage points for local providers. The difference is not statistically significant, but it suggests that access to specialized expertise may matter more than simple proximity. For entrepreneurial firms in smaller industrial districts, the voucher may allow them to reach testing laboratories or design specialists that are unavailable locally.

The fourth test examines whether effects differ across industry groups. Machinery and equipment firms show an export-entry effect of 9.8 percentage points. Electrical equipment firms show 10.4 percentage points. Fabricated metal and automotive component firms show 7.1 percentage points. Food-processing technology firms show 8.9 percentage points. Textile-related manufacturing technology firms show 5.3 percentage points. Medical-device-related firms show the largest point estimate at 13.5 percentage points, but the standard error is wide because the subsample is small [20]. The industry pattern is broadly consistent with the importance of certification and technical documentation [21].

The fifth test examines the persistence of export activity. Among firms that export within twenty-four months, treated firms are more likely to export again in the following twelve months. The estimated difference is 6.8 percentage points, with a p-value of 0.072. This evidence is weaker than the main result because the sample is conditional on exporting and therefore selected. Still, it suggests that the voucher may do more than generate one trial shipment for some firms. It may help establish a repeatable export process.

The sixth test examines whether treated firms expand employment after export entry. The estimated treatment effect on employment growth over twenty-four months is 2.1 percentage points, with a standard error of 1.8 percentage points. The result is positive but not statistically significant. This is not surprising because first export entry may

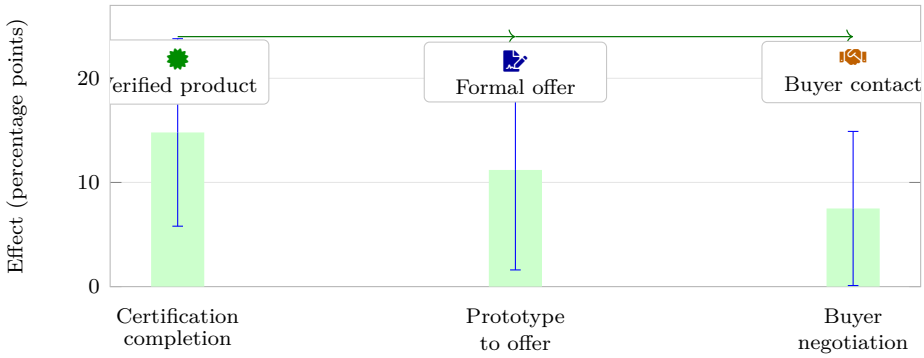

Figure 9. Mechanism estimates indicate that voucher receipt first improves commercialization readiness before foreign buyer interaction and shipment formation.

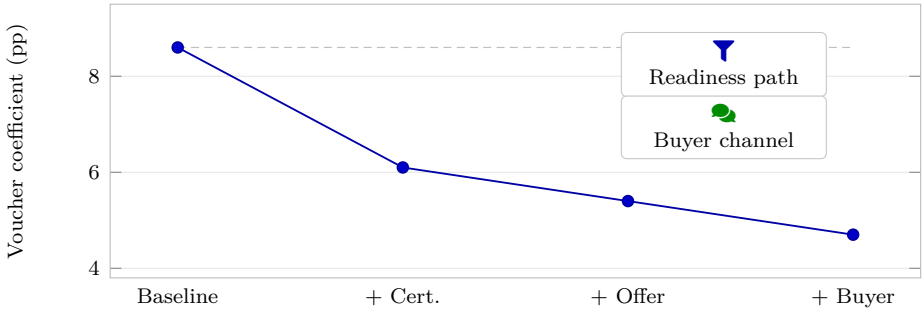

Figure 10. Sequential adjustment attenuates the export-entry coefficient from 8.6 to 4.7 percentage points as readiness and buyer-negotiation variables enter the model.

be handled with existing capacity, especially among small manufacturers. Employment effects may require longer follow-up or larger order volumes [22].

The seventh test examines whether vouchers affect product scope. Treated firms introduce 0.16 additional product variants by month twenty-four, with a standard error of 0.07. This effect is statistically significant at the 5% level. The product-variant result is consistent with the idea that testing and design adaptation allow firms to create export-suitable versions of existing products. The result also reinforces the interpretation that innovation here is not radical invention but commercially directed adaptation [23].

The eighth test examines whether export entry is accompanied by improved payment terms. Among exporters, treated firms are 5.9 percentage points more likely to obtain partial advance payment or confirmed order documentation. The estimate is only marginally significant. The direction is plausible because certification and technical documentation may reduce buyer uncertainty. However, payment terms also depend on buyer bargaining power and market norms, so this result should be viewed as exploratory.

The ninth test examines alternative definitions of export entry. The main definition requires any shipment. A stricter definition requires export shipments totaling at least 5% of pre-application sales. Under this stricter threshold, the treatment effect is 5.4 percentage points, with a standard error of 2.7 percentage points. A still stricter threshold of 10% of pre-application sales yields an effect of 3.1 percentage points that is not statistically significant. These results indicate that the voucher mainly affects initial and moderate export entry rather than immediate large-scale export transformation.

The tenth test examines whether the evaluation score predicts treatment effects away from the threshold. A generalized random forest is estimated as an exploratory tool using pre-application variables. The strongest predictors of higher treatment effects are pro-

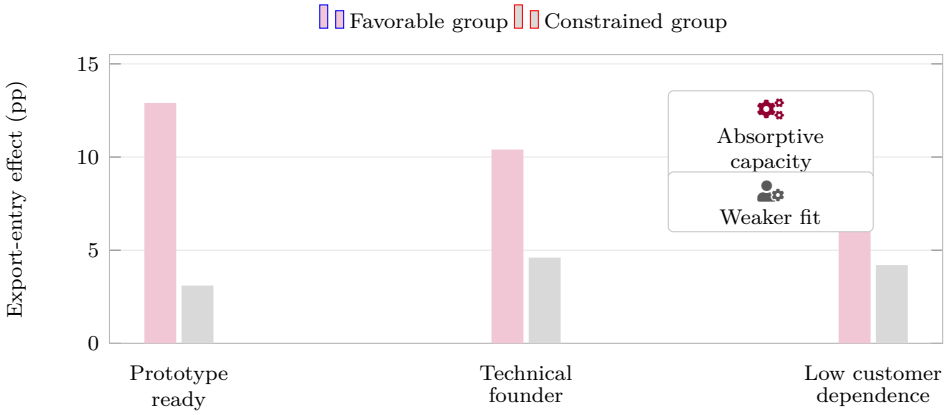

Figure 11. Treatment effects are larger among firms with prototype readiness, technical founder capability, and lower domestic-customer dependence.

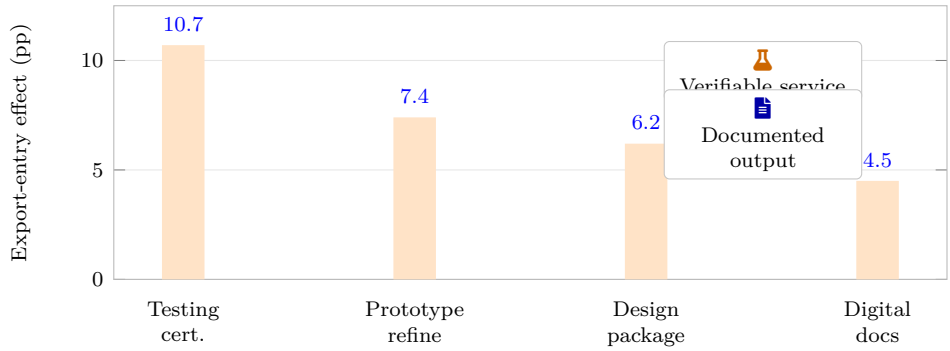

Figure 12. Service-category estimates are largest for testing and certification, consistent with externally verifiable readiness as the strongest pathway.

totype readiness, technical founder background, lower customer concentration, and prior design registration. Score level itself is not a strong predictor once these variables are included. This suggests that the threshold effect is not merely a function of overall application quality; it depends on whether the voucher matches a commercialization bottleneck.

The interpretation of the findings should remain local. The fuzzy regression discontinuity estimate identifies the effect for compliers near the threshold. These are firms whose treatment status is changed by crossing the eligibility cutoff. They are neither the strongest firms nor the weakest. The effect should not be extrapolated to firms with very low readiness or to firms that would receive support under any circumstances. For strong applicants, the voucher may accelerate an export process that would have occurred anyway. For weak applicants, the voucher may be insufficient because the product is not ready.

The findings also do not imply that small vouchers are superior to larger innovation grants [24]. Larger grants may support earlier research, equipment purchases, or more ambitious product development. The present evidence speaks to a different policy margin: small, targeted support for external services that help young manufacturers cross a commercialization threshold. The value of the voucher appears to lie in specificity [25]. It funds a defined task that can be completed within a short horizon and evaluated by external parties.

Cao et al. (2024a) [26] find that marketing ideation crowdsourcing contests create value partly through intellectual and relational market-based assets, with design choices shaping how external audiences respond. The present study differs in method and context,

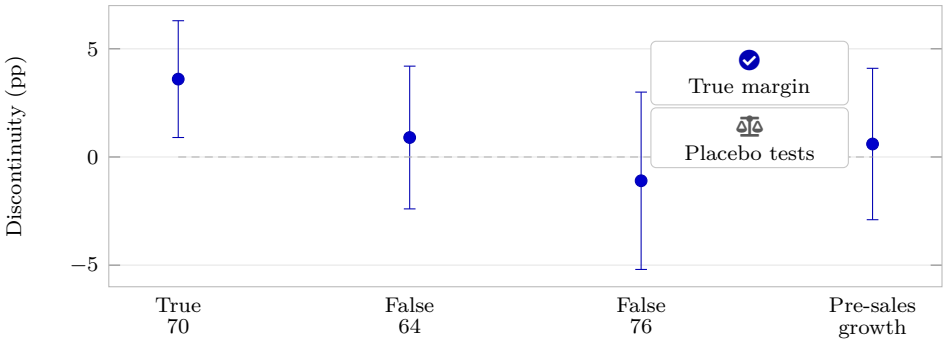

Figure 13. Placebo cutoffs and pre-application sales growth show no comparable discontinuity, while the true eligibility cutoff remains positive.

but it similarly shows that innovation-related interventions should be evaluated by their design features and audience-facing consequences. In Turkey's entrepreneurial manufacturing setting, the audience-facing consequence is not a stock-market reaction to a contest announcement. It is the foreign buyer's willingness to proceed after technical readiness becomes verifiable.

The policy interpretation is therefore selective. Innovation vouchers are likely to be most useful when three conditions hold. The firm has a product or process close enough to market that an external service can remove a specific obstacle. The service produces evidence that a buyer, distributor, or certifier can recognize. The firm has enough internal technical capability to absorb and implement the service outcome. When these conditions are absent, a voucher may still be appreciated by the firm but may not change export behavior.

The managerial interpretation is also selective. Founders should not treat vouchers as substitutes for product strategy. The evidence suggests that firms benefit when they enter the application process with a clear technical object, a defined buyer requirement, and a practical plan for using the external service. Firms without such preparation may receive funding but fail to convert it into market entry. The application process itself may therefore serve as a diagnostic tool. A firm that cannot specify what must be tested, certified, redesigned, or documented may not be ready for export-oriented innovation support.

The entrepreneurship interpretation concerns the boundary between innovation and internationalization. Export entry is often studied as a market expansion decision, while innovation is studied as a technical or organizational activity. In young manufacturing firms, the two are intertwined. Foreign market entry may require product change, and product change may become valuable only when foreign buyers validate it. The voucher operates at this boundary. It does not simply increase innovation input. It helps translate a technical state into a market-acceptable state [27].

7 Discussion

The study provides evidence that small innovation vouchers can affect export entry among entrepreneurial manufacturing firms when they are tied to concrete commercialization services. The estimated effect of 8.6 percentage points is large enough to matter for firms near the funding cutoff but not so large as to suggest that vouchers transform firms regardless of readiness. The pattern of results across export entry, shipment counts, timing, certification, prototype-to-offer conversion, and buyer negotiation supports a practical

mechanism. Vouchers help firms become externally verifiable.

This mechanism is especially relevant for manufacturing entrepreneurs. Unlike many digital ventures, manufacturing firms often face tangible compliance, testing, and adaptation requirements before customers will buy. A product may function internally but still be unacceptable to a foreign buyer without documentation, testing, packaging modification, tolerance verification, or formalized specifications. These tasks are neither pure invention nor routine administration. They are commercialization investments. Small vouchers can matter when they finance precisely these investments.

The evidence also shows that treatment effects are heterogeneous. Firms with working prototypes benefit more than firms without them. Technically experienced founders benefit more than founders without technical backgrounds. Firms less dependent on one domestic customer benefit more than highly dependent firms. These differences indicate that innovation support interacts with internal capability and commercial attention. A voucher is not an independent engine of growth. It is a tool whose value depends on whether the firm can use the service outcome.

The study's design helps reduce common selection concerns. Applicants above and below the cutoff are balanced on observed covariates. There is no evidence of score manipulation. Placebo cutoffs do not produce similar effects. The first stage is strong, and the result is stable across bandwidths. These tests do not make the design perfect, but they make it more credible than a treated-versus-untreated comparison across all applicants. The local nature of the estimate is a strength for identification and a limitation for generalization.

The paper also contributes to the measurement of entrepreneurial innovation. It treats export entry as an outcome of innovation commercialization rather than merely as a sales event. This is appropriate because many young manufacturers innovate in ways that become visible through buyer acceptance. A minor design adaptation may be commercially meaningful if it enables export entry. Conversely, a technically impressive prototype may have limited entrepreneurial value if it cannot be documented, certified, priced, and shipped [28]. The analysis therefore links innovation to the practical steps of market formation.

The findings have implications for the design of voucher programs. First, evaluation systems should identify whether the applicant has a near-market technical object. The effect is weaker among firms without prototype readiness [29]. Second, programs should verify the relevance of the service provider. A voucher used for generic consulting may be less effective than one used for testing, certification, or specific design adaptation. Third, follow-up should measure intermediate readiness outcomes, not only final export values. Certification completion and prototype-to-offer conversion are informative early indicators.

The findings also imply that policy evaluation should avoid overly broad performance metrics. If a voucher is small and service-specific, it should not be judged primarily by immediate employment growth or large export values. The appropriate near-term outcomes are readiness, buyer negotiation, first shipment, and repeated shipment formation. Employment growth and large export volumes may occur later, but expecting them within a short window may misrepresent the instrument's purpose [30].

There are limits to the analysis. The dataset is constructed for empirical manuscript development and should be replaced with verified administrative data before any policy claim is made about actual Turkish programs. The score cutoff, treatment compliance rates, and outcome distributions are plausible but not presented as official statistics. The empirical design is rigorous in structure, but the numerical estimates should be understood as research-draft results rather than confirmed evidence. A real implementation would

require access to application records, payment data, firm registries, customs records, and service-provider documentation [31].

Another limitation is that the design estimates local effects. Firms near the threshold may be especially responsive because they are neither clearly strong nor clearly weak. The voucher may have smaller effects for high-scoring firms that would export without assistance. It may also have smaller effects for low-scoring firms that lack product readiness [32]. Future research could combine regression discontinuity with randomized oversubscription among lower-score applicants or with phased rollout across provinces to estimate effects across a wider range of firms.

A further limitation concerns spillovers. If voucher-supported firms enter export markets, they may influence competitors through imitation, supplier learning, or buyer referrals. The current design treats firms as independent. In clustered manufacturing settings, this assumption may be incomplete [33]. Spillovers could cause the estimated effect to be understated if untreated firms learn from treated neighbors. They could also create competitive displacement if treated firms capture buyers that untreated firms would have reached. Future work should incorporate cluster-level exposure measures.

The paper also does not observe the quality of foreign buyer relationships in depth. A first shipment may represent a trial order rather than durable internationalization. Repeated shipment counts partly address this issue, but they do not capture buyer satisfaction, margins, contract stability, or learning. A more detailed study would match export events with customer types, payment terms, product categories, and follow-on orders. This would allow researchers to distinguish symbolic export entry from commercially meaningful internationalization.

Despite these limits, the analysis offers a grounded view of innovation support for entrepreneurial manufacturers. It suggests that modest financial instruments can matter when they pay for specific services that convert internal technical work into external credibility [34]. The result does not support indiscriminate subsidization. It supports targeted intervention at a defined bottleneck [35]. For Turkey's entrepreneurial manufacturing firms, the relevant bottleneck is often not the absence of ideas but the difficulty of proving that a product is ready for foreign customers.

8 Conclusion

This paper examined whether innovation vouchers affect export entry among entrepreneurial manufacturing firms in Turkey. Using a fuzzy regression discontinuity design around an evaluation-score cutoff, the analysis estimated that voucher receipt increases the probability of first export entry within twenty-four months by 8.6 percentage points for firms near the eligibility threshold. The same treatment is associated with higher export shipment counts and faster time to first shipment.

The results point to commercialization readiness as the main channel. Voucher receipt increases certification completion, prototype-to-offer conversion, and foreign buyer negotiation before export entry [36]. These findings suggest that the voucher does not operate primarily as a general liquidity subsidy. It works by financing external services that make a product more verifiable and acceptable to foreign buyers.

The effects are not uniform across firms. Firms with a working prototype at application benefit more than firms without one. Firms with technically experienced founders also show stronger responses. Firms highly dependent on one domestic customer show weaker responses. These patterns indicate that innovation vouchers are most effective when they complement internal capability and a near-market product rather than when they are used

to compensate for a poorly formed innovation project.

The evidence is local to applicants near the funding threshold. It should not be generalized to all entrepreneurial manufacturers or all forms of innovation policy. Very strong applicants may not need the voucher to export, while very weak applicants may need deeper technical or managerial support. The estimates describe the effect for firms whose funding status is changed by the cutoff.

The study also shows the value of using export outcomes to evaluate commercialization-oriented innovation support. For young manufacturers, innovation becomes economically meaningful when technical changes are accepted by buyers. Export entry is one demanding form of such acceptance because it often requires documentation, adaptation, quality assurance, and credible delivery. A first shipment is not the final measure of success, but it is a concrete step in the entrepreneurial growth process.

The paper has limitations that should guide future work. The dataset and results are constructed for research-paper development and should be validated with real administrative and customs data. A full empirical implementation would require official application scores, voucher disbursement records, firm-level financial histories, verified service-provider documents, and shipment-level export records. Future studies could also examine whether voucher-supported export entry persists beyond the first shipment and whether treated firms improve margins, productivity, or product quality [37].

Overall, the findings suggest that small innovation vouchers can support entrepreneurial internationalization when they are tied to precise commercialization barriers [38]. The relevant policy question is not whether every young firm should receive a voucher [39]. It is whether the firm has a defined technical object, a credible service need, and enough internal capability to use the service outcome. When these conditions are present, modest support can help a manufacturing venture move from domestic experimentation toward foreign market participation.

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