economies

# The Impact of Remittances on Saving Behaviour and Expenditure Patterns in Vietnam: Supplementary Material

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## Part I. Tests for balancing properties

### Tests for the balancing property of the separate covariate distributions

*t-tests* – The first test is the *t*-test that compares the differences in the means of each covariate between the treated and control groups before and after matching (Rosenbaum and Rubin 1985; Caliendo and Kopeinig 2008). Mainly, two-sample *t*-tests for equality of means are conducted for all covariates in the logit regression. Before matching, these *t*-tests could be significant. After matching, we expect all test results to be insignificant suggesting that the balancing property is satisfied.

*Absolute standardised bias (ASB)* – The second test evaluates the ASB for each covariate before and after matching, which is the absolute difference of the sample means between treated and non-treated households divided by the square root of the average of sample variance in both groups (Rosenbaum and Rubin, 1985). Formally,

$$ASB = 100\frac{\left|\overline{x}_T - \overline{x}_N\right|}{\sqrt{0.5\left(V_T + V_N\right)}}, \quad \text{(S1)}$$

where $\overline{x}_T$ and $\overline{x}_N$ are the means and $V_T$ and $V_N$ the variances of the covariates in the treated and non-treated groups, respectively.

According to Caliendo and Kopeinig (2008), the balancing property is satisfied if the ASB after matching is below 5%. Nevertheless, Garrido et al. (2014) argued that the maximum ASB after matching could range from 10% to 25%. Similarly, Clément (2011) used 10% as the threshold bias, and Jimenez-Soto and Brown (2012) accepted a 20% bias in their study.

*Variance ratio (VR)* – The third test evaluates for each continuous covariate the ratio of the variance in the treated group to that in the control group (Austin 2009). Variance ratios should be approximately equal to 1 for proper balancing, meaning that the variances of the samples are similar. A ratio lower than 0.5 or higher than 2 is too extreme, and indicates a misleading matching result.

### Tests for the balancing property of the joint covariate distribution

*Joint significance and pseudo $R^2$* – As a first group of tests, Sianesi (2004) suggests re-estimating the propensity score for the matched sample (including treated and matched non-treated households after matching), and compare the pseudo $R^2$ before and after matching. A large pseudo $R^2$ before, and a small pseudo $R^2$ after matching are expected. Notably, a small pseudo $R^2$ suggests that the observed characteristics explain very little for the propensity score after matching. Thus, the propensity score distributions of treated and non-treated groups after matching are balanced. Also, a likelihood ratio (LR) test on the joint significance of all predictors in the logit model can be performed. The test should

be significant before, and insignificant after matching. Also here, an insignificant LR test result means that, after matching, none of the covariates can explain the difference in propensity score between treated and non-treated groups. In other words, the propensity score distributions of the two groups are balanced.

*Mean and median standardised difference in covariates* – A second balance diagnostic, as suggested by Ho et al. (2007) and Austin (2009), is the evaluation of the mean and median of the absolute standardised difference or bias in the covariates across the treated and non-treated households of the matched sample. Smaller values of the mean and median bias after matching are better. In addition, Garrido et al. (2014) proposed to compare the means and medians of the absolute standardised bias among the matching estimators. The matching estimator with the smallest mean and median reduces the bias the most.

**Test results**

Tables S1-S3 summarize the test results for the balancing property of the separate covariate distributions, based on the 5 nearest neighbour matching estimator (Table S1), the radius matching estimator with $r=0.001$ (Table S2) and the kernel matching estimator (Table S3). Table S4 summarizes the test results for the balancing property of the joint covariate distribution.

**Table S1.** Tests for the balancing property of each covariate using the 5 nearest neighbour matching estimator.

| Variable | Sample | Mean | | *t*-test | Prob | ASB (%) | VR |
|---|---|---|---|---|---|---|---|
| | | Treated | Control | | | | |
| Age of the household head | Unmatched | 58.111 | 46.507 | 36.46 | 0.000 | 92.8 | 0.79 |
| | **Matched** | **58.095** | **58.243** | **-0.41** | **0.680** | **1.2** | **0.99** |
| Squared age household head (mean-centred) | Unmatched | 213.740 | 183.150 | 4.78 | 0.000 | 11.0 | 1.71 |
| | **Matched** | **213.470** | **217.530** | **-0.44** | **0.658** | **1.5** | **1.13** |
| South-Eastern Area | Unmatched | 0.070 | 0.137 | -8.34 | 0.000 | 22.1 | |
| | **Matched** | **0.070** | **0.072** | **-0.24** | **0.813** | **0.6** | |
| Central Highlands | Unmatched | 0.035 | 0.076 | -6.69 | 0.000 | 17.9 | |
| | **Matched** | **0.035** | **0.034** | **0.18** | **0.856** | **0.4** | |
| Northern and Coastal Central Region | Unmatched | 0.262 | 0.212 | 4.81 | 0.000 | 11.7 | |
| | **Matched** | **0.262** | **0.257** | **0.37** | **0.709** | **1.2** | |
| Midlands and Northern Mountainous Areas | Unmatched | 0.149 | 0.176 | -2.94 | 0.003 | 7.4 | |
| | **Matched** | **0.148** | **0.137** | **1.02** | **0.306** | **2.9** | |
| Red River Delta | Unmatched | 0.264 | 0.207 | 5.52 | 0.000 | 13.4 | |
| | **Matched** | **0.264** | **0.273** | **-0.61** | **0.542** | **1.9** | |
| Urban | Unmatched | 0.223 | 0.322 | -8.79 | 0.000 | 22.4 | |
| | **Matched** | **0.223** | **0.224** | **-0.05** | **0.959** | **0.1** | |
| Members with high-school degree or above | Unmatched | 0.737 | 0.871 | -4.87 | 0.000 | 12.4 | 0.80 |
| | **Matched** | **0.738** | **0.736** | **0.06** | **0.948** | **0.2** | **0.95** |
| Married household head | Unmatched | 0.786 | 0.842 | -6.01 | 0.000 | 14.4 | |
| | **Matched** | **0.785** | **0.772** | **1.10** | **0.273** | **3.6** | |
| Children 6-14 years | Unmatched | 0.285 | 0.645 | -19.25 | 0.000 | 50.9 | 0.56 |
| | **Matched** | **0.285** | **0.268** | **0.96** | **0.336** | **2.4** | **1.11** |
| Household size | Unmatched | 3.531 | 3.992 | -12.40 | 0.000 | 29.3 | 1.40 |
| | **Matched** | **3.533** | **3.569** | **-0.71** | **0.475** | **2.3** | **1.11** |
| Kinh household head | Unmatched | 0.896 | 0.831 | 7.23 | 0.000 | 18.8 | |
| | **Matched** | **0.895** | **0.901** | **-0.62** | **0.534** | **1.7** | |

**Table S2.** Tests for the balancing property of each covariate using the radius matching estimator ($r = 0.001$) .

| Variable | Sample | Mean | | *t*-test | Prob | ASB (%) | VR |
|---|---|---|---|---|---|---|---|
| | | Treated | Control | | | | |
| Age of the household head | Unmatched | 58.111 | 46.507 | 36.46 | 0.000 | 92.8 | 0.79 |
| | **Matched** | **58.006** | **58.265** | **-0.72** | **0.470** | **2.1** | **1.00** |
| Squared age household head (mean-centred) | Unmatched | 213.740 | 183.150 | 4.78 | 0.000 | 11.0 | 1.71 |
| | **Matched** | **212.16** | **216.33** | **-0.45** | **0.653** | **1.5** | **1.14** |
| South-Eastern Area | Unmatched | 0.070 | 0.137 | -8.34 | 0.000 | 22.1 | |
| | **Matched** | **0.071** | **0.074** | **-0.47** | **0.638** | **1.2** | |
| Central Highlands | Unmatched | 0.035 | 0.076 | -6.69 | 0.000 | 17.9 | |
| | **Matched** | **0.356** | **0.356** | **0.03** | **0.978** | **0.1** | |
| Northern and Coastal Central Region | Unmatched | 0.262 | 0.212 | 4.81 | 0.000 | 11.7 | |
| | **Matched** | **0.258** | **0.248** | **0.76** | **0.447** | **2.4** | |
| Midlands and Northern Mountainous Areas | Unmatched | 0.149 | 0.176 | -2.94 | 0.003 | 7.4 | |
| | **Matched** | **0.147** | **0.145** | **0.17** | **0.865** | **0.5** | |
| Red River Delta | Unmatched | 0.264 | 0.207 | 5.52 | 0.000 | 13.4 | |
| | **Matched** | **0.270** | **0.267** | **-0.01** | **0.994** | **0.0** | |
| Urban | Unmatched | 0.223 | 0.322 | -8.79 | 0.000 | 22.4 | |
| | **Matched** | **0.226** | **0.232** | **-0.54** | **0.589** | **1.6** | |
| Members with high-school degree or above | Unmatched | 0.737 | 0.871 | -4.87 | 0.000 | 12.4 | 0.80 |
| | **Matched** | **0.746** | **0.764** | **-0.56** | **0.575** | **1.6** | **0.93** |
| Married household head | Unmatched | 0.786 | 0.842 | -6.01 | 0.000 | 14.4 | |
| | **Matched** | **0.783** | **0.768** | **1.23** | **0.217** | **4.0** | |
| Children 6-14 years | Unmatched | 0.285 | 0.645 | -19.25 | 0.000 | 50.9 | 0.56 |
| | **Matched** | **0.288** | **0.272** | **0.87** | **0.382** | **2.2** | **1.13** |
| Household size | Unmatched | 3.531 | 3.992 | -12.40 | 0.000 | 29.3 | 1.40 |
| | **Matched** | **3.545** | **3.594** | **-0.97** | **0.333** | **3.1** | **1.09** |
| Kinh household head | Unmatched | 0.896 | 0.831 | 7.23 | 0.000 | 18.8 | |
| | **Matched** | **0.895** | **0.897** | **-0.24** | **0.814** | **0.6** | |

**Table S3.** Tests for the balancing property of each covariate using the kernel matching estimator.

| Variable | Sample | Mean | | *t*-test | Prob | ASB (%) | VR |
|---|---|---|---|---|---|---|---|
| | | Treated | Control | | | | |
| Age of the household head | Unmatched | 58.111 | 46.507 | 36.46 | 0.000 | 92.8 | 0.79 |
| | **Matched** | **58.095** | **58.236** | **-0.39** | **0.695** | **1.1** | **0.98** |
| Squared age household head (mean-centred) | Unmatched | 213.740 | 183.150 | 4.78 | 0.000 | 11.0 | 1.71 |
| | **Matched** | **213.47** | **219.03** | **-0.60** | **0.547** | **2.0** | **1.11** |
| South-Eastern Area | Unmatched | 0.070 | 0.137 | -8.34 | 0.000 | 22.1 | |
| | **Matched** | **0.070** | **0.074** | **-0.50** | **0.621** | **1.3** | |
| Central Highlands | Unmatched | 0.035 | 0.076 | -6.69 | 0.000 | 17.9 | |
| | **Matched** | **0.035** | **0.035** | **0.03** | **0.975** | **0.1** | |
| Northern and Coastal Central Region | Unmatched | 0.262 | 0.212 | 4.81 | 0.000 | 11.7 | |
| | **Matched** | **0.262** | **0.250** | **0.93** | **0.355** | **2.9** | |
| Midlands and Northern Mountainous Areas | Unmatched | 0.149 | 0.176 | -2.94 | 0.003 | 7.4 | |
| | **Matched** | **0.148** | **0.148** | **0.03** | **0.979** | **0.1** | |
| Red River Delta | Unmatched | 0.264 | 0.207 | 5.52 | 0.000 | 13.4 | |
| | **Matched** | **0.264** | **0.264** | **-0.00** | **0.998** | **0.0** | |
| Urban | Unmatched | 0.223 | 0.322 | -8.79 | 0.000 | 22.4 | |
| | **Matched** | **0.223** | **0.230** | **-0.49** | **0.624** | **1.4** | |
| Members with high-school degree or above | Unmatched | 0.737 | 0.871 | -4.87 | 0.000 | 12.4 | 0.80 |
| | **Matched** | **0.738** | **0.748** | **-0.29** | **0.769** | **0.9** | **0.94** |
| Married household head | Unmatched | 0.786 | 0.842 | -6.01 | 0.000 | 14.4 | |
| | **Matched** | **0.785** | **0.770** | **1.26** | **0.208** | **4.1** | |
| Children 6-14 years | Unmatched | 0.285 | 0.645 | -19.25 | 0.000 | 50.9 | 0.56 |
| | **Matched** | **0.285** | **0.277** | **0.47** | **0.642** | **1.2** | **1.10** |
| Household size | Unmatched | 3.531 | 3.992 | -12.40 | 0.000 | 29.3 | 1.40 |
| | **Matched** | **3.533** | **3.590** | **-1.12** | **0.261** | **3.6** | **1.10** |
| Kinh household head | Unmatched | 0.896 | 0.831 | 7.23 | 0.000 | 18.8 | |
| | **Matched** | **0.895** | **0.890** | **0.57** | **0.570** | **1.6** | |

**Table S4.** Tests for the balancing property of the joint covariate distribution.

| Sample | Total sample size | Number of treated households | Number of non-treated households | Pseudo $R^2$ | LR Chi-Square | $p >$ Chi-Square | Mean bias (%) | Median bias (%) |
|---|---|---|---|---|---|---|---|---|
| Unmatched | 8,778 | 2,174 | 6,604 | 0.189 | 1,852.70 | 0.000 | 25.0 | 17.9 |
| 5NN | 5,656 | 2,171 | 3,485 | 0.001 | 6.93 | 0.906 | 1.5 | 1.5 |
| Radius | 8,509 | 2,150 | 6,359 | 0.001 | 6.97 | 0.904 | 1.6 | 1.6 |
| Kernel | 8,775 | 2,171 | 6,604 | 0.001 | 7.52 | 0.873 | 1.5 | 1.3 |

Note: The mean or median bias is the mean or median standardised difference in covariates.

**Part II: Rosenbaum bounding approach for sensitivity analysis**

The bounding approach proposed by Rosenbaum (2002) estimates confidence bounds of the outcomes that indicate how strongly an unobserved variable must affect selection into treatment in order to undermine the conclusions from the PSM approach.

Let us assume that the probability of receiving remittances for household *i* is

$$P_i = P\left(REMIT_i = 1 | x_i\right) = F\left(\beta x_i + \gamma u_i\right), \tag{S2}$$

Where $x_i$ is the vector of observed covariates of household *i*, $\beta$ the effect of $x_i$ on the probability of receiving remittances, $u_i$ an unobserved covariate, $\gamma$ the effect of $u_i$ on the probability of receiving remittances, and *F* is the logistic distribution.

Therefore, the logit regression is

$$logit\left(P_i\right) = \ln\left(\frac{P_i}{1-P_i}\right) = \beta x_i + \gamma u_i . \tag{S3}$$

If the unobserved covariate does not impact the probability of receiving remittances, or the study is free of hidden bias, then $\gamma$ will be zero in equation (S3) and the probability of receiving remittances will be determined only by the observed characteristics. However, if there is any hidden bias, two households with the same characteristics could differ in the probability of receiving remittances.

Let us assume we have a matched pair of household *i* and household *j*. The *odds* for each of these households is the ratio of the probability of receiving remittances and the probability of not receiving remittances and given by

$$odds\left(i\right) = \frac{P_i}{1-P_i} = \exp\left(\beta x_i + \gamma u_i\right) \quad \text{and} \quad odds\left(j\right) = \frac{P_j}{1-P_j} = \exp\left(\beta x_j + \gamma u_j\right).$$

The *odds ratio* of household *i* and household *j* is then defined as

$$\frac{P_i/(1-P_i)}{P_j/(1-P_j)} = \frac{\exp\left(\beta x_i + \gamma u_i\right)}{\exp\left(\beta x_j + \gamma u_j\right)} = \exp\left[\beta\left(x_i - x_j\right) + \gamma\left(u_i - u_j\right)\right]. \tag{S4}$$

If the PSM approach is applied, household *i* and household *j* have identical characteristics; thus $x_i$ is similar to $x_j$, and the odds ratio in equation (S4) becomes

$$\frac{P_i/(1-P_i)}{P_j/(1-P_j)} = \exp\left[\gamma\left(u_i - u_j\right)\right]. \tag{S5}$$

If the unobserved covariate has no influence on the probability of receiving remittances $(\gamma = 0)$ or if the unobserved covariates of household *i* and *j* are nearly the same $(u_i = u_j)$, then the odds ratio is 1, referring to the absence of a hidden or unobserved selection bias. The sensitivity analysis is constructed based on the changes of $\gamma$ and $u_i = u_j$. Assuming that the unobserved covariate is a dummy variable $(u_i = 1$ or $u_i = 0)$ (Aakvik 2001), Rosenbaum (2002) proposed the following bounds on the odds ratio that either of the two matched households will receive remittances:

$$\frac{1}{\Gamma} \leq \frac{P_i/(1-P_i)}{P_j/(1-P_j)} \leq \Gamma, \tag{S6}$$

where $\Gamma = e^{\gamma}$. If $\Gamma=1$, the odds for the matched households are equal. If $\Gamma=2$, the matched households could differ in their odds of receiving remittances by as much as a factor of 2.

By varying the value of $\Gamma$, confidence intervals of the outcomes can be estimated and inspected (for details see Aakvik 2001; Rosenbaum, 2002). We calculated the bounds of the confidence intervals using the *rbounds* command in Stata developed by Gangl (2004).

If the lower and upper bounds of the confidence intervals have the same signs at a value of $\Gamma<2$, the *ATT* is free of hidden bias. However, if these lower and upper bounds have different signs, there could be a hidden bias. The odds ratio at which the bounds of the confidence intervals are no longer of the same sign is called the critical odds ratio (Li 2012). The lower the critical odds ratio, the more sensitive the outcomes are to hidden bias. We note that the result from this sensitivity analysis does not imply the existence of a hidden bias in the *ATT*. Instead, it indicates a worst-case scenario where the *ATT* could be zero and the unobserved covariates largely determine the treatment assignment (Clément 2011; Li 2012). That is why not all researchers who follow the PSM approach conduct a sensitivity test (see, e.g., Esquivel and Huerta-Pineda 2007; Randazzo and Piracha 2019).

The following tables summarize the test results for our sample.

**Table S5.** Rosenbaum bounds sensitivity analysis on the matching estimators for the impact of remittances on saving and adjusted income.

| Γ | 5 nearest neighbour | | Radius | | Kernel | |
|---|---|---|---|---|---|---|
| | **Lower 95% CI** | **Upper 95% CI** | **Lower 95% CI** | **Upper 95% CI** | **Lower 95% CI** | **Upper 95% CI** |
| | | | **Saving amount** | | | |
| **1** | **-1,076.800** | **2,112.900** | **-2,479.650** | **633.395** | -3,473.750 | -526.600 |
| **1.2** | -4,017.600 | 5,223.700 | -5,266.820 | 3,694.360 | **-6,086.650** | **2,441.540** |
| | | | **Saving rate** | | | |
| **1** | 0.143 | 0.182 | 0.154 | 0.191 | 0.248 | 0.286 |
| **2** | **-0.006** | **0.319** | 0.014 | 0.318 | 0.104 | 0.422 |
| **3** | -0.101 | 0.398 | **-0.077** | **0.389** | 0.013 | 0.500 |
| **4** | -0.175 | 0.454 | -0.147 | 0.440 | **-0.057** | **0.554** |
| | | | **Adjusted income** | | | |
| **1** | **-4,639.000** | **488.100** | -6,726.340 | -1,740.490 | -7,627.300 | -2,806.150 |
| **1.2** | -9,286.200 | 5,482.300 | **-11,220.400** | **3,126.420** | **-11,922.300** | **1,934.420** |

Note: The critical values corresponding to the lowest value of Γ that produces a confidence interval including zero are in bold.

**Table S6.** Rosenbaum bounds sensitivity analysis on the matching estimators for the impact of remittances on the expenditure shares.

| Γ | 5 nearest neighbour | | Radius | | Kernel | |
|---|---|---|---|---|---|---|
| | **Lower 95% CI** | **Upper 95% CI** | **Lower 95% CI** | **Upper 95% CI** | **Lower 95% CI** | **Upper 95% CI** |
| | | | **Health** | | | |
| **1** | -0.010 | -0.005 | -0.013 | -0.008 | -0.018 | -0.012 |
| **1.2** | **-0.014** | **0.000** | -0.017 | -0.003 | -0.022 | -0.007 |
| **1.4** | -0.018 | 0.005 | **-0.020** | **0.003** | -0.025 | -0.001 |
| **1.6** | -0.021 | 0.010 | -0.023 | 0.007 | **-0.027** | **0.004** |
| | | | **Assets** | | | |
| **1** | -0.013 | -0.009 | -0.018 | -0.014 | -0.025 | -0.020 |
| **1.2** | -0.017 | -0.005 | -0.021 | -0.010 | -0.027 | -0.015 |
| **1.4** | -0.021 | -0.002 | -0.024 | -0.006 | -0.030 | -0.010 |
| **1.6** | **-0.024** | **0.001** | -0.026 | -0.002 | -0.031 | -0.005 |
| **1.8** | -0.026 | 0.005 | **-0.029** | **0.002** | -0.031 | -0.000 |
| **2** | -0.029 | 0.010 | -0.030 | 0.007 | **-0.032** | **0.004** |
| | | | **House repairs** | | | |
| **1** | -0.002 | -0.001 | -0.005 | -0.004 | -0.011 | -0.011 |
| **2** | -0.008 | -0.000 | -0.011 | -0.001 | -0.012 | -0.010 |
| **3** | -0.015 | -0.000 | -0.000 | -0.000 | -0.012 | -0.009 |
| **4** | **-0.021** | **0.001** | -0.018 | -0.000 | -0.013 | -0.005 |
| **5** | -0.025 | 0.007 | **-0.020** | **0.007** | **-0.013** | **0.007** |
| | | | **Food** | | | |
| **1** | -0.024 | -0.011 | -0.021 | -0.009 | -0.022 | -0.011 |
| **1.2** | **-0.035** | **0.000** | **-0.032** | **0.002** | -0.033 | -0.000 |
| **1.4** | -0.045 | 0.010 | -0.042 | 0.011 | **-0.043** | **0.008** |

Note: The critical values corresponding to the lowest value of Γ that produces a confidence interval including zero are in bold.

**Table S7.** Rosenbaum bounds sensitivity analysis on the matching estimators for the impact of remittances on the per capita expenditures.

| Γ | 5 nearest neighbour | | Radius | | Kernel | |
|---|---|---|---|---|---|---|
| | **Lower 95% CI** | **Upper 95% CI** | **Lower 95% CI** | **Upper 95% CI** | **Lower 95% CI** | **Upper 95% CI** |
| | | | **Health** | | | |
| **1** | -216.850 | -121.083 | -336.376 | -243.442 | -545.519 | -444.725 |
| **1.2** | -305.950 | -24.270 | -417.887 | -146.035 | -625.828 | -333.563 |
| **1.4** | **-382.978** | **68.333** | -484.815 | -50.953 | -685.031 | -226.585 |
| **1.6** | -452.754 | 160.054 | **-542.801** | **43.531** | -731.229 | -127.135 |
| **1.8** | -516.900 | 252.077 | -594.509 | 137.208 | -768.632 | -34.508 |
| **2** | -576.300 | 342.022 | -641.417 | 228.193 | **-800.135** | **55.017** |
| | | | **Assets** | | | |
| **1** | -320.833 | -225.000 | -512.354 | -414.263 | -705.909 | -619.592 |
| **2** | **-727.917** | **108.333** | -832.083 | -13.258 | -866.722 | -198.389 |
| **3** | -982.417 | 549.000 | **-1,027.810** | **429.879** | **-963.649** | **299.458** |
| | | | **House repairs** | | | |
| **1** | -33.333 | -12.500 | -126.623 | -99.312 | -291.693 | -279.847 |
| **2** | -166.667 | -0.000 | -270.536 | -24.921 | -323.591 | -233.655 |
| **3** | -301.667 | -0.000 | -373.507 | -0.000 | -342.002 | -193.974 |
| **4** | **-496.667** | **12.000** | -464.114 | -0.000 | -353.158 | -145.137 |
| **5** | -600.000 | 125.000 | **-550.000** | **92.500** | **-360.640** | **20.545** |

Note: The critical values corresponding to the lowest value of Γ that produces a confidence interval including zero are in bold.

## References


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