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| **Table S1. Characteristics of the markers for BC detection identified in training set.** |
| **Gene** | **Type** | **P (wilcox test)** | **Fold change (mean)** | **Fold change (median)** |
| BEX2 (DEG in TCGA BC) | Protein coding | 0.000310028 | 1.551658348 | 1.630823933 |
| AC104843.1 | Processed pseudogene | 1.46E-05 | 1.9550703 | 2.181653303 |
| AL136981.2 | Unprocessed pseudogene | 0.000206439 | 1.606567296 | 3.475874025 |
| KRT19 | Protein coding | 6.51E-05 | 2.549444982 | 11.3287037 |
| NPM1P25 | Processed pseudogene | 0.000357388 | 1.216086475 | 4.044264819 |
| CTSG | Protein coding | 0.000410313 | 1.872959802 | 5.614639397 |
| CBR3 | Protein coding | 8.25E-05 | 1.651809737 | 2.903473492 |
| HOXB7 | Protein coding | 0.000166308 | 1.524901639 | 1.636319099 |
| AL691447.3 | Processed pseudogene | 1.82E-05 | 1.78739331 | 2.080022052 |
| RNA5SP141 | rRNA pseudogene | 5.56E-05 | 1.892021691 | Infinity |
| chr13\_42953948\_42970670\_- | circRNA | 0.000460577 | 1.688474834 | 2.761911793 |
| Abbreviations: DEG, differentially expressed gene; TCGA, the Cancer Genome Atlas. |

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| **Table S2. Relationship between MSMO1 expression and clinicopathological features in 291 primary BC patients.** |
| **Characteristics**  | **Low (%)** |  | **High (%)** | ***p*-value** |
| **n=153** |  | **n=138** |
| **Age(years)** |  |  |  | 0.104  |
|  ≤ 45 | 36 (23.5) |  | 35 (25.4) |  |
|  ＞45 and ≤ 60 | 86 (56.2) |  | 62 (44.9) |  |
|  ＞60 | 31 (20.3) |  | 41 (29.7) |  |
| **Menopausal status\*** |  |  |  | 0.766  |
|  Pre | 63 (41.2) |  | 52 (37.7) |  |
|  Post | 87 (56.9) |  | 84 (60.9) |  |
| **Grade\***  |  |  |  | 0.763  |
|  G1/2 | 90 (58.8) |  | 81 (58.7) |  |
|  G3 | 51 (33.3) |  | 49 (35.5) |  |
| **pT stage\*** |  |  |  | 0.692  |
|  T1 | 56 (36.6) |  | 46 (33.3) |  |
|  T2/3 | 96 (62.7) |  | 90 (65.2) |  |
| **pN stage** |  |  |  | 0.854  |
|  N0 | 64 (41.8) |  | 61 (44.2) |  |
|  N1 | 50 (32.7) |  | 39 (28.3) |  |
|  N2 | 16 (10.5) |  | 17 (12.3) |  |
|  N3 | 23 (15.0) |  | 21 (15.2) |  |
| **LVI\*** |  |  |  | 0.307  |
|  Negative | 85 (55.6) |  | 65 (47.1) |  |
|  Positive | 65 (42.5) |  | 71 (51.4) |  |
| **ER status\*** |  |  |  | 0.590  |
|  Negative | 45 (29.4) |  | 38 (27.5) |  |
|  Positive | 107 (69.9) |  | 100 (72.5) |  |
| **PR status\*** |  |  |  | 0.403  |
|  Negative | 34 (22.2) |  | 25 (18.1) |  |
|  Positive | 119 (77.8) |  | 112 (81.2) |  |
| **HER2 status\*** |  |  |  | **0.033**  |
|  Negative | 113 (73.9) |  | 82 (59.4) |  |
|  Positive | 34 (22.2) |  | 48 (34.8) |  |
| **Ki67\*** |  |  |  | 0.272  |
|  Low | 58 (37.9) |  | 45 (32.6) |  |
|  High | 35 (22.9) |  | 43 (31.2) |  |
| Abbreviations: pT, pathological tumor size; pN, pathological lymph-node status; LVI, lymphovascular invasion; ER, estrogen receptor; PR, progesterone receptor; HER2, human epidermal growth factor receptor 2;  |
| \*Excluded the unknown category.  |

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| **Table S3. Univariate and multivariate Cox regression analyses of DFS in BC patients.**  |  |
|  | **Univariate analysis** |  | **Multivariate analysis** |
| **Covariates**  | **HR (95% CI)**  | ***p*-value**  |  | **HR (95% CI)**  | ***p*-value**  |
| **Age (years)** |  | 0.425  |  |  |  |
|  **41-60 versus ≤40** | 0.648 (0.371-1.133) | 0.128  |  | —— |  |
|  **>60 versus ≤40** | 0.596 (0.298-1.190) | 0.143  |  | —— |  |
| **Grade (G3 versus G1/2)**  | 1.404 (0.837-2.355) | 0.199  |  | —— |  |
| **pT stage (T2/3 versus T1)**  | 2.113 (1.166-3.828) | **0.014**  |  | 1.668 (0.903-3.081) | 0.102 |
| **pN stage**  |  | **<0.001** |  |  | **<0.001** |
|  **N1 versus N0**  | 2.477 (1.267-4.843) | **0.008**  |  | 3.342 (1.570-7.113) | **0.002** |
|  **N2 versus N0**  | 2.861 (1.237-6.614) | **0.014**  |  | 3.952 (1.553-10.057) | **0.004** |
|  **N3 versus N0**  | 5.276 (2.640-10.544) | **<0.001** |  | 7.757 (3.192-18.851) | **<0.001** |
| **LVI (positive versus negative)** | 2.011 (1.198-3.375) | **0.008**  |  | 0.668 (0.345-1.291) | 0.230  |
| **ER (positive versus negative)**  | 0.900 (0.526-1.539) | 0.700  |  | —— |  |
| **PR (positive versus negative)**  | 0.769 (0.431-1.374) | 0.375  |  | —— |  |
| **HER2 (positive versus negative)** | 1.327 (0.761-2.314) | 0.319  |  | —— |  |
| **Ki67 (high versus low)**  | 1.565 (0.854-2.869) | 0.147  |  | —— |  |
| **MSMO1 expression level (high versus low)**  | 2.373 (1.416-3.976) | **0.001**  |  | 2.683 (1.571-4.583) | **<0.001** |
| Abbreviations: DFS, disease-free survival; pT, pathological tumor size; pN, pathological lymph-node status; LVI, lymphovascular invasion; ER, estrogen receptor; PR, progesterone receptor; HER2, human epidermal growth factor receptor 2; HR, hazard ratio; CI, confidence interval. |